home power

The Hands-On Journal of Home-Made Power

Issue 103

October – November 2004

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After installing six SW Plus Inverter/Chargers over the past three months, Pat Bailey of Solar Solutions is a bona fide fan of the product. "It's an excellent inverter that improves upon the already good SW," says Pat. "It has much more room for wiring, making installation easier. And the surge capacity of the SW Plus 2524 actually exceeds that of the 4000 watt SW."

Pat is one of hundreds of installers who are discovering the SW Plus. It provides superior efficiency at load levels typically found in an off-grid home. In addition to added features such as Silent Mode for improved battery performance, it also has non-volatile memory so customized settings will never have to be reprogrammed. And, while the SW Plus raised the bar on performance, it still costs up to 20% less than the original.

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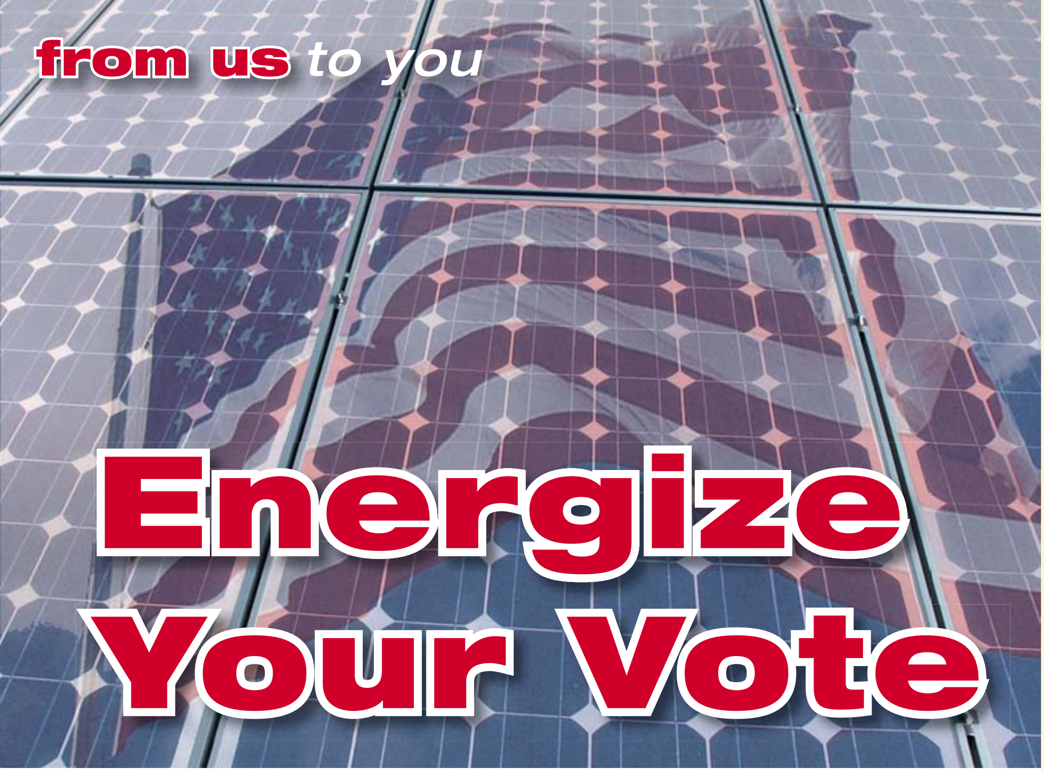
HP103 contents

On the Cover

Folk music hero Pete Seeger shows off the solar-electric array at his homestead overlooking the Hudson River in New York.

Photo by Ed Witkin

Regulars



Energize Your Vote

Every day we vote with our wallets, whether we're buying PV systems or SUVs. When we vote in political elections, we're voting on where our tax dollars go, as well as how we are represented.

Although we don't recommend basing your vote on any single issue, energy policy is an important factor to consider. Think about energy's sweeping impact on social, economic, security, environmental, and geopolitical concerns. Then make yourself a promise to learn each candidate's stance on renewable energy, and get out there and vote!

Not sure who your elected officials are? That's not unusual since most of us have a dozen or more representatives on the state and national levels alone—a lot to keep track of. Get in touch with your local election office or pay a visit to www.vote-smart.org for a rundown of who's representing you.

The people who win this season's elections will have a very direct effect on how quickly renewable energy is adopted in the United States and elsewhere. With that in mind, the stakes seem high. Let's vote our renewable energy values.

—The *Home Power* crew

Think About It...

"Nobody can do everything, but everybody can do something, and if everybody does something, everything will get done."

—song "Work For Peace," Gil Scott-Heron, 1994

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

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

HP access

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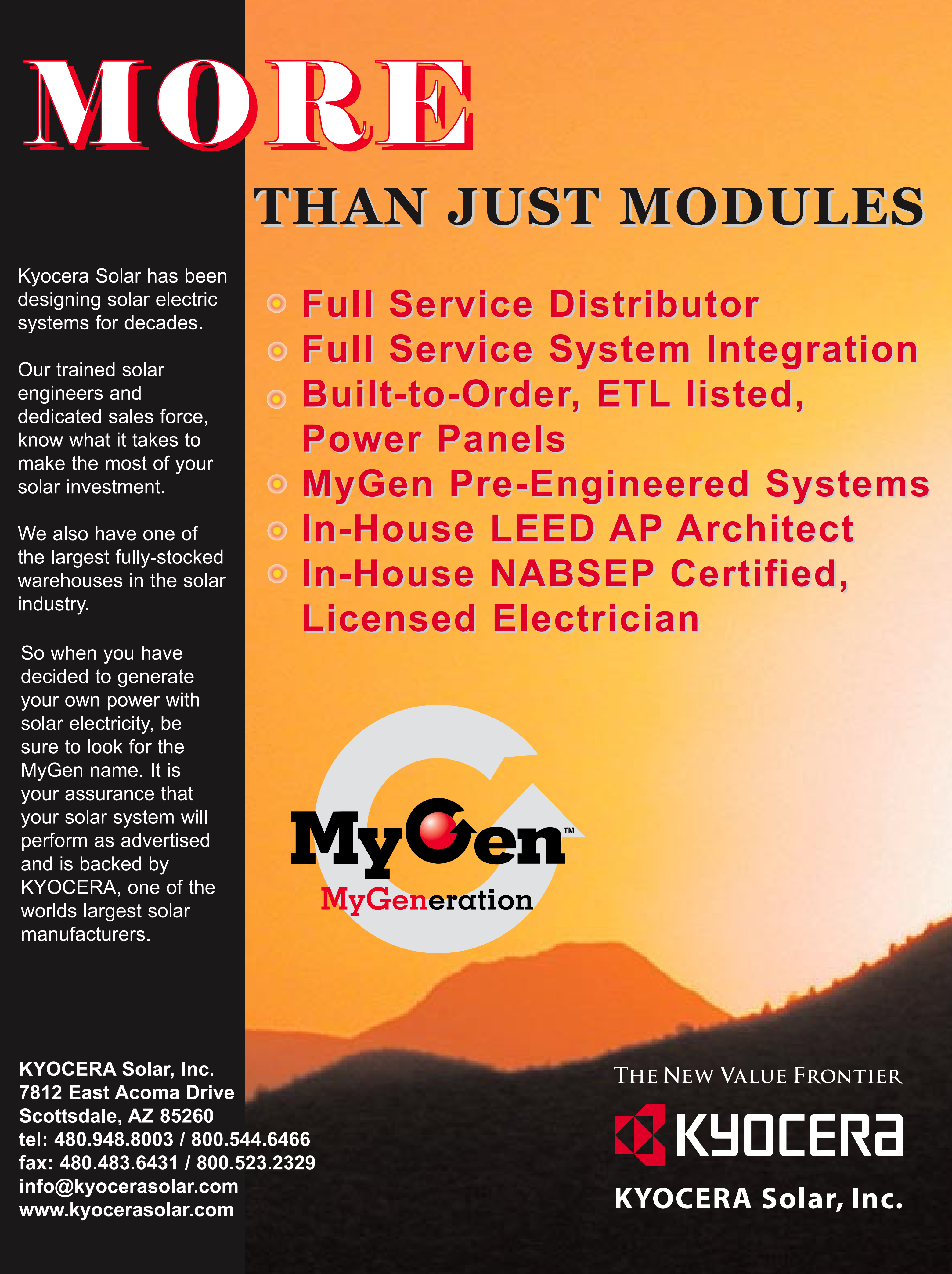
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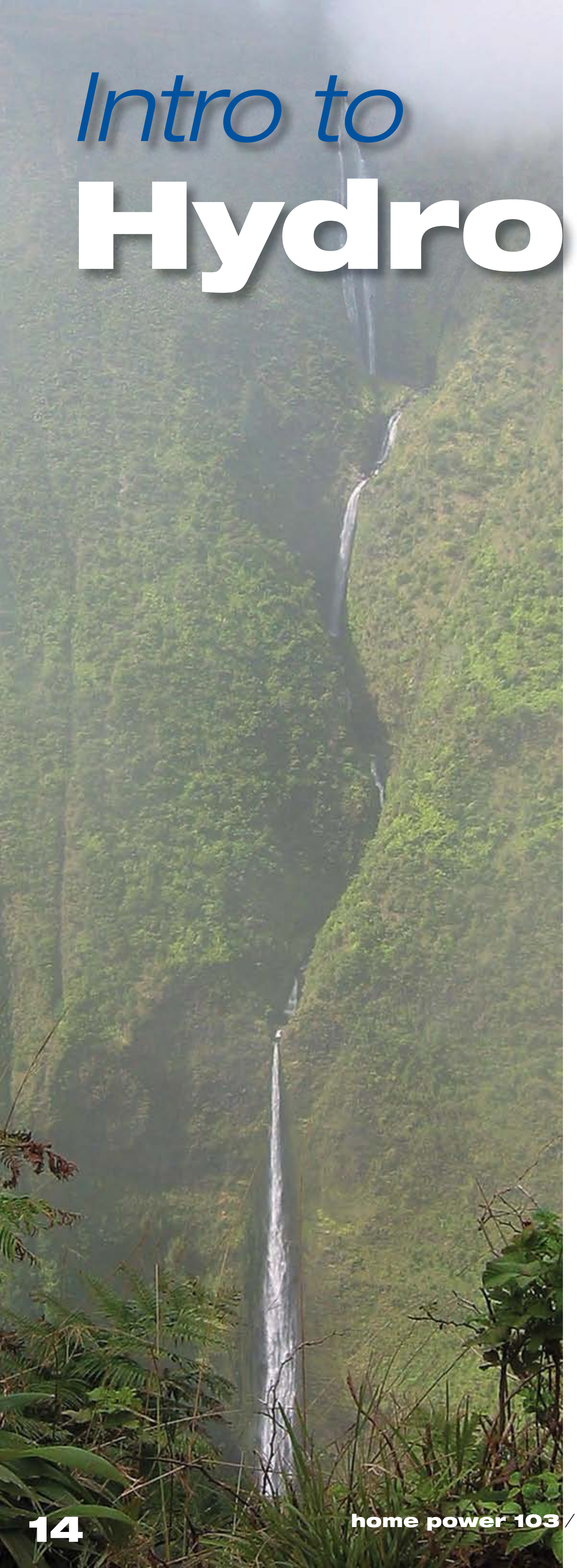
Intro to Hydropower

Part 1: Systems Overview

Dan New



Hydropower is based on simple concepts. Moving water turns a turbine, the turbine spins a generator, and electricity is produced. Many other components may be in a system, but it all begins with the energy already within the moving water.

What Makes Water Power

Water power is the combination of *head* and *flow*. Both must be present to produce electricity. Consider a typical hydro system. Water is diverted from a stream into a pipeline, where it is directed downhill and through the turbine (flow). The vertical drop (head) creates pressure at the bottom end of the pipeline. The pressurized water emerging from the end of the pipe creates the force that drives the turbine. More flow or more head produces more electricity. Electrical power output will always be slightly less than water power input due to turbine and system inefficiencies.

Head is water pressure, which is created by the difference in elevation between the water intake and the turbine. Head can be expressed as vertical distance (feet or meters), or as pressure, such as pounds per square inch (psi). Net head is the pressure available at the turbine when water is flowing, which will always be less than the pressure when the water is turned off (static head), due to the friction between the water and the pipe. Pipeline diameter has an effect on net head.

Flow is water quantity, and is expressed as "volume per time," such as gallons per minute (gpm), cubic feet per second (cfs), or liters per minute. Design flow is the maximum flow for which your hydro system is designed. It will likely be less than the maximum flow of your stream (especially during the rainy season), more than your minimum flow, and a compromise between potential electrical output and system cost.

You need not have this kind of head and flow to have a good hydropower site—but you could fantasize.

Head and flow are the two most important things you need to know about your site. You must have these measurements before you can seriously discuss your project, how much electricity it will generate, or the cost of components. Every aspect of a hydro system revolves around head and flow. In Part 2 of this series, we will discuss how to measure them.

Power Conversion & Efficiency

The generation of electricity is simply the conversion of one form of energy to another. The turbine converts the energy in the moving water into rotational energy at its shaft, which is then converted to electrical energy by the generator.

Energy is never created; it can only be converted from one form to another. Some of the energy will be lost through friction at every point of conversion. Efficiency is the measure of how much energy is actually converted. The simple formula for this is:

Net Energy = Gross Energy x Efficiency

While some losses are inevitable as the energy in moving water gets converted to electricity, they can be minimized with good design. Each aspect of your hydro system—from water intake to turbine-generator alignment to transmission wire size—affects efficiency. Turbine design is especially important, and must be matched to your specific head and flow for best efficiency.

A hydro system is a series of interconnected components. Water flows in at one end of the system, and electricity comes out the other. Here is an overview of these components, from the water source to the electrical controls.

Water Diversion (Intake)

The intake is typically the highest point of your hydro system, where water is diverted from the stream into the pipeline that feeds your turbine. A diversion can be as simple as a screened pipe dropped into a pool of water, or as big and complex as a dam across an entire creek or river. A water diversion system serves two primary purposes. The first is to provide a deep enough pool of water to create a smooth, air-free inlet to your pipeline. (Air reduces horsepower and can damage your turbine.) The second is to remove dirt and debris.

Trash racks and rough screens can help stop larger debris, such as leaves and limbs, while an area of quiet water will allow dirt and other sediment to settle to the bottom before entering your pipeline. This helps reduce abrasive wear on your turbine. Another approach is to use a fine, self-cleaning screen that filters both large debris and small particles.

Useful Hydro Conversions

Power*

1 horsepower = 746 watts

1 kilowatt = 1.34 horsepower

* Efficiency not accounted for

Static Head & Pressure

1 foot of head = 0.43 pounds per square inch (psi)

1 psi = 2.31 feet of head

Flow

1 gallon per minute (gpm) = 0.0022 cubic feet per second (cfs)

1 gpm = 0.000063 cubic meters per second

1 gpm = 3.8 liters per minute

1 cfs = 449 gpm

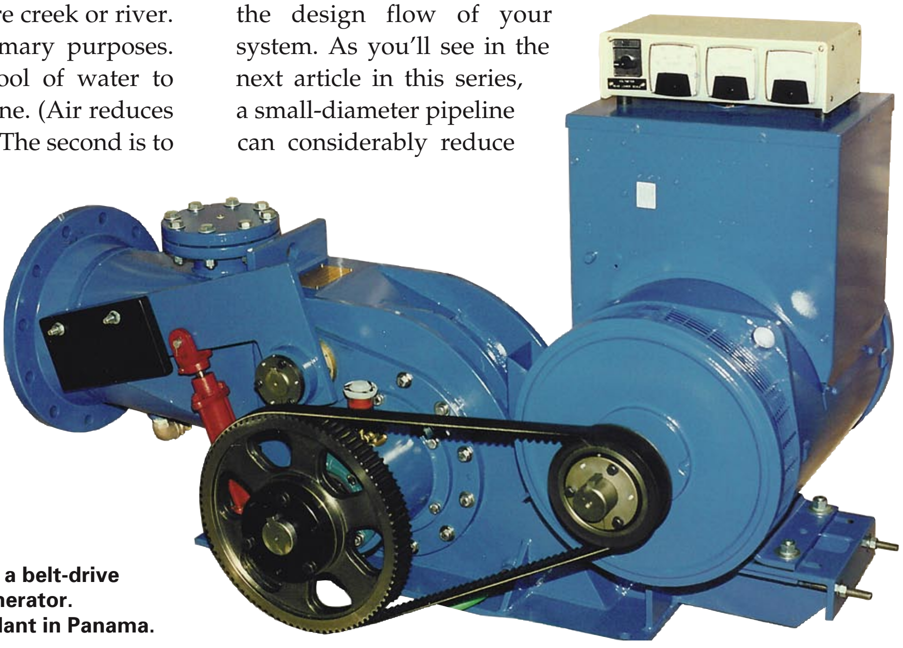
1 cfs = 0.283 cubic meters per second

1 cfs = 1,700 liters per minute

Pipeline (Penstock)

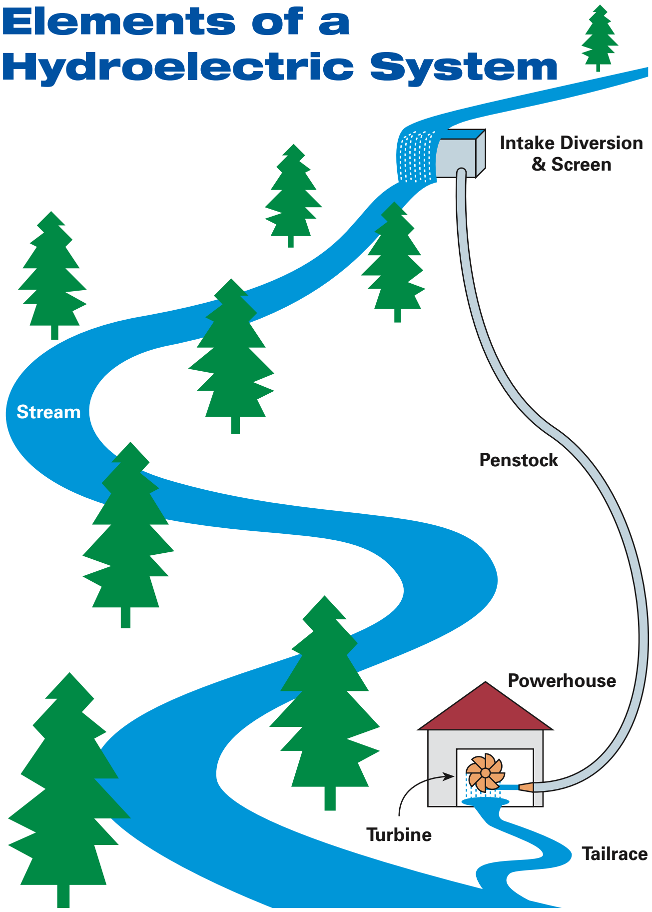
The pipeline, or penstock, not only moves the water to your turbine, but is also the enclosure that creates head pressure as the vertical drop increases. In effect, the pipeline focuses all the water power at the bottom of the pipe, where the turbine is. In contrast, an open stream dissipates the energy as the water travels downhill.

Pipeline diameter, length, material, and routing all affect efficiency. Guidelines are available for matching the size of your pipeline to the design flow of your system. As you'll see in the next article in this series, a small-diameter pipeline can considerably reduce



This variable-flow, crossflow turbine uses a belt-drive coupling to a 40 KW synchronous generator. It supplies electricity to a coffee processing plant in Panama.

Elements of a Hydroelectric System



your available horsepower, even though it can carry all available water. Larger diameter pipelines have less friction as the water travels through.

Powerhouse

The powerhouse is simply a building or box that houses your turbine, generator, and controls. Its main function is to provide a place for the system components to be mounted, and to protect them from the elements. Its design can affect system efficiency, especially with regard to how the water enters and exits your turbine. For example, too many elbows leading to the turbine can create turbulence and head loss. Likewise, any restrictions to water exiting the turbine may increase resistance against the turbine's moving parts.

Turbine

The turbine is the heart of the hydro system, where water power is converted into the rotational force that drives the generator. For maximum efficiency, the turbine should be designed to match your specific head and flow. There are many different types of turbines, and proper selection requires considerable expertise. A Pelton design, for example, works best with medium to high heads. A crossflow design works better with lower head but higher flow. Other turbine types, such as Francis, turgo, and propeller, each have optimum applications.

Turbines can be divided into two major types. Reaction turbines use runners (the rotating portion that receives the water) that operate fully immersed in water, and are typically used in low to moderate head systems with high flow. Examples include Francis, propeller, and Kaplan.

Impulse turbines use runners that operate without being immersed, driven by one or more high-velocity jets of water. Examples include Pelton and turgo. Impulse turbines are typically used with moderate-to-high head systems, and use nozzles to produce the high-velocity jets. Some impulse turbines can operate efficiently with as little as 5 feet (1.5 m) of head.

The crossflow turbine is a special case. Although technically classified as an impulse turbine because the runner is not entirely immersed in water, this "squirrel cage" type of runner is used in applications with low to moderate head and high flow. The water passes through a large, rectangular opening to drive the turbine blades, in contrast to the small, high-pressure jets used for Pelton and turgo turbines.

Regardless of the turbine type, efficiency is in the details. Each turbine type can be designed to meet vastly different requirements. The turbine system is designed around net head and design flow. These criteria not only influence which type of turbine to use, but are critical to the design of the entire turbine system.

Minor differences in specifications can significantly impact energy transfer efficiency. The diameter of the runner, front and back curvatures of its buckets or blades, casting materials, nozzle (if used), turbine housing, and quality of components all affect efficiency and reliability.

An in-stream screen keeps debris and silt out of the penstock at the small-stream intake for a microhydro system in Washington.

Drive System

The drive system couples the turbine to the generator. At one end, it allows the turbine to spin at the rpm that delivers best efficiency. At the other, it drives the generator at the rpm that produces correct voltage and frequency—frequency applies to alternating current (AC) systems only. The most efficient and reliable drive system is a direct, 1:1 coupling between the turbine and generator.

This is possible for many sites, but not for all head and flow combinations. In many situations, especially with AC systems, it is necessary to adjust the transfer ratio so that both turbine and generator run at their optimum (but different) speeds. These types of drive systems can use either gears, chains, or belts, each of which introduces additional efficiency losses into the system. Belt systems tend to be more popular because of their lower cost.

Generator

The generator converts the rotational energy from the turbine shaft into electricity. Efficiency is important at this stage too, but most modern, well-built generators deliver good efficiency. Direct current (DC) generators, or alternators

At the bottom of the penstock, a manifold routes water to the four nozzles of a Harris Pelton turbine that drives a permanent magnet alternator.

Hydro Terms

Flow
Refers to the quantity of water supplied from a water source or exiting a nozzle per unit of time. Commonly measured in gallons per minute (gpm).

Francis Turbine
A type of reaction hydro-turbine used in low to medium heads. It consists of fixed vanes on a shaft. Water flows down through the vanes, driving the shaft.

Friction Loss
Lost energy due to pipe friction. In hydro systems, pipe sized too small can lead to serious friction losses.

Head
The difference in elevation between a source of water and the location at which the water from that source may be used (synonym: vertical drop). Expressed in vertical distance or pressure.

Headrace
A flume or channel that feeds water into a hydro turbine.

Hydroelectricity
Any electricity that is generated by the flow of water.

Impulse Turbine
Turbines with runners that operate in air, driven by one or more high-velocity jets of water from nozzles. Typically used with moderate- to high-head systems. Examples include Pelton and turgo.

Intake
The structure that receives the water and feeds it into the penstock (pipeline). Usually incorporates screening or filtering to keep debris and aquatic life out of the system.

Pelton Wheel
A common impulse turbine runner (named after inventor Lester Pelton) made with a series of cups or "buckets" attached to a hub.

Penstock
The pipe in a hydro system that carries the water from the intake to the turbine.

(continued)

More Hydro Terms

Pipe Loss (Frictional Head Loss)
The amount of energy or pressure lost due to friction between a flowing liquid and the inside surface of a pipe.

Pressure
The "push" behind liquid or gas in a tank, reservoir, or pipe. Water pressure is directly related to "head"—the height of the top of the water over the bottom. Every 2.31 feet of vertical head gives 1 psi (pound per square inch) of water pressure.

Reaction Turbine
Turbines with the runner fully immersed in water, typically used in low- to moderate-head systems with high flow. Examples include Francis, propeller, and Kaplan.

Runner
The wheel that receives the water, changing the pressure and flow of the water to circular motion to drive an alternator, generator, or machine.

Tailrace
The pipe, flume, or channel in a hydroelectric system that carries the water from the turbine runner back to the stream or river.

Trash Rack
A strainer at the input to a hydro system. Used to remove debris from the water before it enters the pipe.

Turgo
A type of impulse hydro runner optimized for lower heads and higher volumes than a Pelton runner.

with rectifiers, are typically used with small household systems, and are usually augmented with batteries for reserve capacity, as well as inverters for converting the electricity into the AC required by most appliances. DC generators are available in a variety of voltages and power outputs.

AC generators are typically used with systems producing about 3 KW or more. AC voltage is also easily changed using transformers, which can improve efficiency with long transmission lines. Depending on your requirements, you can choose either single-phase or three-phase AC generators in a variety of voltages.

Shown from beneath—the 4-inch (10 cm) turgo runner in an Australian-made Platypus turbine.

One critical aspect of AC is frequency, typically measured as cycles per second (cps) or Hertz (Hz). Most household appliances and motors run on either 50 Hz or 60 Hz (depending on where you are in the world), as do the major grids that interconnect large generating stations. Frequency is determined by the rotational speed of the generator shaft; faster rotation generates a higher frequency. In battery-based hydro systems, the inverter produces an AC waveform at a fixed frequency. In batteryless hydro systems, the turbine controller regulates the frequency.

A view into a turbine shows a relatively large (2 feet in diameter) Pelton wheel. Peltons vary in size from 3 inches to 13 feet or more, depending on head and flow.

AC Controls

Pure AC hydro systems have no batteries or inverter. AC is used by loads directly from the generator, and surplus electricity is burned off in dump loads—usually resistance heaters.

Governors and other controls help ensure that an AC generator constantly spins at its correct speed. The most common types of governors for small hydro systems accomplish this by managing the load on the generator. With no load, the generator would "freewheel," and run at a very high rpm. By adding progressively higher loads, you can eventually slow the generator until it reaches the exact rpm for proper AC voltage and frequency. As long as you maintain this "perfect" load, known as the design load, electrical output will be correct. You might be able to maintain the correct load yourself by manually switching devices on and off, but a governor can do a better job—automatically.

By connecting your hydro system to the utility grid, you can draw energy from the grid during peak usage times when your hydro system can't keep up, and feed excess electricity back into the grid when your usage is low. In effect, the grid acts as a large battery with infinite capacity.

If you choose to connect to the grid, however, keep in mind that significant synchronization and safeguards must be in place. Grid interconnection controls do both. They will monitor the grid and ensure that your system is generating compatible voltage, frequency, and phase. They will also instantly disconnect from the grid if major fluctuations occur on either end. Automatic disconnection is critical to the safety of all parties. At the same time, emergency shutdown systems interrupt the water flow to the turbine, causing the system to coast to a stop, and protecting the turbine from overspeed.

A Power Pal turbine with a Francis runner direct-coupled to the alternator above.

The underside of a low-head, high-flow Nautilus turbine showing the Francis runner, and above it, the innovative nautilus-shaped headrace.

DC Controls

A DC hydro system works very differently from an AC system. The alternator or generator output charges batteries. A diversion controller shunts excess energy to a dump load. An inverter converts DC electricity to AC electricity for home use. DC systems make sense for smaller streams with potential of less than 3 KW.

AC systems are limited to a peak load that is equivalent to the output of the generator. With a battery bank and large inverter, DC systems can supply a high peak load from the batteries even though the generating capacity is lower.

Series charge controllers, like those used with solar-electric systems, are not used with hydro systems since the generators cannot run without a load (open circuit). This can potentially damage the alternator windings and bearings from overspeeding. Instead, a diversion (or shunt) controller must be used. These normally divert energy from the battery to a resistance heater (air or water), to keep the

A Canadian-made Energy Systems and Design turbine uses a permanent magnet alternator and a turgo runner.

battery voltage at the desired level while maintaining a constant load on the generator.

The inverter and battery bank in a DC hydro system are exactly the same as those used in battery-based, solar-electric or wind-electric systems. No other special equipment is needed. Charge controller settings may be lower than used in typical PV and wind systems, since hydro systems are constant and tend to run with full batteries much of the time.

Head, Flow, & Efficiency

If you expect to sell electricity back to the utility, pay extra attention to the efficiency of your hydro system because higher output and a lower cost-per-watt will go straight to your bottom line. Your turbine manufacturer can give you guidance on the most efficient design, as well as grid interconnection controls and safeguards. If you're off-grid, and your site doesn't have lots of head and flow, high efficiency can make the difference between ample electricity for your needs and having to use a backup, gasoline-powered generator.

Whether a hydro system generates a few watts or hundreds of megawatts, the fundamentals are the same. Head and flow determine how much raw water power is available, and the system efficiency affects how much electricity will come out the other end. Each component of a hydro system affects efficiency, so it's worthwhile to optimize your design every step of the way.

Is hydropower feasible for you? The next article in this series will help you answer this question. I'll discuss methods for measuring head and flow, offer tips for determining pipeline size, and provide formulas for calculating electrical output and efficiency.

Access

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"From Water to Wire: Building a Microhydro System," by Peter Talbot, *HP76*

Adobe

Building with Earth

Quentin Wilson

A home near Northern New Mexico Community College, built by Hal Miguel with help from students over several semesters.

Adobe has a long and dependable history. Although many people classify it as an "alternative" building material, it is neither experimental nor alternative. Basic design details for adobe construction were worked out millennia ago. According to a 1960 census, 60 percent of the world's population lived in adobe or other earthen structures such as rammed earth, cob, wattle and daub, sod, and cast-in-place.

The use of adobe in unexpected parts of the United States is continually being rediscovered. The Spanish arrived in what is now the American Southwest to find the Pueblo people using adobe in their multistory buildings. The Spaniards moved in next to or on top of the pueblos and continued the tradition that they already knew from Spain.

When the Anglos arrived, they too embraced and continued the adobe tradition with homes, forts, and government offices. Today, you can find adobe homes not only in the Southwest, but also lurking in neighborhoods from Denver to San Diego to Lubbock, Texas, and beyond.

Making Your Own

Several rules for adobe construction are enforced by gravity, climate, and the first law of thermodynamics. Buildings need to be built on solid, dry ground that drains well. The height of the walls can be only about ten times their thickness. Door and window openings should not be in corners, and the total area of openings cannot be too large. In wetter climates, a foundation top must be well above the ground level. A roof with large overhangs and gutters is especially important to keep moisture away from the walls, just as they are in lumber, steel, and timber construction. All of these rules are well known.

You can buy adobe bricks from an adobe block maker, or you can make your own. Brick making is simple, but it's hard work. The concept of making sun-dried bricks and bonding them together with mortar to create walls was brought to the Americas by the Spanish. The technique probably developed in North Africa or Asia and was introduced into Spain by the Moors.

The most cost effective and energy conserving method is to start with a loose pile of earth that has a workable blend of sand and clay (see soils sidebar on the next page). Make a little crater in the side of the dirt pile and add 5 to 10 gallons (20–40 l) of water, which will soak in quickly. As soon as the water is gone from the surface, shovel the mud into a wheelbarrow. Wheel it to a flat piece of ground without too much grass, and pour it into a form that makes four bricks at a time. That is just the amount that is comfortably carried in a wheelbarrow.

Repeat the process, lift the form off the first adobes, and pour the next batch. If the mix is stiff enough, the adobes will hold their shape and not slump. You might have to get down on your knees and press the mix into the corners of the form. Once the mix and stiffness is adjusted, repeat the process.

Using mud exterior plaster saves money. Stonework accents use up some of the savings, but add character.

Hal Miguel's fireplace, built by mason Neal Bockman with help from students, is a modified Count Rumford style, which enhances the performance of the traditional corner fireplaces.

Five thousand bricks will make a home of about 1,700 square feet (160 m^2). The New Mexico standard, 10- by 14- by 4-inch (25 x 36 x 10 cm) bricks, average 32 pounds (14.5 kg) each, equaling 160,000 pounds (72,580 kg) or 80 tons (72 metric tons) or 50 cubic yards (38 m^2). Right away you can see the dominant feature of adobe construction—incredible mass.

Two people can make a hundred adobes in two to four hours. Two hundred per day is a reasonable production goal, and people who make adobes for a living routinely crank out five hundred per day with two people. At that rate, it only takes ten days to make bricks for a 1,700 square foot (160 m^2) home. Settle for a more humane, four weeks of two hundred adobes per day, or eight weeks of making one hundred every evening.

Putting Up the Walls

Adobe walls need to be protected from ground moisture. A foundation does this, along with spreading the load of the building onto the ground, tying the building together, and preventing frost damage. To meet code in our area, we need an 8 inch (20 cm) thick footing with two runs of $^1/_2$ inch (12 mm in Europe) continuous rebar in it. The footing needs to be 2 inches (5 cm) wider on each side than the wall it supports. I think that it should actually be 4 inches (10 cm) wider on each side. The bottom of the footing needs to be on undisturbed ground at or below the local frost line.

Adobe Soils

Soils suitable for adobe can be found anywhere, usually just out the back door. New Mexico State University tested all sorts of soil samples and concluded that the strongest adobes, mortars, plasters, and floors result from 70 percent sand and 30 percent clay. Nothing else is needed. Adobe can be made with considerably less clay without losing significant strength. Higher percentages of clay are no stronger, but resist moisture better.

High clay mixtures will crack when drying out. The solution is to add straw. Straw minimizes cracking, but adds no compressive strength while adding another component to the mix. Straw may increase tensile strength and elasticity, but its effect has never been measured in a systematic way. Most soils contain silt, which is between clay and sand in its particle size. It contributes neither strength nor adhesiveness, but it is not worth trying to remove when present.

Favorable soils are right at the surface of most of New Mexico and other arid areas. In wetter areas, adobe makers have to dig below the pesky topsoil to find strata of sand and clay. I have built adobe homes for 25 years without doing any soil tests. My ultimate diagnostic tool is the cement mixer. If the soil sticks to the blades and turns with the drum, I add sand until the mix begins to fall to the bottom of the barrel and slips cleanly off the blades as would a good concrete mix. If there is too little clay, I can see the grains of sand, so I add a high clay soil until the grains mostly disappear.

Adobes to the vanishing point—Mel Medina's adobe factory in Alcalde, New Mexico.

Student Charles Knight and some specialized, custom forms for making adobe bricks in place, directly on the wall.

A stem wall that is the same width as the adobe wall can be built on the footing and it should extend 6 inches (15 cm) above the finished grade of the property and 4 inches (10 cm) above the finished floor level. Many different types of foundations have been used with adobe structures, such as concrete blocks, a monolithic pour (where the foundation and a concrete floor are poured all at once), and rubble trench foundations (see *HP99*, "From the Ground Up: A Primer on Natural House Building").

Walls can be built quickly using two items: speed leads and rough bucks. Speed leads are posts placed at each corner that are plumbed and braced in place. Marks on the leads show where each course will go, and strings stretched between them align the adobes on each course. Rough bucks are rectangles made of 2 by 6s, 8s, or 10s with an inside opening equal to the rough opening called for by door and window suppliers. They are built into the adobe wall, and the windows and doors later attach to them.

Door bucks are stood up on the foundation, plumbed, and braced in place just like the speed leads. Window bucks go into place when the walls reach the appropriate height, and are then plumbed and braced. With this system, no great masonry skills are required. Adobes are laid to the string, never quite touching it, and the walls go up without endless measuring, leveling, and plumbing. Care is required in setting up the speed leads and bucks, but after that, it's just one brick after another.

Speed leads can go on the inside or outside of corners. Whichever side is chosen will be the straighter wall because adobes vary in width. As courses go up, door and window bucks are anchored into the wall with gringo blocks, which are solid blocks of wood or 2 by 4s made into 10 x 14 inch (25 x 36 cm) rectangular frames that replace adobes and are

Adobe Mud Throw 1: This is wrong—the older guy is throwing the shovel of mud to the younger guy!

Adobe Mud Throw 2: There goes the mortar onto the wall. Note the speed leads outlining the corners of the walls.

filled with mud mortar. Two on each side of windows and three or four on each side of doors does the job. I've found that 3 inch (7.6 cm) gold deck screws are a perfect way to fasten the bucks to the gringo blocks. Screws allow the bucks to be repositioned later if needed.

Mortar

Adobes are laid in a full bed of horizontal mortar about $^3/_4$ inch (19 mm) thick. This varies since adobes are not uniform in their thickness. The code does not require the vertical joint to be fully bedded. In fact, it is better to have gaps if the wall will be plastered—the vertical slots form nice keyways for the plaster and stucco to get a grip on the wall.

The mortar used to stick the bricks together should be as similar to the bricks themselves as is practical. Sometimes a cement/lime mortar is used. The amount of mortar used is 20 percent or one-fifth the amount of the adobe figured by weight or volume. A house weighing 80 tons (72 metric tons) will require 16 tons (14.4 metric tons) or 10 cubic yards (7.6 m^3) of mortar material!

A three-person crew should be able to lay five hundred adobes per day using speed leads and rough bucks. One person mixes mud, one person hauls mud and adobes to the wall, and one person lays adobes. We always rotate members of the crew to equalize the workload.

At this rate, the five thousand adobes mentioned earlier will go into place in ten working days. A second or third crew can be added to speed things up. However, nature limits the upward progress to six or seven courses a day during warm weather. Working any faster results in wobbly walls, which tell the workers to slow down.

Lintels & Bond Beams

Above the bucks, lintels span over the openings to carry the load of the wall above. Lintels are most often wood timbers 6 inches high by 10 inches wide (15 x 25 cm) to meet the code. They should be long enough to bear on 12 inches (30 cm) of solid wall on each side of the opening. I recommend 18 inches (46 cm) on each side. Lintels can also be reinforced concrete of the same dimensions.

Above the lintels, the wall is capped with a bond beam, also known as a tie beam, belt course, or collar beam. It serves to tie the walls together and spread the load of the ceiling and roof systems over the walls and provide a good attachment point. These beams are found in all masonry systems—block, brick, or concrete—and are equivalent to the double top plate in a frame wall system.

The bond beam is also 6 inches high by 10 inches wide (15 x 25 cm), and can be constructed of cement or wood. Cement bond beams have anchor bolts to attach ceiling/roof members if their location can be determined, or else

Here you can see a wooden bond beam, wood lintel, and door rough buck with gringo blocks in the wall to anchor the buck and cabinets. Steel strapping is optional.

Traditionally, young people use ropes to hoist vigas to the top of the wall. If you are older, a boom truck makes sense.

The original code called for 4-inch (10 cm) thick bond beams. It was raised to 6 inches (15 cm), since 4-inch beams are hard to do in concrete. The 4-inch wood bond beam has more tensile strength than the concrete, and is more than adequate for those in nonpermit areas.

It is important to have sufficient solid sections in each wall to serve as shear panels, and to avoid placing openings too close to corners. Although present codes don't specify, previous versions of the code required a minimum of 28 inches (71 cm) of solid adobe measured inside each direction from a corner, and adobe columns were required to be a minimum of 28 inches.

a wood plate is anchored to the bond beam. Ceiling/roof members can then be nailed, screwed, bolted, or attached with metal bands to the plate.

The wood bond beam can be solid timbers with lap joints at corners and intersections, or it can be built up with lumber as small as 1 inch (2.5 cm) nominal with staggered joints. We just lay a 2 by 10 into a long bed of mortar and continue around the building. The second and third layers are nailed on with 16-penny nails at 16-inch (40 cm) intervals 1 inch from the inside and outside edges. A few more nails at corners and laps add strength.

Wood will stick to adobe mortar as well as an adobe brick does, so the wood bond beam is well attached to the wall.

Roofs

In New Mexico, it is common to span across the walls with large diameter, peeled poles called vigas to carry the roof load. The ceiling/roof deck on top of the vigas is sometimes smaller diameter, peeled poles called latillas. Vigas are often 16 to 24 feet (5–7 m) long and 6 to 10 inches (15–25 cm) in diameter near the smaller end. Cut green, each weighs 400 to 800 pounds (180–360 kg). A big flatbed truck or trailer is needed to get them to the building site.

On top of the vigas and latillas is insulation, either rigid or fiberglass in the roof cavity. Hot mop (built-up roofing), torch-down roofs (modified asphalt), and elastomeric synthetics or even rubber make the surface waterproof.

Freddie Ocana spikes a viga into a solid timber bond beam. Note the special lap joint.

A finished ceiling built with latillas (small diameter peeled poles) on top of vigas.

Steeply pitched roofs became the appropriate response to the climate in the uplands of New Mexico. Today, metal roofs are commonplace. My own home has a 12:12 pitch roof with nine gables. In the 1970s, homes with two shed roofs, one on the south and one higher on the north, with a clerestory between the two, became popular among solar adobe designers.

Plastering

Interior walls can be left alone if the course-work was done with reasonable care. To soften the look, walls can be washed with a sponge, terry cloth, or sheepskin. Adding a slip of mud while washing will soften the look even more. Plasters can be adobe, gypsum, lime-based, or cement/lime stucco. All these surfaces can be painted with latex, oil, or clay-based paints. Whitewash and lime paints work as well as milk and wheat-paste blends. My greenhouse has mud plaster over the adobe bricks. It is painted white above and copper below with local high-mica soils favored by potters for slips.

For exterior walls, cement/lime stucco is the most prevalent in the Southwest. It works just fine and should be used without the treated paper barrier necessary in plastering wood frame buildings. Cement/lime plaster breathes—it has a measured rating of 5 to 6 perms (units of permeability or "breathability").

Mud plasters with various stabilizers like lime, asphalt, cow manure, cactus juice, and molasses are used here and in various parts of the world. Mud plaster is great and is culturally significant in Pueblo, Spanish, African, and Asian cultures. Once a year, families replaster homes, and village groups work to maintain monumental structures. This great tradition is slipping away in many places.

Electrical/Plumbing

We do most of the electrical runs right in the wall. The 2002 *National Electrical Code* actually uses the word "adobe" now, and permits the use of NMC cable embedded in the walls [Article 334.10, Paragraph (B) (3)]. That's nonmetallic sheathed cable type "C," which has no interior paper wrap like nonmetallic Romex. NMC is sold back East as barn cable. It is hard to find out West, so most electricians use type UF, which is underground feeder [NM Electrical Code, Article 340.10, Paragraph (8)].

We make all the horizontal runs to the receptacles around the rooms in the middle of the mortar joint closest to 12 inches (30 cm) above the finished floor. We install metal boxes for outlets and switches when the cable goes in. Bricks and mortar are then fit around them along with the occasional nail, screw, or tie wire to anchor them.

The ground wires with the green screws bonding them into the metal boxes contribute to a superbly grounded electrical system. Vertical runs to switches and lights require snaking between coursework, cutting a channel after bricks are in place, or sneaking up and down the backs of bucks. I prefer to maximize my runs in fireproof adobe and minimize the use of wood or flammable areas. All of this is easy enough to do, though working with an electrician not familiar with adobe requires some negotiation and education.

Water lines and a drain line are in place to service the bathroom sink. Adobes and mortar easily fit around the pipes.

For plumbing rough-in, we also like to embed the pipes in the wall or near the interior surface. The technique is to do the plumbing ahead of the coursework and to cut and fit adobes and mortar around the pipes. This is common practice on commercial jobs where plumbing tubes can be seen sitting above a slab awaiting wall construction. I would rather do that than create a chase, or a dedicated frame wall around areas with plumbing service. I think it's easier than persuading pipes to fit into existing wall spaces. Again, it is easily done (if plumbing is *ever* easy) by the owner/builder, but negotiation is required with a subcontractor. Heating and other mechanical considerations are a combination of the electrical and plumbing techniques.

Adobe Advantages

The real bonus in heating is the fact that adobe is one of the best materials for storing passive-solar heat. This is because of two features built into adobe by the planet's architects. First, adobe has high heat capacity. At 0.2 BTUs per pound per degree of temperature change, adobe holds the same amount of heat as stone, concrete, gravel, and dense brick.

Second, adobe has just the right amount of sluggishness in the speed with which it transfers heat (call it conductivity or thermal diffusivity). Adobe is slower to transfer heat than other masonry materials, and gives a time lag best attuned to the 24-hour diurnal cycle of the planet. That's why in New Mexico the word is not really adobe—it's *solaradobe*. Direct gain, Trombe wall, or greenhouse—all work best when coupled with adobe.

From the simple, small, humble home to the largest of immemorial monumental structures, adobe serves nicely. In the United States, earthen construction seems to enjoy popularity when economic times are tough. With several waves of depression and recession, earthen structures have appeared in most parts of the country.

Unfortunately, when times get better, connotations of poverty seem attached to adobe, and people hide it or replace it. I hope that more and more people will realize the environmental and aesthetic benefits of this natural building material. Adobe is embedded in culture and tradition. As people shape adobe, it shapes them, their families, their villages, and their cities.

Access

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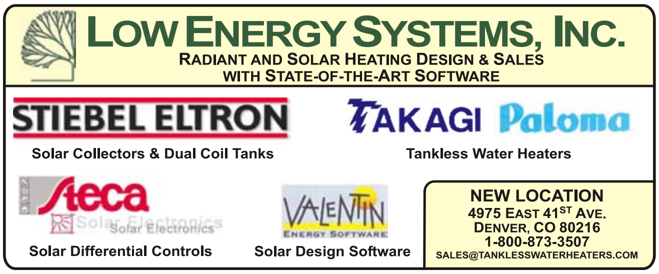
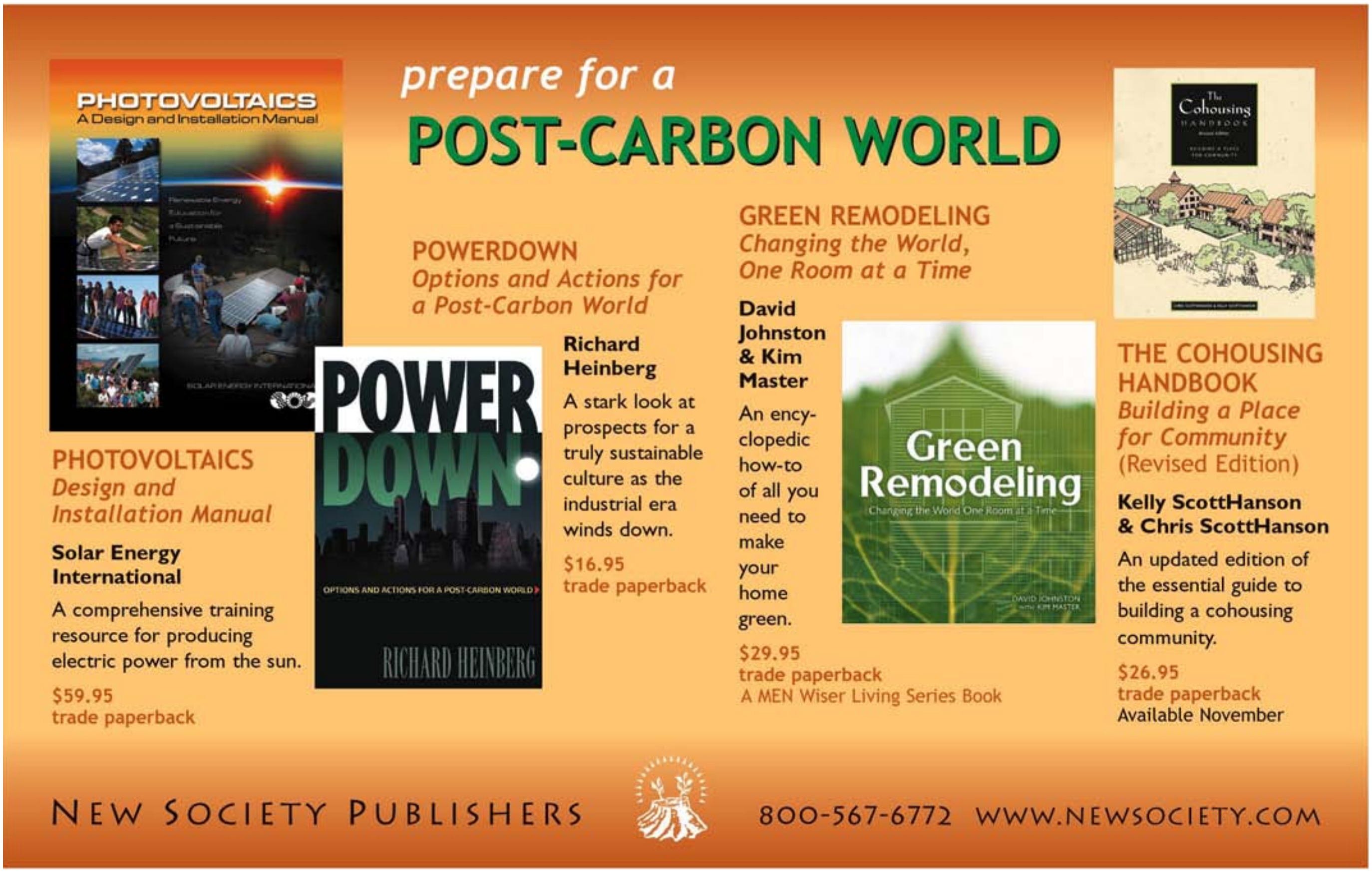
Adobe and Rammed Earth Buildings, Paul Graham McHenry, 1989, Paper, 217 pages, ISBN: 0-8165-1124-1, US$27.95 from University of Arizona Press, 355 S. Euclid Ave. Suite 103, Tucson, AZ 85719 • 800-426-3797 or 520-626-4218 • Fax: 520-621-8899 • uap@uapress.arizona.edu • www.uapress.arizona.edu



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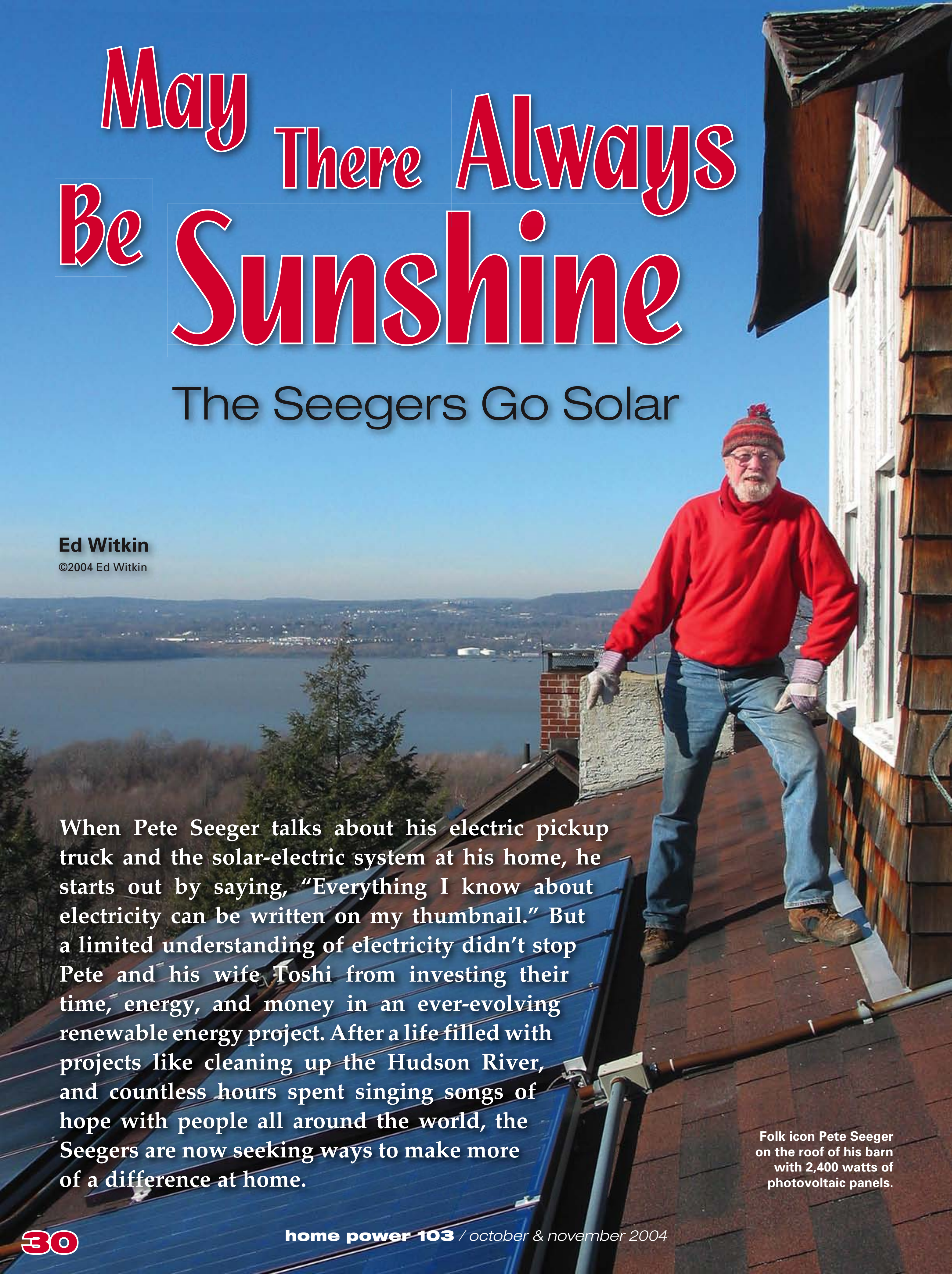
May There Always Be Sunshine

The Seegers Go Solar

Ed Witkin



Folk icon Pete Seeger on the roof of his barn with 2,400 watts of photovoltaic panels.

When Pete Seeger talks about his electric pickup truck and the solar-electric system at his home, he starts out by saying, "Everything I know about electricity can be written on my thumbnail." But a limited understanding of electricity didn't stop Pete and his wife Toshi from investing their time, energy, and money in an ever-evolving renewable energy project. After a life filled with projects like cleaning up the Hudson River, and countless hours spent singing songs of hope with people all around the world, the Seegers are now seeking ways to make more of a difference at home.

Pete was born in 1919, and has been involved with the social and environmental movement for decades. In his twenties, he traveled and sang with Woody Guthrie, "from California to the New York Island." In 1941, Pete, Lee Hayes, and other activists formed the Almanac Singers to sing for unions. After a stint in the army during World War II, Pete continued to sing songs of support for working people. In 1948, Pete, Lee, Fred Hellerman, and Ronnie Gilbert formed the Weavers, a quartet that recorded songs including "If I Had a Hammer," "Kisses Sweeter than Wine," and "Good Night Irene."

Pete and Toshi married in 1943, and in 1949 they found a few acres for sale on a wooded mountainside overlooking the Hudson River. It was here that they built their home and raised their family. Pete, with others, helped found the Clearwater Organization, which built and maintains a replica of a Hudson River sloop. Each summer at the annual Clearwater Festival, in Croton, New York, people from up and down the river gather to celebrate.

I met Pete at Clearwater in 1991, when he stopped by to check out my 1969 solar-electric VW microbus. The bus was being used to provide electricity for one of the many music stages at the festival. Pete said he was interested in finding a four-wheel-drive, electric pickup truck that could be charged with solar electricity. He wanted to be able to navigate his steep, dirt driveway, haul firewood for his home, and drive to town and back.

People gather around to hear what Pete has to say about energy and the future during the Clearwater Festival.

Truxie

After the festival, I got in touch with my friend Bob Batson of Electric Vehicles of America. Within a few weeks, Bob had located a converted 1988 Ford Ranger, four-wheel-drive, electric pickup. A week or two later, "Truxie," as Pete calls her, was towed from near Boston to the Seegers' hillside home.

A 120 VDC receptacle under the hood of Truxie is used to plug in the battery charger.

From the outside, Truxie looks like any other small pickup truck. But a look at the dashboard reveals that the fuel and oil pressure gauges have been removed and replaced with voltmeters, ammeters, and a Curtis Instruments state-of-charge meter. Truxie's propulsion system has only a few components. They include an Advanced DC Motors, 9-inch motor; twenty, 220-amp-hour, U.S. Battery, flooded lead-acid batteries; a Curtis 1231C power controller; contactors (heavy-duty relays); fuses; and wiring. There are significantly fewer mechanical parts in an electric vehicle than in a typical gasoline vehicle.

On the main roads, Pete takes his time driving. He's discovered that

Pete enjoys an ice cream cone and talks to a crowd about electric vehicles during the Clearwater Festival.

being light on the accelerator increases the range of the vehicle. Once while riding with him, we passed a 10 mph (16 kph) sign in his town. Pete said, "I've never understood why they put that sign there, but since there's a police car behind us, I'll drive nice and slow. Truxie will like that." So we crept along the road, first Pete in Truxie, then a police car, and then a long line of cars, eager to get on down the road. I think Pete got a kick out of holding the police to the speed limit in his electric truck!

EV Operation

To run Truxie, Pete turns the ignition key, which engages the primary contactor located in the motor compartment. This completes an electrical circuit between the battery pack and the controller. Truxie is "on," but cannot start moving until Pete puts it in gear. (There are four forward gears, plus low range and four-wheel drive.) Then he steps on the accelerator pedal, which engages the secondary contactor in the motor compartment. At this point, electricity can flow from the battery pack through the controller to the drive motor. Pushing down on the accelerator pedal tells the controller to give more juice from the battery bank to the electric motor, which increases the speed.

The state-of-charge meter is the "fuel gauge" for the truck. It has ten LED lights stacked neatly on top of one another. When all ten LEDs are lit, the battery bank is full. The battery bank's state of charge will start to drop at varying rates, depending on the terrain, the speed, the temperature, and the driving style of the person behind the wheel.

The terrain is quite hilly where Pete and Toshi live, which isn't ideal for an electric vehicle. The truck needs quite a bit of energy to pull all that weight up the hills. Truxie tends to have an average range of 10 to 20 miles (16–32 km), depending on the hills and the load Pete is hauling.

At home, Truxie is plugged into a Lester battery charger, which is the size of a breadbox. This device converts 240-volt AC electricity into the 120-volt DC electricity needed by the battery bank. When initially plugged in, the batteries will be charged at about a 25 amp rate. As the voltage increases in the battery bank during charging and starts reaching a full state of charge, the current (amperage) will begin to taper off. A complete charge takes five to seven hours. Once the battery bank is completely full, the charger automatically shuts off.

Electric Firewood

Pete and Truxie can often be found out on a steep dirt road around his land, cutting and hauling firewood. Pete wondered why he couldn't use some of the energy stored in the truck's battery bank to run his electric chainsaw. Truxie's 120-volt DC battery bank has a storage capacity of about 26 kilowatt-hours.

Exeltech makes an inverter that uses 120 volts DC input and generates 1,100 watts at 120 volts AC. The chain saw uses 8 amps at 120 volts AC. Though the chain saw surges to twice that at startup, the Exeltech inverter is able to handle this surge, and runs it very well. To hook the inverter up to Truxie, we wired a #8 (8 mm^2), 2-conductor, 5-foot (1.5 m) extension cord to the inverter, and on the other end we

Pete's electric chain saw runs off of an inverter installed in the pickup.

installed the same type of safety plug that is used to plug the Lester battery charger into the truck.

When Pete is ready to saw, he lifts the hood of the truck and plugs the inverter into the 120-volt DC charging receptacle of the truck. The inverter could be permanently hardwired to the truck battery pack, but this plug-in approach works fine, and Pete has stuck with it. In addition to running his chain saw, Pete has used the Exeltech inverter to run amplifiers for a PA system. The Exeltech is a high-quality, sine wave inverter, which is actually better for this type of sensitive electrical load, so it works well for both applications.

The primary maintenance performed on Truxie is checking the sixty cells in the batteries (twenty batteries with three cells each). Pete makes sure that the plates are covered with distilled water and the specific gravity of the electrolyte is OK. Sixteen of the twenty traction batteries are under the tilt-up bed of the pickup truck, and the other four are lined up in the front of the motor compartment under the hood. There is also a standard, 12-volt DC accessory battery in the motor compartment for lights, radio, etc.

Solar-Electricity for Truxie

While Truxie has zero emissions out of the nonexistent tailpipe, the electricity to charge the vehicle was initially coming from the utility grid. The majority of the electricity in Pete's area comes from various polluting sources. Pete and Toshi have spent fifty years downwind of the Indian Point nuclear power station, located several miles down the Hudson River from their home. Ten miles (16 km) north of them is the Central Hudson Power Company's oil-fired generating station. The idea that Truxie was getting its electricity from Indian Point led Pete and Toshi to invest in the next phase of their project—a solar-electric system for their home.

Pete suggested that the roof of the barn might be a good spot for solar-electric panels. "Up we go," he said, as he nimbly scampered up a hand-built ladder, leading through a trap door and into the cupola on the barn roof. His 6-foot (1.8 m) square cupola has windows on all four sides, giving a grand view of the Hudson Valley.

The roof of the barn faces slightly southwest, and has access to unobstructed sun for most of the day. There was a bit of shading from a large red oak tree to the southeast, but Pete thought that he could sacrifice that tree for firewood and lumber. We chose this roof for the location of the solar-electric panels.

PV System

We measured the available roof area on the barn, and found that we could mount twenty, 120-watt photovoltaic (PV) modules in five, four-module subarrays. With the PV modules in place, there would be room remaining for a solar hot water system if the Seegers decide to install one later.

While the primary objective of installing the PV panels was to provide solar electricity for Truxie, Pete and Toshi also wanted to have some backup electricity available during the inevitable utility outages that occur up on the hill. Toshi recalls times when Pete was out on the road performing, and the electricity would go out so the water

Clearwater Festival

In the late 1960s, Pete and Toshi started to raise a little money to build and maintain a full-size replica of a 75-foot (23 m) cargo sloop once common on the rivers. This sloop, Clearwater, is used as a floating classroom. Hundreds of thousands of children of all ages, from all over, have sailed the Clearwater up and down the golden Hudson River.

At one of the Hudson River Revival festivals in the 1980s, Pete was seen climbing a tree early in the morning to hang a large "No Nukes, Shut Indian Point Power Plant" banner. The Indian Point power plant looms a few miles downstream from the Seegers' hillside home overlooking the Hudson River. It is only one of many sources of Hudson River pollution.

Since then, solar electricity and other forms of renewable energy have become an integral part of the festival. In 1985, Richard Gotlieb and Carol Levin, of Sunnyside Solar, brought a solar-electric system to the festival to provide electricity for one of the stages. In the 1990s, Pete suggested that we create a renewable energy (RE) area at the festival, and have workshops, displays, and discussions about RE. Today all five stages at the festival are powered by some form of renewable energy.

This area has become a popular attraction at the festival. Young and old enjoy playing with the solar toys and looking at the various examples of how to incorporate sustainable technologies and techniques into their own lives. Crowds gather around to hear Pete talk about his electric truck, and learn about biodiesel, wind power, straw bale construction, and solar cooking.

The Clearwater Festival is held each June at Croton Point Park in Croton-on-Hudson, New York.

The author with a sculpture of Pete Seeger he constructed. The PV panel activates the rocking chair and a recording of Pete playing banjo.

Tech Specs

System Overview

System type: Battery-based, grid-intertied PV

Location: Beacon, New York

Solar resource: 4.5 average daily peak sun hours

Production: 227 AC KWH per month average

Utility electricity offset by PV system: 22 percent

Photovoltaics

Modules: Twenty AstroPower, AP 1206 F, 120 W STC, 12 VDC

Array: 2,400 W STC, 48 VDC

Array combiner box: Xantrex TCB-10 with 15 A fuses

Array installation: Roof mount with AstroPower track system

Balance of System

Inverter: Xantrex SW4048, 48 VDC input, 120 VAC output

DC power center: Xantrex PC250 with 60 A array disconnect breakers, and 60 A PWM charge controller

System performance metering: TriMetric 2020 AH meter

Energy Storage

Batteries: Eight Concorde, PVX-1040, VRLA, 12 VDC, 100 AH at 20-hour rate

Battery pack: 48 VDC, 200 AH total

Battery/inverter disconnect: 250 A mounted in the Xantrex PC250 enclosure

pumps wouldn't work. She would have to go down to the brook in the woods below their house and haul water up in buckets for the family.

In addition to wanting to keep the water flowing, the Seegers have a large deep freezer out in the barn. It is always full of food (much of which Toshi has grown in her bountiful garden) that feeds the constant flow of people living and visiting with the Seegers. Keeping this freezer running during utility outages was another important role for the solar-electric system. We installed 2 inches (5 cm) of rigid insulation around the deep freeze to keep as much of the cold in and heat out as possible.

Utility outages haven't had a significant effect on the Seegers' heating system, since they primarily heat the house with two woodstoves. So the basic plan was to use the solar electricity for Truxie, and have electricity available during utility outages to pump water, run the freezer, and keep a few lights running.

Installation

We mounted the PV panels on the roof using a track system designed by AstroPower. The one big advantage of this mounting system is that the tracks are first attached to the roof, and the panels can be installed one at a time. This type of mounting system, which was fairly new at the time, has become common in the industry. The four, 12 V modules in each subarray are wired in series to produce 48 volts DC.

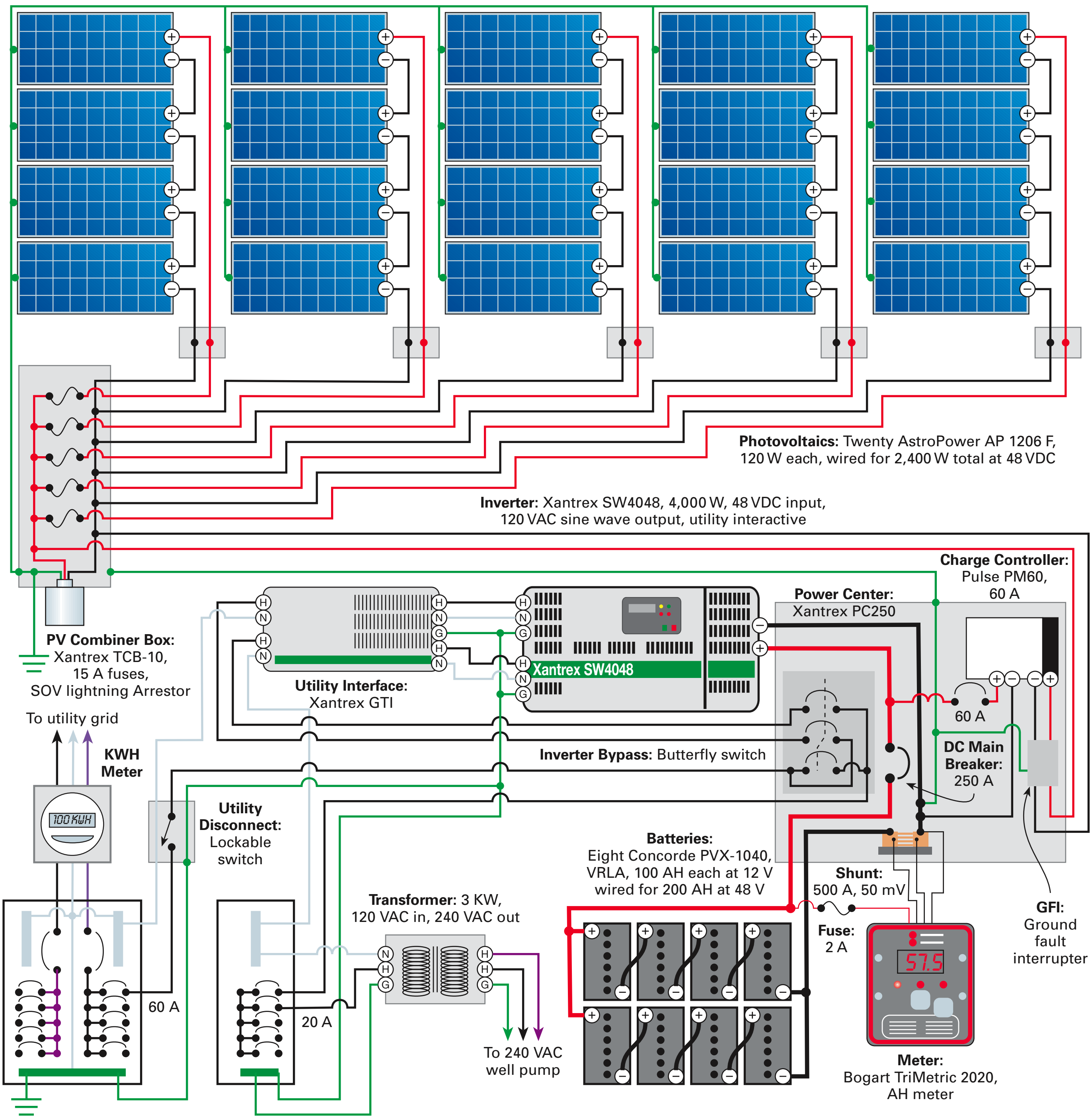
Each subarray has a junction box that connects to a central junction box via metal conduit. From this point, we ran 1-inch conduit down to a Xantrex TCB-10 combiner box. We used #10 (5 mm^2)THHN wiring from each four-module subarray. A ground wire from each subarray also comes into this combiner box.

Two #6 (13 mm^2) THHN and one ground wire exit the combiner box and are carried in conduit to Pete's shop, two stories down, where the balance of system (BOS) components are located. These include a Xantrex PC250 power center, which contains the main PV/battery and charge controller circuit breakers, and a 60-amp, PWM charge controller. Balance of system components are the batteries, the inverter, and a transformer, which provides 240 volts AC for the well pump.

We chose an area adjacent to an electrical service panel to install this equipment. This allowed us to make an easy connection to the AC input of the inverter. In a grid-tied system, the inverter uses electricity from the utility grid, if needed, for battery charging, and also can sell electricity back through the same circuit breaker in the service panel.

The PV system components are located in Pete's workshop.

The Seegers' Photovoltaic System



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

We pulled the wiring for the critical loads (the freezer, the well pump, and a couple of outlets in Pete and Toshi's bedroom and bathroom) out of the main service panel, and moved them to a subpanel connected to the output of the inverter. During utility outages, this critical load panel gets its electricity from solar energy stored in the batteries.

Net Metering

If the batteries are fully charged, the electricity will find its way to an electrical load that can use it. If, for instance, Truxie is hooked up to the Lester battery charger, the solar electricity can help charge the truck. If the freezer is running, or the well pump is pumping, the electricity from

Seeger System Costs

Item	Cost (US$)
20 AstroPower 120-watt PV modules	$15,700
Labor	5,390
Xantrex SW4048 inverter	3,250
Xantrex PC250 power center	1,495
8 Concorde batteries, 12 V, 100 AH	1,264
5 AstroPower 4-AP-1206 mounts	750
Two Seas battery box	408
Transformer, 120 to 240 VAC	360
TriMetric battery monitor	328
Subpanel & breakers	285
5 Junction boxes	264
Conduit & wire	230
Combiner box, 10 lug	229
Xantrex GFI option	149
Cable to stage, 30 ft.	133
Hardware for mount	125
Utility disconnect switch	120
Xantrex inverter conduit box	85
2 Inverter cables	72
6 Battery interconnect cables	72
System manual (Solar Works)	25
Battery temperature probe	24
10 Fuses, 15 A	10
2 Cable Lugs	3
System Total	$30,771
NYSERDA rebate, $3/watt	-$7,200
NY tax credit, $1.50/watt	-3,600
Grand Total	$19,971

the PVs can help power those loads. If none of the loads in the critical load panel are being used, and Truxie is not being charged, the inverter (which is programmed to be in the "sell" mode) will send the electricity back through the AC1 input circuit breaker and into the main service panel of the house. Any electrical loads that are turned on can use the solar electricity.

If more energy is being produced by the solar-electric system than is being consumed by the house, the electricity will head out through the electric utility meter, which will spin backwards. The solar-electric system will offset the Seegers' Central Hudson utility bill by the amount of electricity produced by the PV panels. This arrangement, called "net metering," is becoming widely accepted throughout the country. The Seegers, in effect, sell electricity to Central Hudson whenever they have a surplus.

At the time of this installation, the NY Shines solar initiative was just getting underway, and the Seegers were one of the first families to take advantage of the state tax credits and rebates. The state was giving a US$3 per watt rebate off the cost of a solar-electric system, and an additional US$1.50 per watt tax credit.

Production

How much can the system produce? Since there are twenty panels rated at 120 watts each, the most the array can produce is 2,400 watts. Very rarely will a photovoltaic panel produce its rated output. This will only occur in ideal conditions with intense sunlight and cold temperatures. An example would be a crystal-clear winter day, when snow is on the ground and the PV panels don't have any snow on them. Considering losses from wire resistance, equipment efficiency losses, and weather patterns, grid-tied systems like this can produce approximately 60 to 70 percent of the PV array's rated output.

To get a rough idea of how much energy this system would produce for the Seegers, I computed the output using 4.5 for the average daily sun hours, based on National Renewable Energy Lab (NREL) weather data for New York City. So, 2,400 watts for 4.5 sun hours at 70 percent system efficiency is about 7.6 KWH per day.

If we go back to the original plan for the system—to provide solar electricity for Truxie—we can see how long it will take to make enough energy for the truck from the solar-electric panels. As mentioned earlier, the electrical storage capacity in Truxie is 26.4 kilowatt-hours. Batteries should never be completely discharged. An 80 percent discharge would be 21.12 kilowatt-hours. If you divide that by the 7.56 kilowatt-hours per day produced by the solar-electric system, it will take an average of 2.8 days to make enough electricity to charge the truck if the batteries are empty.

Pete doesn't discharge the batteries to 80 percent depth-of-discharge in the truck every time he drives. If he's only used one-third of the capacity of the batteries, it will take a little less than a day for the solar-electric panels to generate that much electricity.

During the course of the day, the solar-electric system may only offset a small percentage of the Seegers' overall energy usage. On average, they use about 35 KWH per day in their home. So the PV system accounts for about 22 percent of their electrical consumption.

At the Seegers' house, there are times of heavy electrical usage, such as when Pete and Toshi's daughter, Tinya, is running the electric kilns (which can approach 100 KWH per firing) to fire her exquisite pottery. There are also seasonal electrical demands. One comes in the winter when Pete pumps a lot of water to make an ice skating rink. Many years ago, Pete had an inspiration to flood the parking area in front of their house to make the rink. In the fall, he creates a curb of earth around the low parts of the perimeter. Once the ground has frozen, Pete turns on the hose and pumps water for a few cold nights to fill the "pond."

While Pete claims the rink is for his children and grandchildren, he loves to skate as much as anyone. One day while my daughters and I were skating with Pete and his grandchildren, Toshi came outside to tell Pete he needed to meet someone in town for an interview. "Oh good," said Pete, "I'll drive Truxie to town right now. I've always wanted to try driving with my skates on." Toshi convinced Pete that he should change into his boots, but we all had a good laugh.

How to Change the World

Pete and Toshi continue to go about their life on the hill overlooking the Hudson. Pete makes regular trips to town in Truxie, attending meetings at the Sloop Club, where folks come to share food, sing songs, and think of new ways to continue to clean up the Hudson River.

Pete summarizes where he is today:

My wife Toshi and I are in our eighties but in moderately good health, on good terms with our neighbors, and working with others in our town of 13,000. We're involved in half a dozen projects, such as a floating swimming pool, now that the Hudson River is clean enough to swim in again. For 65 years, I made a living as a musician. Now my voice is gone, eyes and ears are going, but I would like to live another ten years just to see what surprises will come next.

If there is a human race still here in a hundred years, I think it will be hundreds of millions of little things that will have saved us. Imagine a big seesaw: one end is on the ground with a basket

Pete's Song

While we were doing the solar-electric installation, Toshi was often digging into the freezer, the pantry, and the garden to create delicious meals for everyone. Sitting around the Seegers' table, we'd discuss politics, talk about how to make the Hudson River Revival better, and hear stories of days gone by. After a meal, we'd sometimes take out some instruments and sing a few songs. When asked about a song to include with this article, Pete suggested this one he'd written in 1966 called "Quite Early Morning."

Don't you know it's darkest before the dawn
And this thought keeps me movin' on
If we could heed these early warnings
The time is now quite early morning
If we could heed these early warnings
The time is now quite early morning

Some say that humankind won't long endure
But what makes them so doggone sure?
I know that you who hear my singing
Could make those freedom bells go ringing
I know that you who hear my singing
Could make those freedom bells go ringing

And so we keep on while we live
Until we have no, no more to give
And when these fingers can strum no longer
Hand the old banjo to young ones stronger
And when these fingers can strum no longer
Hand the old banjo to young ones stronger

So though it's darkest before the dawn
These thoughts keep us moving on
Through all this world of joy and sorrow
We still can have singing tomorrows
Through all this world of joy and sorrow
We still can have singing tomorrows

Don't you know it's darkest before the dawn
And this thought keeps me movin' on
If we could heed these early warnings
The time is now quite early morning
If we could heed these early warnings
The time is now quite early morning

half-full of rocks on it. The other end is up in the air with a basket one-quarter-full of sand on it. Some of us have teaspoons and are trying to put more sand in the basket.

Most people are scoffing at us: "Don't you see the sand is leaking out as fast as you put it in?" We say, "That's true, but we're getting more people with teaspoons all the time." One of these days, you'll see that basket so full that the whole seesaw will go zoo-oop in the opposite direction, and people will say, "Gee, how did it happen so suddenly?" Us and all our little teaspoons.

Access

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Sunnyside Solar Inc., 1014 Green River Rd., Guilford, VT 05301 • Phone/Fax: 802-254-4670 • info@sunnysidesolar.com • www.sunnysidesolar.com • Project support and installation

Electric Vehicles of America, PO Box 2037, Wolfeboro, NH 03894 • 603-569-2100 • Fax: 603-569-2900 • EVAmerica@aol.com • www.ev-america.com • Truxie support and equipment

Clearwater Festival: The Great Hudson River Revival, Hudson River Sloop Clearwater Inc., 112 Little Market St., Poughkeepsie, NY 12601 • 800-67-SLOOP or 845-454-7673 • Fax: 845-454-7953 • office@clearwater.org • www.clearwater.org

Wanted: Cleaner & Greener Wheels

Lizzy Scully

Big rigs, construction equipment, buses, and passenger cars—anything that runs on petroleum diesel can run on biodiesel.

Because biodiesel is far more energy efficient to make than petroleum diesel, can be locally produced, and requires no mechanical conversions for use in diesel engines, this innovative alternative fuel may help change the U.S. transportation industry.

I'm a conscious consumer. I live on the grid, but just barely. I ride my bike when I can, and I consider how my actions affect others. Despite my eco-friendly leanings, because I also rely on a car for transportation, I am one of the 1.7 billion members of a class that consumes goods and services at an unsustainable pace, to the detriment of the rest of the world.

This bothers me. It bothers me even more knowing that making the changeover to alternative fuels is often cost prohibitive. A hybrid electric car costs more than I earn in a year. However, I recently discovered biodiesel fuel, and my hope has been renewed.

The Scoop on Biodiesel

A "green" fuel, biodiesel produces far fewer emissions than petroleum diesel. It can be produced from domestically grown, renewable resources, such as soybean, mustard seed, and rapeseed oil crops. Biodiesel is made through a chemical process called transesterification, which separates the oil into glycerin and methyl esters (the chemical name for biodiesel). It would be possible to make biodiesel in my own backyard, but I'll leave that messy, smelly, and potentially risky endeavor to others.

Diesel (compression-ignition) engines in cars and other machinery can use biodiesel with little or no modification. But according to Pierre Purney, an auto mechanic at Rocky Mountain National Park, people who have older model diesel engines should avoid using 100 percent biodiesel in the engines right away. "One hundred percent biodiesel can shock the systems of the old diesel engines because, unlike petroleum fuels, biodiesel tends to clean out diesel engines," he explains. A stronger solvent than petroleum diesel, biodiesel can loosen the muck that accumulates in the fuel tank. This muck can clog fuel filters and fuel lines.

Purney recommends starting out with a mixture of petroleum diesel and biodiesel, and changing fuel filters frequently. Biodiesel can be blended at any level with petroleum diesel to create a biodiesel blend. B20 is a blend of 20 percent biodiesel with 80 percent petroleum diesel; B100 is pure biodiesel.

Dollars & Sense

Biodiesel fuel can benefit the environment, the economy, and the agricultural industry, says John Long, owner of Blue Sun Biodiesel in Fort Collins, Colorado. Biodiesel dramatically reduces greenhouse gas and particulate emissions, and is biodegradable. And it's a renewable fuel source that can be produced and processed entirely in the United States, helping to regenerate the economy while reducing our dependence on imported oil.

Photo by Eric Grisen

Eric Grisen fills up his 2001 Volkswagen Golf TDI with B100 at a pump in northern California. Even modern diesel cars can burn biodiesel without modification.

Jenna Higgins, director of communications for the National Biodiesel Board, agrees that the production of biodiesel would benefit the United States. "Every gallon of biodiesel used is one less gallon that we will import from the Middle East," she says. And keeping the production and transportation of biodiesel fuel in the United States will create jobs in this country.

"As demand increases, new biodiesel plants will have to employ people," says Higgins. "Biodiesel also contributes to the farm economy through the growth of oil feedstock crops like soybeans or rapeseed." Blue Sun capitalizes on this by working with Colorado farmers to help them develop biodiesel crops that can be grown successfully in an arid, high plains environment. According to Blue Sun, an additional benefit for regional farmers is the opportunity to grow biodiesel crops on unused cropland during the winter wheat crop rotation, adding profit to the farmers' bottom line.

Marketing for Success

Blue Sun is working hard to bring biodiesel to the common consumer. The company's CEO, Jeff Probst, says that Blue Sun focuses on innovation and marketing because "even if people love this stuff, unless you can get it to them, it's not going anywhere." Blue Sun announced the opening of ten more retail sites in Colorado on Earth Day, for a total of sixteen. "Our focus has to be on the supply side—growing and refining feedstock—but also in making sure it goes to the market in a way that people can evaluate the real advantages of burning the fuel," says Probst. "Biodiesel is a viable fuel, not just a new technology."

The Blue Sun gang is making biodiesel accessible to consumers in the Colorado area.

Its viability results from the ease with which it can be integrated into the already-existing infrastructure of the petroleum diesel industry. Probst markets to the "jobber and dealer networks." Jobbers run bulk plants, where big loads of products are stored and then delivered to individuals; dealers are companies that deliver the products to retail sites. Because biodiesel can be easily mixed with petroleum diesel, major changes in distribution aren't required. The only problem that biodiesel producers face is educating people about the ease of making the changeover and the positive benefits of biodiesel.

Better for the Environment

Convincing people to switch to biodiesel may sometimes be difficult, but Higgins says, "Once people find out about this fuel—that it works with what we already have—they want to use it, even if it costs more. They know it's the right thing to do." According to the Department of Energy, biodiesel is the fastest growing alternative fuel. More than 400 U.S. fleets—public and private companies with a large number of vehicles—now use biodiesel.

Burning biodiesel produces about half the emissions of burning petroleum diesel, and emissions of sulfur oxides—the major components of acid rain caused by burning fossil fuels—are virtually eliminated, says Higgins. However, reduced emissions aren't the only benefit, she says. "The other thing to consider is that biodiesel has a positive energy balance: For every unit of fuel used to make biodiesel, 3.2

Photo by Eric Grisen

A commercial fuel supplier in Oregon advertises biodiesel—are all gas stations next?

units of biodiesel are produced." This is not the case with petroleum, the costs of which outweigh what is produced, according to a study done in 1998 by the departments of energy and agriculture.

Additionally, the study found that compared to using petroleum diesel, biodiesel reduces net carbon dioxide emissions by 78 percent. "When considering a fuel, you don't just account for what it burns," explains Higgins. "In the case of biodiesel, you also account for the process of planting and harvesting the soybeans, as well as producing and transporting the fuel. When soybeans are grown, they take carbon dioxide out of the air through photosynthesis."

Plain & Simple

Undeniably, biodiesel fuel could change the face of the North American transportation industry. If this technology becomes accessible worldwide, it could easily encourage alternatively fueled engines of all kinds. "Biodiesel is a very appropriate technology for developing countries," explains Blue Sun's John Long. "Now, they pay US$4 to US$6 per gallon for fossil fuels. At the same time, they have all these resources that produce oil—palms, coconuts, and all sorts of materials that have high oil content."

Biodiesel is a smart fuel for anyone to use. For me, it's plain and simple: using biodiesel means reducing the emissions of harmful pollutants, while supporting the U.S. economy and U.S. farmers—instead of propping up an out-of-control, imported-oil infrastructure. And driving a biodiesel-fueled vehicle instead of my petroleum-guzzling Chevy also could ease my eco-conscience during my frequent commutes and road trips.

So now I'm on the lookout for a cheap diesel-engine car. I've checked out my local car dealerships, and have found that diesel-engine cars are not so common in the United States because of existing stereotypes that they are dirty and unreliable. Automotive repair expert and host of National Public Radio's *Car Talk* radio show Tom Magliozzi says otherwise. "A lot of diesel engines last a long time. They are durable, and they get pretty good gas mileage." And the smelly and sooty problems normally associated with diesel engines are reduced when biodiesel is used. I've renewed my hope in America's future, and am in the market to make a change.

Access

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

The Professor & the Panels

John A. Bloom

John Bloom's solar-electric system produces more than a third of his family's summer electricity needs and almost two-thirds of their needs the rest of the year.

If you weren't living in California during the summer of 2000, you might not appreciate all of the reasons that prompted me to install a photovoltaic (PV) system the following winter. The state's poor deregulation policies allowed unforeseen price gouging, as regional energy suppliers created an artificial shortage to drive prices higher. It looked like affordable electricity was not something that our family could take for granted anymore.

Reliability was another problem. In addition to the threat of rolling blackouts (which our home never experienced, fortunately), our neighborhood lost electricity three times over two months due to auto accidents in which utility poles were struck. The specter of food thawing in the freezer (in summer) or a gradually chilling home (in winter) motivated me to look into backup electricity options.

The Dream

My initial interest in solar electricity focused on inverter/charger units with battery backup so that we would have the ability to run off-grid. However, as I read one inverter's 150-page instruction manual and began to visualize several large cabinets in my garage full of lead-acid batteries that required monthly maintenance, it struck me that such a system would be a liability instead of an asset when we went to sell the house.

After all, we were not living in the remote desert off-grid, or where frequent utility outages were the norm, but in suburban Los Angeles. So we bought a 4-kilowatt portable gas generator to have on hand for emergencies, but still, the PV dream didn't fade.

OK, I'll admit it—I think photovoltaics are "cool." The ability to harvest electrical energy directly from the sun is as exciting to me as the World Series may be to others. But I get to watch my game every day!

Benefits

Several factors combined to push this dream into reality.

Net metering. Most of the electricity I produce is credited against the highest-cost tier of energy I actually buy, so we reduce our energy costs by 15 to 20 cents per KWH generated.

Ease of use. Grid-tie inverters, unlike inverter/charger units, have no user controls, so there is much less technology to fear, or to scare future home buyers away.

Low maintenance. Hosing off the panels every now and then is no more difficult than washing the car.

Financial incentives. Two California state rebates—a US$3 per watt reimbursement, plus a state income tax credit, underwrote half the cost of the system.

Stewardship. If I can make better use of the sunlight that falls on my roof, and encourage others to do the same, then I'm helping manage the energy resources that God gave us.

With these motivations, I began to explore possible system configurations. I found the helpful Web site of Northern Arizona Wind and Sun (NAW&S). It provided a lot of background information, in addition to offering one-stop shopping.

Given the layout of our house, the best roof area is the southern side over our garage. It is clear of vent pipes and the underside is easy to access for installing roof supports. However, it is less than 300 square feet ($28m^2$) of area and in plain view from the street, although the grade of the front yard helps to screen it. Thus my panel options were limited by the need for high efficiency in a small area, and aesthetics. Kyocera won the aesthetics factor because its cells are square, and the panels are almost solid blue instead of blue dots on a white background.

Going with a Sun Tie inverter from Xantrex seemed like a good idea to me because the company had a good family of products, and I had received very good information and help over the phone from their tech support staff.

The new and improved Sun Tie inverter is as quiet and maintenance-free as any appliance in the house.

Tech Specs

System type: Batteryless, grid-tie PV system

System location: La Mirada, California

Solar resource: 5.5 average daily peak sun hours

Production: 200 to 400 AC KWH per month

Utility electricity offset: 33 percent (summer), 66 percent (rest of year)

Photovoltaics

Modules: 24 Kyocera KC120-1, 120 W STC, 12 VDC

Array: Six, four-module series strings, 2,880 W STC total, 48 VDC

Array combiner box: Built-in Xantrex Sun Tie with 20 A fuses

Array disconnect: Built-in Xantrex Sun Tie, 100 A breaker and 1 A GFI

Array installation: Mounts from Northern Arizona Wind & Sun placed on south-facing roof, 13-degree tilt

Balance of System

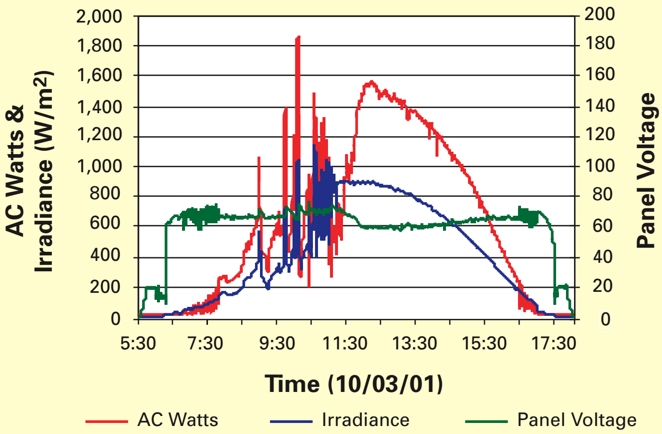
Inverter: Initially Xantrex Sun Tie ST2500, now ST2500 XR-UPG, 48 VDC input, 240 VAC output, 120 VDC maximum DC input voltage, 44–85 VDC MPPT voltage window

System performance metering: Xantrex XR remote, Solar Guppy PC software, data logger and solar irradiance sensor (provided by Xantrex for beta testing)

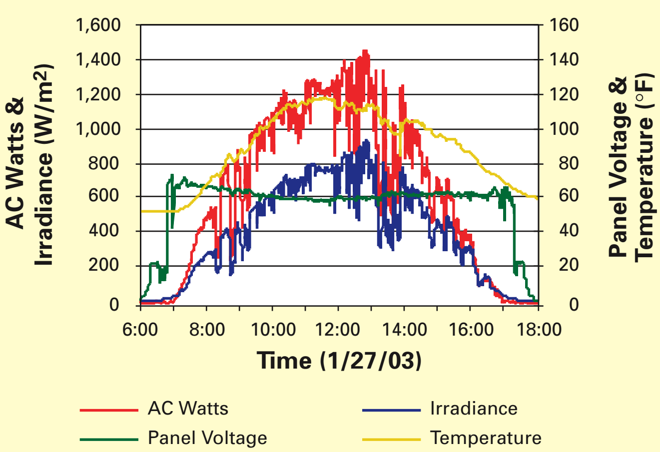
Installation

The installation went smoothly and I did almost all of it myself. Since our main breaker panel was at the opposite corner of the house, I installed a 60-amp branch panel in the garage to connect the inverter to, and to provide additional circuits for the kitchen and bath remodeling that I was doing. Along with the PV panels and inverter, I ordered mounting rail kits from NAW&S, which simplified the installation.

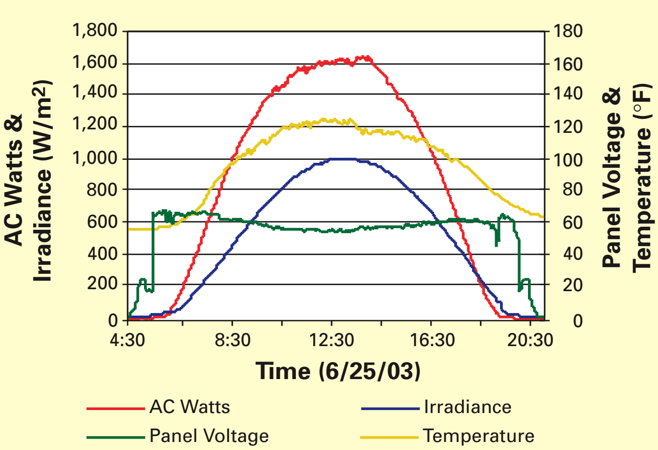
Sun Tie Inverter Performance Tests



Original Sun Tie XR Version 3.2, Slow Recovery: Output of an early XR-version inverter on a cloudy day, showing its inability to determine the maximum power point for about a half-hour after the clouds dispersed, (note problem at 11:30).



Sun Tie XR-UPG, Version 5.03, Beta Model: Following software improvements, the inverter output is accurately tracking the rapid irradiance changes due to partly cloudy weather conditions.



Sun Tie XR-UPG Production Model, Perfect Sunny Day: Sample output from the improved XR-UPG. Daily output during summer is about 13.4 KWH.

The aluminum mounting rails were secured to the roof with 1/2-inch stainless bolts that tie into 2 by 6 blocking between the rafters at appropriate points. By bolting to boards in between the rafters, I had more flexibility in positioning the rails. I used nuts with nylon inserts to ensure that thermal cycling would not loosen the mount.

The rails hold six panels each and run the entire length of the roof from the eaves to the peak. I did this to maximize panel surface area ("I left no shingle uncovered"), but this also turns out to be an advantage for air circulation. When the panels are mounted right to the edge of the roof, there are no hot shingles below them to preheat the air that is being drawn up under the hot panels by convection.

I had friends help me carry the panels up to the roof and assemble the arrays in place. Given the low pitch (about 13 degrees, or 3:12), this proved to be safe and easy to do, even though I am afraid of heights. I secured the rails to their brackets at the bottom of the roof, and temporarily held them up with 4-foot (1.2 m) 2 by 4s at the top so that I could crawl underneath them. I wired the panels together using metal-reinforced 1/2-inch liquid-tight conduit, figuring that I wanted the wiring to last as long as the panels.

Kyocera tech support recommended using anticorrosion compound on the panel screw terminals, and I made all of the panel connections with spade lugs crimped and then soldered on the wires to maximize connection stability. Also, the conduit between the panel array and the roof jack is about 10 feet (3 m) longer than necessary, so that each array section can be carried over to the north side of the roof when the time comes to reshingle the south side.

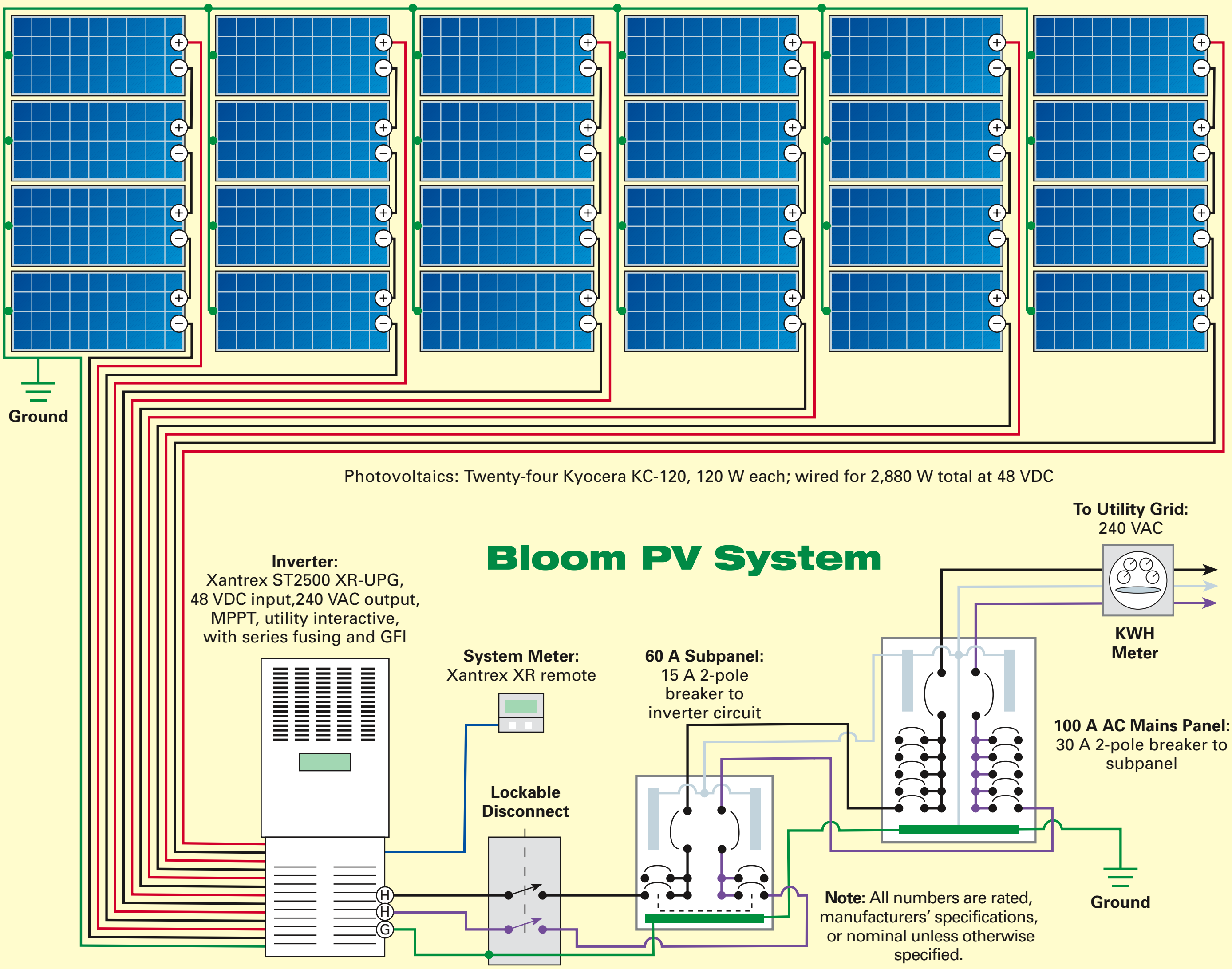
One problem with my design is that the six panels per rail set makes the wiring more difficult, since they are connected in sets of four. The weight of each rail set also turned out to be too much for the average person to lift. The next time around, I would not put more than four panels on a pair of rails.

In retrospect, one foolish thing I did was to wire the panels "live." I had enough experience in electrical wiring (and an angel at my side) that I never had a problem, but I would certainly not recommend this approach to anyone else, especially since it's easy enough to "turn the panels off" by covering them with a tarp or blanket.

Bugs & Beta Testing

The net metering paperwork with the utility company was straightforward, and we connected in early January 2001. The system worked, although there were some problems. The inverter fan was very noisy, which was especially annoying since the inverter hangs on the garage wall that is shared with our guest bedroom. Worse, the inverter output appeared to fluctuate greatly. It reacted poorly to passing clouds, shutting down completely when the panels were shaded, and often taking a half-hour to recover from even brief shading (top graph).

I contacted the company, and soon found myself talking with a product manager who invited me to help Xantrex beta test and improve the Sun Tie. For the next year and a half, I collected data, monitored solar irradiance and panel



temperatures, and tested a series of five upgraded and improved units, until we reached the model as it is sold today. My field data was valuable for evaluating design enhancements and was featured in at least one Xantrex technical report.

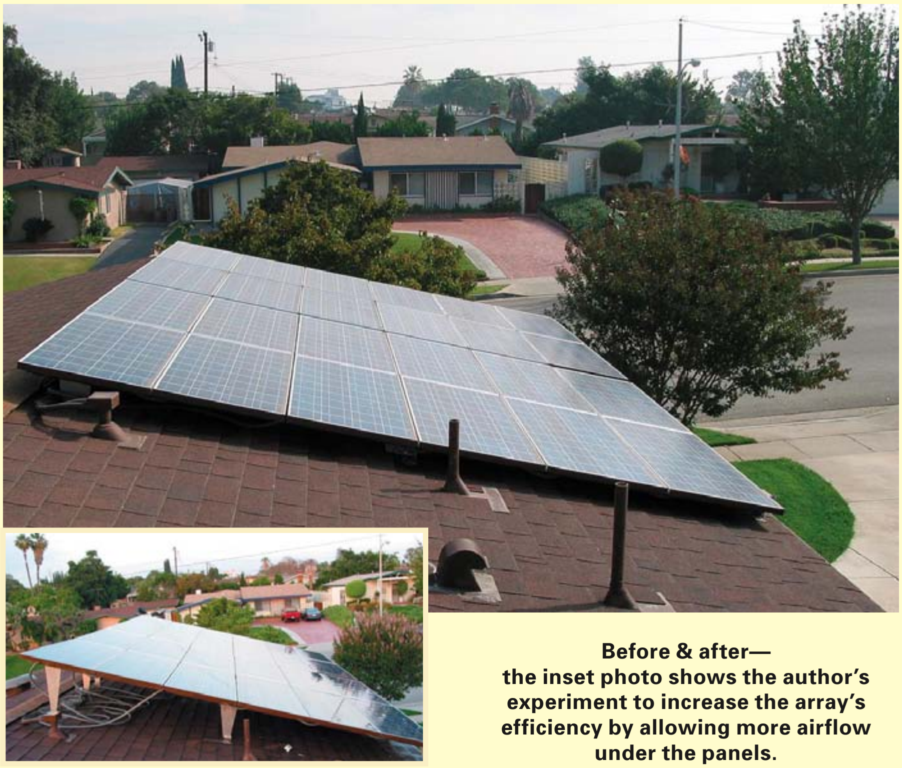
The fan noise was greatly reduced by redesigning the fan mount and adjusting the fan's speed to be proportional to the heat sink temperature. The fan now makes no more noise under normal conditions than a refrigerator. The inverter's tracking of the modules' maximum power point is far superior to the initial models, and it very quickly responds to irradiance increases and decreases without overreacting and shutting down. I've spent a fair amount of time in the garage doing remodeling projects recently, so I've been able to monitor its behavior. The Sun Tie blends right in like the garage refrigerator—just another appliance doing its job.

For all of its initial problems (which were efficiency related, not safety or hazard issues), the Sun Tie is now a great unit, in my opinion. I've been running the current production model for the past year and have seen or monitored no glitches, performance problems, or "personality" issues. As the renewable energy industry promises, grid-tie inverters really are no-maintenance, high-reliability units, requiring no user involvement other than watching your electric meter spin backwards.

What impresses me the most about the Sun Tie is the company that makes it. They stood behind their product and even sought my input to help them get the bugs out. That level of commitment to quality is rare in the world today.

Recommendations

Is there room for improvement? Of course. The Sun Tie produces a fair amount of radio frequency noise at around 1 megahertz, so I can't use an AM radio in the garage or nearby rooms when it's running. That RF noise is also propagated by the data cable that connects the Sun Tie to the XR remote LCD display, and this would be reduced if Xantrex provided a shielded and earth-grounded data cable.



**Before & after—
the inset photo shows the author's experiment to increase the array's efficiency by allowing more airflow under the panels.**

It would also be nice to have an LED accessory other than the XR remote to tell you at a remote location that the unit is operating. The CPU board in the inverter has a green diagnostic LED that lights to indicate when the array is producing energy. I taped a photocell to this LED and use it to control an LED mounted under the inverter disconnect box beside my garage door. This remote LED allows me to tell from outside the house that the unit is operating. Such a remote LED option could easily be added, although it might not be used by anyone but me.

A system enhancement I recommend involves how the panels are wired together. My twenty-four panels are wired in series in sets of four, and I have six DC lines that come down to a combiner board inside the inverter. Each of these six lines is individually fused, and then they are all connected in parallel to feed electricity to the inverter. Unfortunately, if you wire energy sources in parallel, they must all produce a virtually identical output voltage. Otherwise, the lower voltage source(s) will not contribute their share.

At present, if one of my six subarrays fails, it is very difficult to detect, other than noticing a 10 to 20 percent drop in AC output from what it "used to be." To help monitor panel performance, it would be nice if a "smart" combiner board could be developed that would tell when one or more of the incoming lines was not contributing its share. I found that I can easily test the contribution of each subarray manually by measuring the voltage drop across each line's fuse. This is typically about 20 millivolts under full sun conditions when the panels are generating 4 to 5 amps (remember the fuse has a very low internal resistance, and I'm measuring the voltage drop across it). The voltage drop is almost identical for all six subarrays when they are all working properly.

Unfortunately, the bypass diodes on two panels shorted out last fall. Bypass diodes prevent reverse current through a panel when it is not producing as much energy as the other panels in the string. This failure caused the bad panel's output voltage to drop to half of normal—from 20 to 10 V—so the open circuit voltage of their subarrays dropped from 80 to 70 V. I was able to spot this by noticing that the voltage drop at the fuse on these two sets was less than half what the other four were. Removing the fuses allowed me to measure the open circuit voltage on the subarrays and discover which two were 10 V lower than the others. A 10 V drop doesn't sound like much, but because the sets are connected in parallel, that was enough to reduce overall production by about 15 percent.

My other concern is the disappointing performance (or optimistic rating) of the photovoltaic panels themselves. My 24 KC120-1 panels, in theory, will produce 2,900 watts in full sun at 25°C (77°F). I oversized the array when I designed it, installing twenty-four panels instead of twenty, to compensate for the low roof-mounting angle I was using for aesthetic reasons (13 degrees instead of the 44 degrees recommended for my latitude). But I did not adequately figure on the heating degradation.

The panels easily warm up to 60°C (140°F) or more on a summer day, and raising the panels to improve the airflow on their bottom sides did not help appreciably and sure hurt the aesthetics—my neighbor was not thrilled with that experiment! Panel heat combined with Los Angeles haze and inverter inefficiency reduces my overall system efficiency to around 50 percent. So my "2,900 W array" typically produces around 1,500 to 1,600 W AC, with about 500 W of this loss due to heating, and the balance to clouds and haze, reflection, and inverter inefficiency.

I can see the heating effect by watching the inverter output on a partially cloudy day, particularly when heavy

Bloom System Costs

Item	Cost (US$)
24 Kyocera KC120-1 panels	$12,000
Xantrex ST2500 inverter	2,000
4 Rail kits, 6-panel (custom from NAW&S)	1,000
Wire, conduit, connectors, hardware	1,000
CEC Rebate & State Tax Credit Total	-8,000
Grand Total	$8,000

clouds are breaking up. The panels are cool from the heavy shade (I have a remote thermometer installed on the back of one of the top-row panels), and when the bright sun suddenly peeks from behind the clouds, the inverter output will quickly ramp up to 2,000 watts or more, but then drop to 1,700 or 1,500 watts as the panels heat up.

Lifeboat

Even with this reduced performance, I generate between 200 and 400 KWH per month, or US$50 to $80 a month of electricity. So the system will pay for itself in 10 years (thanks to the state rebates).

I have also learned the value of the proverb, "An ounce of prevention is worth a pound of cure." We made a sizeable reduction in our electricity usage by installing compact fluorescent lights, motion sensors for outside lighting, and simply remembering to turn lights off when we're not in a room. It turns out that the electricity you *don't* use can save you as much or more than the electricity you generate yourself.

Would I do it again? Sure. Given the advancements in panel technology over the past two years, I would now install the new Sanyo HIT panels that promise greater heat tolerance. But otherwise I'm very satisfied with the results. True, we still have a monthly utility bill, and I don't have a system that permits my home to run off-grid the next time a car hits a utility pole. But my system's level of maintenance is much more practical without the batteries, and we still have the generator in the shed out back.

By the way, California solved its electrical energy problems—at least for the short term. So now, I tell people that my "lifeboat" PV system is only a recreational boat, but one that is an asset to my pocketbook, as well as to the environment, and uses electronics that I had a hand at improving. Not bad!

Access

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Kyocera Solar Inc., 7812 E. Acoma Dr., Scottsdale, AZ 85260 • 800-544-6466 or 480-948-8003 • Fax: 480-483-6431 • info@kyocerasolar.com • www.kyocerasolar.com • PVs

Xantrex Technology Inc., 5916 195th St. NE, Arlington, WA 98223 • 360-435-8826 • Fax: 360-435-3547 • info@xantrex.com • www.xantrex.com • Inverter

Several excellent, free consumer guides • www.consumerenergycenter.org/erprebate/forms.html

Henry Cutler, 2623 Woodwind Hills Ln., Lakeland, FL 33813 • www.solar-guppy.com • Information about Sun Tie and other inverters

Living with a Masonry Stove

Kate Mink

In some climates, the only shelter people really need is a roof to keep off the worst of the sun and rain. For most of us, however, shelter means not only some sort of enclosure, but also some means of moderating the environment inside. Shelter takes a lot of our resources, and it's worth our time to consider how we can best provide ourselves with comfortable nests.

Since you're reading *Home Power*, your definition of "best" probably includes some measure of efficiency and sustainability, as well as safety and perhaps beauty. After a lot of thought and research, I decided a few years back that for me, the best fit for all of these criteria was a masonry, or Russian, stove.

This was a big decision, in many ways. Masonry stoves are expensive—US$5,000 and up. And they are big—they weigh a few tons, and require a hefty foundation and a lot of floor space. It would be an ongoing embarrassment to end up with a mistake that big crouching in my living room!

This masonry stove is the focal point of the author's living room and provides soft radiant heat long after the fire is out.

Well, for me it wasn't a mistake—I love the thing. Still, as with the people, the books, or even the foods that I love, I can see that a masonry stove might not be for everyone. So here is a brief report of my experiences that I hope will help you judge for yourself.

My masonry stove has a core of special precast pieces, a facing of local stone, and a conventional masonry chimney. The core came from Masonry Stove Builders of Shawville, Quebec, Canada. Norbert Senf, the owner, is very knowledgeable, helpful, and enthusiastic, and was a delight to work with. He can design stoves of widely varying sizes, shapes, and amenities. He included doors, foundation and chimney specifications, and all of the directions that my local mason needed to finish the stove. Ellis Brothers of Binghamton, New York, built the shell and chimney.

It's Still a Stove

A masonry stove is not a furnace with a thermostat. You have to light and stoke the fire; you have to clean out and haul away the ashes. You *can* hide a masonry stove in the basement, or even in its own building, and run forced air or hot water heating ducts or pipes from it. However, that loses its major advantage—thermal mass. It's far more efficient and comfortable to have it radiate directly into your living space.

For many of us, the big appeal of a wood (or coal, or pellet) stove is the radiant heat. To have a place in the house that is genuinely, even extravagantly warm, where we can take off our sweaters and bask, even when it's below zero and howling outside…ahhh! If this is what you're looking for, a masonry stove is the best.

You get not only the direct heat when the fire's burning, but also long-lasting, steady warmth from the rock—it stays noticeably warm for 12 to 24 hours after a fire. You can use that warmth to dry and heat your bath towels, boots, and gloves; to dry food; to dress by; and to sit on or lean against. Our cats spend a lot of time loafing on that warm rock, and so do we.

It Needs Wood

A masonry stove has some hassles that are common to any device that burns wood—wood storage, wood bits everywhere, and ashes. Some people are just not up for dealing with wood at all. Sometimes, I can't blame them a bit, such as when I've just dropped a log on my foot.

Wood is a great fuel if you live in a low-density area and are up for a certain amount of physical labor. Otherwise, it's probably not a good choice, and any book on wood heat will make that pretty clear. So, assuming wood's a good fuel for you, when is a masonry stove the best way to burn it? For me, the critical factors were these.

Fuel. I live where it's easy to cut or buy wood. For financial and environmental reasons, I prefer to burn it as efficiently as possible.

Ambiance. I love the feel and features of a woodstove, from drying socks to gazing at the flames.

Opportunity. I was able to design a new house around the masonry stove, providing space for stove and wood, decent insulation, and an open plan that makes good use of a central heat source.

Convenience. I have a day job. I'm not home to feed a regular woodstove all day. With this stove, I only need to make one fire in the morning and one in the evening.

Safety. I have a child and cats, and have lost a wooden house to fire. Except for the firebox door, the surfaces of my masonry stove never get too hot to touch; they rarely get too hot to lean against. Combustion in this stove is so complete that creosote is not deposited, so you don't run the risk of chimney fires. (Nonetheless, you should have your chimney inspected annually—it's worth it to be sure.)

Aesthetics and sentiment. My stove is faced with rocks from my own land that I picked and washed. This saved me a little money, but more important, it was fun and deepened my connection to the land we live on. My stove is very much on the down-home side. You can see lots of sleeker, more upscale examples at many builders' Web sites, including Masonry Stove Builders and Temp-Cast.

The author's daughter Lexa demonstrates efficient basking behavior, warming herself against the warm (but not hot) thermal mass of the masonry stove.

Thermal Mass Comparison

Tile photo courtesy of Sun Spot Solar, 570-422-1292, www.sssolar.com.
Masonry photo courtesy of Temp-Cast Masonry Heaters, 800-561-8594, www.tempcast.com

Building the Fire

Here's the routine I follow through the winter in using the masonry stove. Every evening, and mornings if it's cold enough, I scoop out ashes if there are a lot of them in the firebox, and put them in a small, covered, metal ash can. About once a week, I also open a front access door and pull accumulated ashes from under the firebox. Then I build a fire.

This is a three-step process. First I crumple four or five sheets of newspaper in the bottom, add a couple of pieces of cardboard or heavier paper, and then three or four pieces of kindling (about 1 to 2 inches; 2.5–5 cm in diameter), alternating the cardboard and kindling. Then I put a couple of wedges of larger wood (3 to 4 inches; 7.6–10 cm) on that at right angles to it, and some more cardboard pieces between these. I light this, and close the doors.

In ten minutes, I come back and put a few logs on. Ten minutes after that, I fill the firebox with logs, close the doors again, and I'm done. If I'm running two fires a day, I can put all the logs on as soon as the kindling's well caught.

This is truly a simple process. My ten-year-old does it reliably and safely with supervision. If you actively enjoy fussing with fires, and pride yourself on your skill in building them, this kind of stove may not be for you, because unless the stove's cold and the wood's

Diagram courtesy of Temp-Cast Masonry Heaters

Serpentine air flow through a typical masonry stove helps warm the large thermal mass for efficient and comfortable heat.

wet, there's just no need for virtuosity. Fires seem to catch better if you stack the logs end-on to the door, as opposed to crosswise, because the air flows from front to back, but even that's not critical.

You do use a lot of kindling, compared to a stove where you rarely let the fire go out. If you buy wood, it's worth making sure that you get all sizes in a load. If you cut wood, you can use up a lot of small branches. Once or twice a week, I use a wheelbarrow to bring in wood from various outdoor stacks to indoor storage. This takes fifteen minutes to half an hour. I have room to keep about a week's worth of wood inside.

Hot Water, Dried Fruit, & Baking

My stove has a baking oven in it, over the firebox. This is a "white" oven, which means that the hot fireplace gases don't go through it, but around it. (There are also "black" ovens, which gases go through; these can't be used while the fire is burning—they bake with residual heat only.) I use the oven several times a week, for everything from keeping a pitcher of water hot to drying gloves.

The keys to successfully using this oven, learned from harsh experience, are:

- Keep an oven thermometer in the oven, so you don't try to bake when it's not hot enough.
- Keep a rack on the floor of the oven; don't put things directly on the floor, which gets very hot.
- Never shut the oven door when there's anything in it other than food. Sooner or later, you'll forget that there's something there, start a fire, and end up with singed socks or melted gloves. Yuck.

A few times a year, I cook in this oven, usually roasting a chicken or baking bread. It works fine, and gives me that smug, self-sufficient feeling that is one of the little joys of living with renewable energy. I have to bake a couple of hours after I start the fire, and it helps to rotate bread once (otherwise it becomes lopsided because the heat isn't perfectly even). Allegedly, it can get hot enough to make a really good pizza crust (600°F; 316°C), but I've never seen a temperature above 400°F (204°C).

Heating the Home

We do have a backup heating system—hot-water baseboard heaters fueled by propane. We almost never use it, because its pump is a steady consumer of electricity. I'll turn it on occasionally on a cold, sunny day, but most of winter here is cloudy. When I get my wind generator back on line, I'll have the capacity to run this system more, but I still won't be fond of using gas for heating, and anyway, I've proven that we don't need it.

Handy tools for working with a masonry stove: metal ash can, clean-out hoe, dustpan and brush, poker, gloves, and door opener.

Maintenance Schedule

Frequency	Task	Time
Once or twice daily during heating season	Clear ashes & build fire	10–15 min.
Once or twice weekly during heating season	Bring in wood	15–30 min.
	Empty ashes from main clean-out	10 min.
Once monthly during heating season	Clean glass doors	10 min.
	Brush off or vacuum stove	10 min.
Once a year	Clean whole exterior	30 min.
	Have chimney inspected	30 min.
	Do any required maintenance	0–3 hrs.
	Order wood	5 min.
	Stack wood outdoors (summer & fall)	Several hrs.
Every few years	Vacuum out secondary clean-outs	30 min.

Here in upstate New York, winters are fairly long, dark, and cold. I need to heat the house from October through late April. It's generally below freezing for December through March, and we have lows down to -25°F (-32°C). We're on a hillside and get plenty of wind, which pulls heat off the front (not earth-sheltered) half of the house.

Long-Term Comfort

Given all that, we use 6 full cords of wood each winter, for which I pay US$600-700, delivered. I like to be warm: the main living area runs at 68 to 72°F (20–22°C)—and even warmer right by the stove. My library, where I sleep in the winter, is a steady 72°F. To my surprise and delight, the furthest back bedroom stays above 62°F (17°C). This setup would be even better for people who like to sleep in a cool room. Alternatively, a house that was rounder, more open, or equipped with a few fans would be still more evenly heated.

I started out figuring that if I wanted some kind of fireplace, and could afford it, a masonry stove would be safe, efficient, clean as woodstoves go, and something I could manage with my day job. This has proven to be true, and I'm very satisfied with it.

Living with a masonry stove suits my values, especially that of designing things for a very long, useful lifetime. In actual warmth, versatility, and absence of anxiety, it provides a level of comfort that's even more than I originally hoped for. I hope this little tale has given you an idea of what it might be like to live with one yourself.

We've lived here and used the masonry stove since the fall of 1998, which has included a couple of mild winters and a couple of fierce ones. The house is 3,000 square feet (280 m^2), concrete, and half underground. It's well insulated, but not super-insulated. Concrete is great for thermal mass—we have about 550 tons of it—but it doesn't provide much insulative value. We get that from rigid foam board outside the concrete shell.

It's a long, one-story (no basement, no attic) almost-rectangle, which is not the best shape for heat distribution. But the living room, dining area, and kitchen are all connected and adjacent to the stove. My winter bedroom abuts the back of the stove. There are a lot of big windows and five skylights, and until this winter, none have had storm windows or curtains, which has surely been the biggest heat loss factor. I'm now working to add both interior magnetic storm windows and window quilts all around. I hope to report on that in a future article.

A homemade wooden hoe can be used to pull ashes out of the main clean-out. Kate empties two or three dustpans each week.

Access

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Norbert Senf, Masonry Stove Builders, RR 5, Shawville, QE, Canada J0X 2Y0 • 819-647-5092 • Fax: 819-647-6082 • mheat@mha-net.org • www.heatkit.com • Masonry heater core supplier

Temp-Cast Enviroheat, PO Box 94059, Toronto, ON, Canada M4N 3R1 • 800-561-8594 • Fax: 416-486-3624 • staywarm@tempcast.com • www.tempcast.com • Masonry stoves

"Masonry Stoves," by the Gimme Shelter crew, *HP51*, page 42


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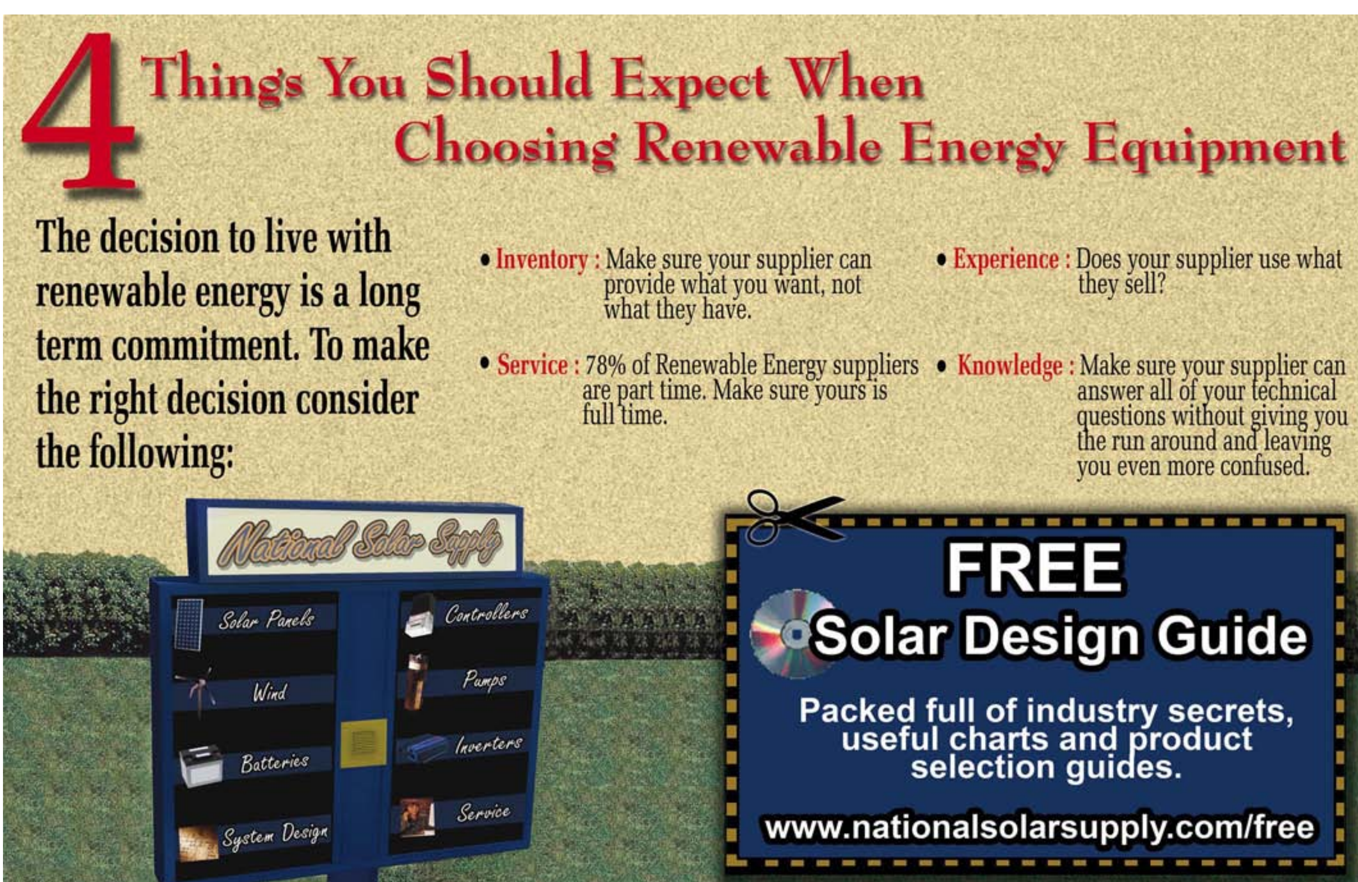
4 Things You Should Expect When Choosing Renewable Energy Equipment
The decision to live with renewable energy is a long term commitment. To make the right decision consider the following:
• Inventory : Make sure your supplier can provide what you want, not what they have.
• Experience : Does your supplier use what they sell?
• Service : 78% of Renewable Energy suppliers are part time. Make sure yours is full time.
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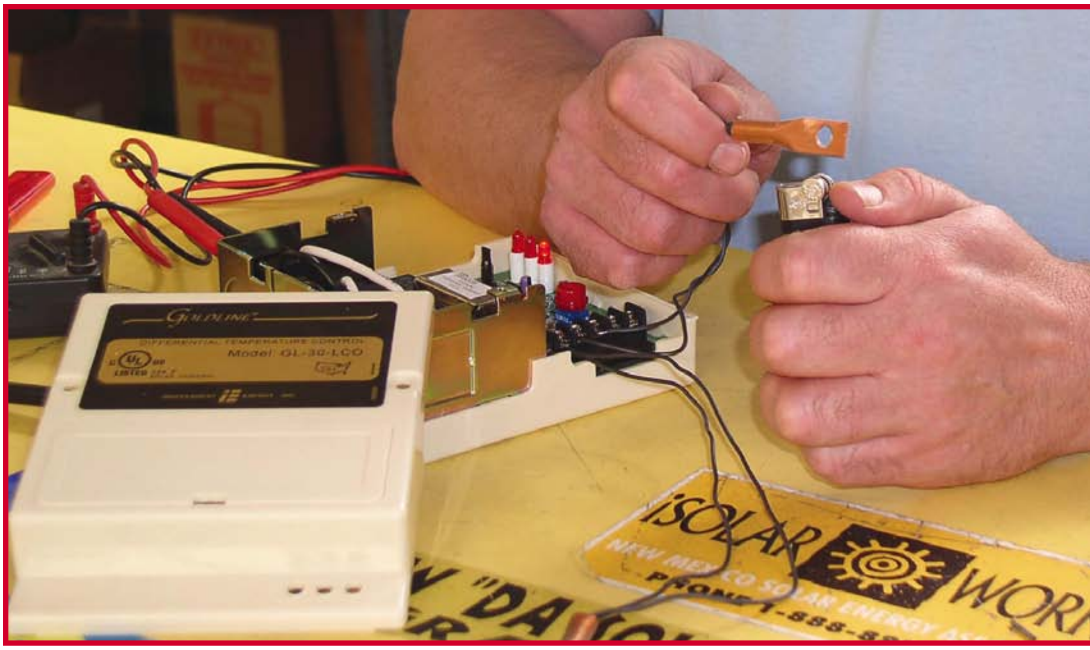
Troubleshooting Solar Water Heating Systems

Part 1: Differential Controls

Chuck Marken



Smitty from AAA Solar uses a lighter to test a sensor connected to a Goldline GL-30 control.

Drainback, closed-loop antifreeze, and direct-pump solar water heaters all use the same type of electronic controller. More than half the time, a malfunction in an active solar water heating system is in the controls. What happens when these control systems malfunction? What can you do if they fail or get out of kilter?

A differential control and sensors (*What the Heck?* #3 and #8 in *HP94* and *HP97*) are used in all solar water heating systems that use AC pumps. *HP94* covered the installation of differential controls, and if you're not familiar with them, a quick review of that article would be helpful.

In the last boom cycle of solar heating, during the 1980s, more than two dozen manufacturers made differential controls in the United States. Today, there are only two major manufacturers. Heliotrope Thermal and Goldline (formerly known as Independent Energy) are very similar in their function and design, and they both use 10 K-ohm (10,000-ohm) thermistors for sensors. We'll concentrate on these two controls in this article. The diagnostic techniques used are similar for nearly all differential controls ever made.

Take a look at the five troubleshooting steps in the sidebar. Recognizing the symptom of any problem is the first step in fixing a malfunction. Control troubleshooting is pretty straightforward. Usually a control problem will be very noticeable—the most common symptom is that the thing doesn't work at all. We'll look at a few other less likely symptoms later.

First the Obvious—Power to the Control

If there is no electricity to the control, the symptom most often will be the pump or pumps in the system not coming on. You will first need to ascertain where the control is and be able to recognize it. Sometimes it can be hidden in clever locations (like under a covered module with other system components). But most of the time, it will be out in the open and will look like one of the controls in the photo (page 63).

Most of these controls have one or more light emitting diode (LED) lights. If they have a single light, it will normally mean that the control has power. Two lights will usually mean "power" and "on (pumping)". Sometimes a third light is used to indicate a special condition.

If the power light (or single light on controls with one light) is not on, you may have found the problem. Is the control plugged in or getting power to the input terminals? Is a breaker tripped or a fuse blown? If so, did resetting the breaker, replacing the fuse, or throwing a switch energize the LED? If it still doesn't work, but you are sure the control has power and the LED is still off, an LED is probably burned out or the control is just not working. (See the troubleshooting logic tree.)

If the power light is on but the pumps don't come on when there is ample sunshine available, it's a good indication that the control system has a problem. It could be the control itself, one or both of the sensors, or a problem with wiring. In rare cases, it might be more than one thing wrong. First we'll look at the control itself, since that is the most likely problem.

The Differential Control

Both the Heliotrope Delta-T and Goldline GL-30 controls have an on-off-auto switch. The Delta-T has two lights and the GL-30 has three. First look at the switch—it must be in the "auto" position to function normally. It must also be in that position to troubleshoot the control. Without the switch in the auto position, the pumps would run all the time if the switch is in the "on" position, and the controller would never turn the pumps on at all if the switch is in the "off" position.

Now, apply a little logic about these controls. Resistance differences at the sensor terminals will cause the control to turn pumps or blowers on and off. Shorting a set of terminals gives the control a signal that the input is very hot—infinitely hot. Open terminals mean just the opposite—very cold. The thermistors (sensors) used with these controls vary their resistance with temperature. When the temperature goes up, the resistance goes down. See the table at the end of this article to match resistances with temperature.

Make sure that the control has power, and that the switch (if it has one) is in the auto position. Sensor wires should be disconnected at the controller. With a modified paper clip, short the two terminals marked "collector." On some older controls, these terminals might be labeled "solar." *Use caution: Make sure you are shorting the sensor terminals only. If you short the 120-volt terminals, you could burn your fingers or shock yourself.*

The Diagnostic Tools

- Differential control and sensors
- Your eyes, ears, and sense of touch
- Multimeter
- Small screwdrivers
- A good thermometer
- System schematic

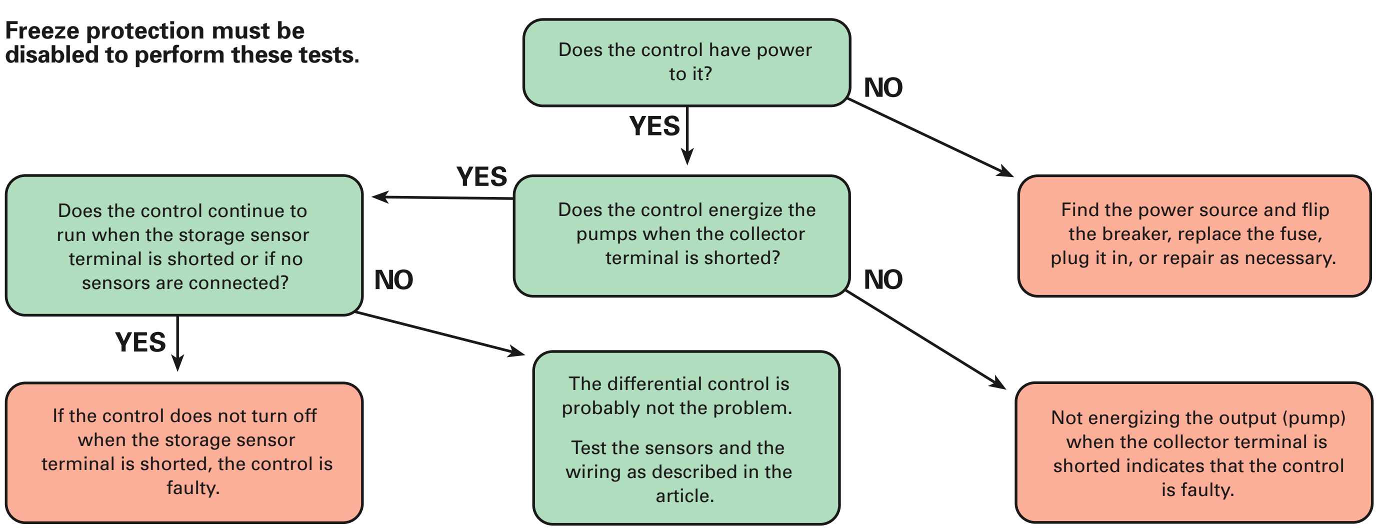
5-Step Control Troubleshooting

1. Symptom recognition
2. Symptom elaboration
3. Listing of probable faulty functions
4. Localizing the faulty function
5. Failure analysis

Thanks to David Sweetman and the U.S. Navy Basic Electronics School for this approach.

If the pump comes on when the collector terminals are shorted and turns off quickly after you remove the short, the control is undoubtedly functioning properly. You should have the pumps connected normally when you perform this test, since the LED light might come on and there will be no real output power if they are disconnected. You might find that the control comes on and powers the pump, but the pump doesn't run. In this case, you probably have a problem with the pump. We'll look at pumps and other system malfunctions in the next article in this series.

Differential Control Troubleshooting Logic Tree



If the control does not energize the pumps when the collector sensor terminals are shorted, the control is bad. It will need repair or replacement, and with the rare exception of multiple problems at the same time, you have found the problem. Pat yourself on the back—troubleshooting is at the top of the pyramid in the world of field technicians.

The Collector Sensor

Assuming the sensor terminal short test worked, and you feel that the control is OK, the sensors are the next thing to check. Use a multimeter to check resistances. The best place to check the resistances is at the ends of the wires while they are still disconnected from the control. The other ends of the wires still need to be connected to the sensors themselves. In most cases, you won't need a thermometer—approximations are good enough for this check.

For one person to do the test at the end of the wires, the pumps will need to be able to be powered. If the control has an on-off-auto switch, they can be powered by flipping the switch to "on." If not, they can be powered with an extension cord from another electrical receptacle. Set the multimeter for ohms, attach the probes to the collector sensor wires, and note the reading.

There is no polarity with thermistors or an ohm meter, so either multimeter probe can go to either wire. In bright sunshine, the collector will be 200 to 300°F (90–150°C), and maybe higher in hot climates. Looking at the resistance chart, a 10 K sensor at 200°F plus will measure less than 1,000 ohms. Turn on the pumps while looking at the meter. When the relatively cold collector loop fluid circulates through the collector, it will begin to cool the sensor. You should see the resistance rise.

If the resistance reading indicates a short (short circuit) or open (open circuit), there is a problem with this sensor circuit. Infinite resistance indicates an open circuit, and extremely low resistance of a few ohms indicates a short circuit. If the sensor's resistance reading is very high when it should be low, or if the sensor does not change when circulation of the collector loop fluid is cooling the sensor, there is a problem.

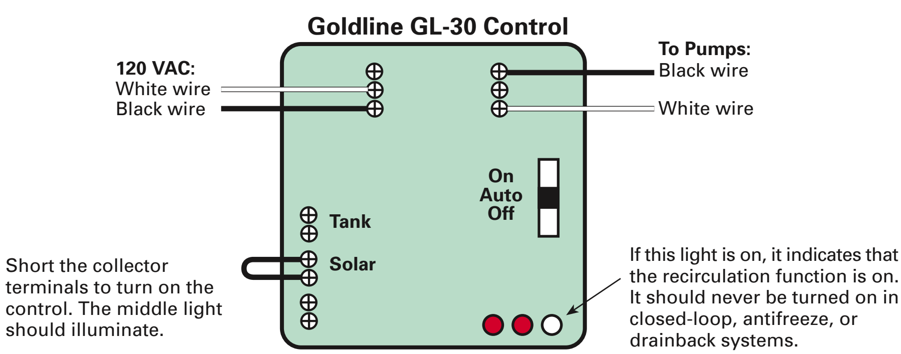
Most often, a sensor not changing resistance with a known temperature change, or a vastly different resistance reading from a good approximation, indicates that the sensor needs replacing. A short or open can also mean a bad sensor, but just as likely there could be a problem with the wiring going to the sensor. In any of these conditions, the next step is to test the sensor at its internally connected leads. We'll go over that procedure with the storage sensor.

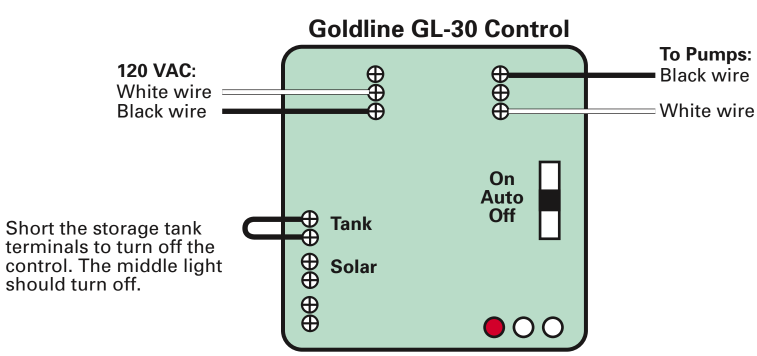
The Storage (Tank) Sensor

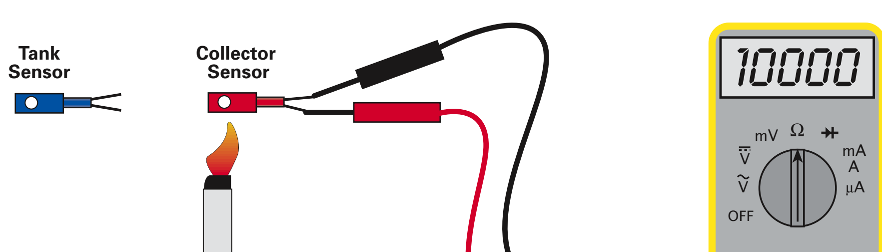
The storage sensor usually will be bolted to the bottom of the tank or attached to a pipe near the bottom of the tank. Because of its location near a large mass of water, the resistance will not change quickly when you circulate the collector fluid. It is best to test this sensor with fire and ice.

Once again, the meter probes should be connected to the sensor wires. Using a butane lighter or match, heat the sensor up while observing the resistance reading. If you have an ice cube, you can cool it down quickly, too. Did the sensor's resistance change

Differential Control Troubleshooting







Set the multimeter to a resistance scale that will read in the thousands of ohms, and test each sensor by gently heating it with a match or lighter.

Ten differential controls used in solar water heating systems over the last 20 years.

A Goldline GL-30 on the left and Heliotrope Delta-T on the right with the covers off. Note the diagrams and explanations on the covers.

when you changed the temperature? Does the resistance reading approximate what the chart gives? If so, this sensor is probably OK. If the resistance is way off, open, or shorted, the sensor is bad. If the sensor is OK, a short or open in the circuit is very possibly a wiring problem.

A Test of All the Components

The above troubleshooting procedures will identify the problem almost all of the time. If you wish to perform a more accurate test without the wiring in the circuit, connect both sensors to the control using only the short leads on the sensors. Make sure that the control has power and the switch is in the auto position.

If both sensors are the same temperature, the pumps or load should not be energized. Using a lighter, heat the collector sensor. It should energize the pumps fairly quickly. Take the heat away when the control comes on. Using the lighter, heat the storage or tank sensor. Keep applying heat until the control shuts off. If all is well with the components, this cycle should work every time, and energize and shut off quickly.

System Runs All the Time or at Odd Times

Two other, less common symptoms are the pump running all the time and running at times when the sun isn't shining. Running all the time can be caused by: the control switch in the on position, an internal relay frozen in the on position, an open tank sensor, or a shorted collector sensor.

If the switch is in the auto position and the pump runs all the time, the problem is likely with the control, sensors, or wiring. A control that runs the pumps with no sensors attached and the switch in the auto position almost always means a problem with the control itself.

A system that runs at odd times is the most difficult to diagnose. The most obvious cause is the third light on a Goldline control (the Heliotrope doesn't have this light). Both controls have the function of recirculation freeze protection. In extremely mild climates where it might freeze once every five or ten years, this function may have been enabled. The Goldline has an internal jumper for enabling this, and the Delta-T has an internal DIP switch.

Recirculation freeze protection is a bad idea in all but the mildest climates. It should never be enabled in drainback or closed-loop antifreeze systems. Check for this if the control is new, or if someone has been fooling around inside the control. The Goldline will have the light to warn you that this feature is enabled, but the real symptom is the pump running when it shouldn't be.

Internal settings can make a control run or not run when it shouldn't. The Delta-T has a series of DIP switches for adjustments in the field. The Goldline has two dials. These settings control the turn-on differential and the storage temperature high limit. Any system with a heat exchanger in the collector loop (drainback and closed-loop antifreeze) should have a higher turn-on differential than a direct pump system without an exchanger.

The Delta-T should be set for an 18:5 differential and the Goldline from 16 to 20. On the Delta-T, the first number is the "on" differential, the second the "off." The Goldline has a fixed "off" differential of 4, so the dial only controls the "on" differential. These settings are temperatures in degrees Fahrenheit.

Lower settings (9:4 on the Delta-T and about 10 on the Goldline) are for direct-pump systems without exchangers used in nonfreezing climates. High-limits should be no more than 180°F (82°C). The high-limit setting will turn the pumps off when the storage gets to that temperature. The Delta-T has two choices—160°F and 180°F. The Goldline has a dial.

What Else Can Go Wrong?

In a few instances out of a thousand, the tests above cannot diagnose a problem. Systems that run at odd times, sporadically, or don't run sometimes when they should can be caused by faulty sensors or controls. If this seems to be the case, there are only a couple of choices. "Shotgun" the

Sensor Temperature vs. Resistance

Temperature (˚F)	Temperature (˚C)	Measured Resistance (KΩ) For 10 KΩ Sensor	Measured Resistance (KΩ) For 3 KΩ Sensor
27	-2.8	39.8	11.9
32	0.0	32.6	9.8
37	2.8	28.3	8.5
42	5.6	24.7	7.4
47	8.3	21.5	6.5
52	11.1	18.9	5.7
57	13.9	16.5	5.0
62	16.7	14.5	4.4
67	19.4	12.8	3.8
72	22.2	11.3	3.4
77	25.0	10.0	3.0
82	27.8	8.8	2.7
87	30.6	7.9	2.4
92	33.3	7.0	2.1
97	36.1	6.3	1.9
102	38.9	5.6	1.7
107	41.7	5.0	1.5
112	44.4	4.5	1.4
117	47.2	4.0	1.2
122	50.0	3.6	1.1
127	52.8	3.2	1.0
132	55.6	2.9	0.9
137	58.3	2.6	0.8
142	61.1	2.4	0.7
147	63.9	2.2	0.6
152	66.7	2.0	0.6
157	69.4	1.8	0.5
162	72.2	1.6	0.5
167	75.0	1.5	0.4
172	77.8	1.4	0.4
177	80.6	1.2	0.3
182	83.3	1.1	0.3

problem (replace components in a logical fashion) or have a professional electronics technician look at the differential control and sensors. If you choose the shotgun approach, replace the sensors first. They cost about one-tenth what a good differential control costs. See the Access section at the end of this article for companies that sell, evaluate, and repair controllers.

Other Controls

Each controller is designed for sensors with a specific resistance. Differential controls that use 10 K-ohm sensors have been the standard for more than twenty years. However, there are still quite a few controls in service that are older than that and may have something besides 10 K-ohm sensors. Four that enjoyed varying degrees of popularity were Honeywell, Johnson Controls, Webb Electronics, and Delta-T. Virtually all other manufacturers used 10 K-ohm thermistors for sensors.

Some early Delta-T controls made before 1983 used 3 K-ohm sensors. These will have orange and gray wires on the control, and will almost always have a metal cover plate. Newer, 10 K Delta-Ts have plastic cover plates.

Webb Electronics used 30 K-ohm thermistors for sensors. If you find one of these and the owners know what they have, expect to pay a reasonably high price. But warranty considerations and the thought of possibly buying another expensive 30 K sensor in the future would make me lean towards just getting a whole new control with a warranty and reasonably priced replacement parts.

Honeywell and Johnson Controls also had odd duck sensors that are very tough to find. The Honeywell used a sensor that reads 3,500 ohms at 85°F (29°C). The resistance and temperature were not inverse, as they are in differential controls made today. Johnson made a control that operated with two, 1 K-ohm sensors at 70°F (21°C), and may have made a few others that were not in wide circulation.

If you have a differential control and know nothing about it, the inside surface of the cover plate is the first and best place to look for information. Delta-Ts and Goldlines made today lay out the terminal connections, switches, or dials as appropriate.

Most DC-pumped systems with a dedicated photovoltaic (PV) module for power don't use a differential control. The control is the module itself, and if it is closely matched to the pump motor, it will work well with the sun cycle. There are a few systems with DC differential controls (I know of none readily available today) and all that I have seen operate just like their AC cousins.

Fault Analysis

Once you've found the problem and corrected it, it is good to try to minimize the risk of it happening again. Most control problems seem to be caused by normal life of the components or voltage spikes. There isn't much you can do about normal wear except to replace the component with one that has a good reputation for reliability, or have the faulty control repaired by a reputable electronics technician.

Voltage spikes are not nearly the problem they used to be. Many early controls had poor surge suppression built in—some had none. With the collector sensor near the top of many homes, this was asking for trouble. Nearby lightning can cause spikes, and controls with poor or nonexistent surge suppression were easy prey. The industry seems to have solved that problem, and we see very few controls with voltage spike damage today.

A caveat on troubleshooting: some differential control manufacturers did not recommend shorting the sensor terminals on their controls. We have been told that it can cause damage. After checking thousands of controls from dozens of manufacturers over the last 25 years with the quick checks given in this article and never seeing any harm caused, we just don't pay any attention to the warning. Manufacturers may still discourage this testing procedure, and if so, you should be aware of it and check with the manufacturer if the warning bothers you.

Differential controls are used in solar domestic water heating, space heating, and pool heating systems. Typically, they will last a long time. Perhaps today they are no longer the most likely component to check when a system malfunctions. But they can fail, and I hope these troubleshooting procedures will help you if they do.

Access

Chuck Marken, AAA Solar Supply Inc., 2021 Zearing NW, Albuquerque, NM 87104 • 800-245-0311 or 505-243-4900 • Fax: 505-243-0885 • info@aaasolar.com • www.aaasolar.com

Goldline Controls Inc., 61 Whitecap Dr., North Kingstown, RI 02852 • 800-294-4225 or 401-583-1100 • Fax: 401-583-1200 • technical_service@goldlinecontrols.com • www.goldlinecontrols.com • Goldline (formerly Independent Energy) controls

Heliodyne, Inc., 4910 Seaport Ave., Richmond, CA 94804 • 510-237-9614 • Fax: 510-237-7018 • info@heliodyne.com • www.heliodyne.com • Delta-T controls

Jon Klima, Conifer Solar Consulting, 360 Trout Ln., Guffey, CO 80820 • Phone/Fax: 719-479-2281 • jon@piopc.net • www.coseia.org/CSC-ad-page.htm • Sales and service for controllers

Control Your Energy Use & Costs with Solar Monitoring

Horst Wend

Author Horst Wend with the photovoltaic system that he can monitor from anywhere via the Web.

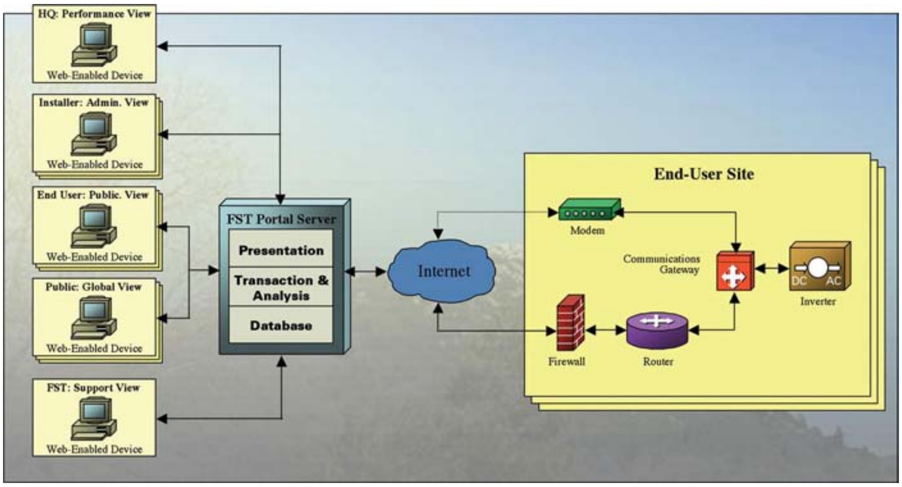
This past year, I installed a 2.5 KW solar-electric system with sixteen Sharp, 185-watt modules and an SMA Sunny Boy 2500 inverter at my home. I chose to go solar because I wanted to do something good for the environment, and I hoped to reduce my electricity bill in the process.

I was really excited about my new solar-electric system, but I was concerned that I might not know if I was making the best energy usage choices, or if I was getting the most out of my investment. How would I know if my system was working to its fullest potential, or if I was making effective energy usage decisions?

Real-Time Solar Monitoring

I realized that I would need access to energy data to gain an understanding of how I could optimize my solar energy system. I contacted my installer, Akeena Solar, and they recommended that I install a monitoring system. They suggested a new monitoring product, PV2Web, a Web-based system developed by Fat Spaniel Technologies (FST).

Here's how it works. Data from sensors at the inverters and the main electrical panel (and environmental channels, if ordered) is sent to a communications gateway. This is preprogrammed, so I did not need to load any software. The



The Fat Spaniel PV2Web links photovoltaic system data to the World Wide Web.

Room for Improvement

On the downside, I would like to see more features, such as reporting capabilities for previously collected data, so I can do more in-depth data analysis. It would be nice if users could select different ways for the Web site to present the data (pie graph, bar graph, etc.).

I would also like to have an option to get into the data itself. I see a lot of possibilities to extend the monitoring system so I could, for example, insert data from electricity bills before the PV system to get a comparison and some idea how much I am saving with the PV system. I sent some suggestions to Fat Spaniel and they already have implemented many of them. It has been great working with them.

information is then sent out to the Internet via broadband, modem, or wireless, where Fat Spaniel Technologies processes the data and presents the Web pages.

What I like most about the Web-based monitoring is that I can access the data in real time from anywhere I have a Web connection. It gives me the option to check on the system even when we are not at home, from any computer, or from my cell phone or PDA. For example, we recently had our roof redone, and the roofers accidentally disconnected one of the solar-electric arrays while I was away. With the monitoring system, I noticed that even though it was a sunny day, the system wasn't generating as much electricity as usual. So I had Akeena come out, and they fixed the system right away.

Production & Usage Data

With the standard PV2Web product suite, I can easily view my historical energy production and usage in real time. The PV2Web product gives reports of my peak energy usage and total energy usage for the day, week, and month. Using these reports allows me to increase my long-term return on investment by allowing me to select the utility rate that best matches my usage and projected solar output.

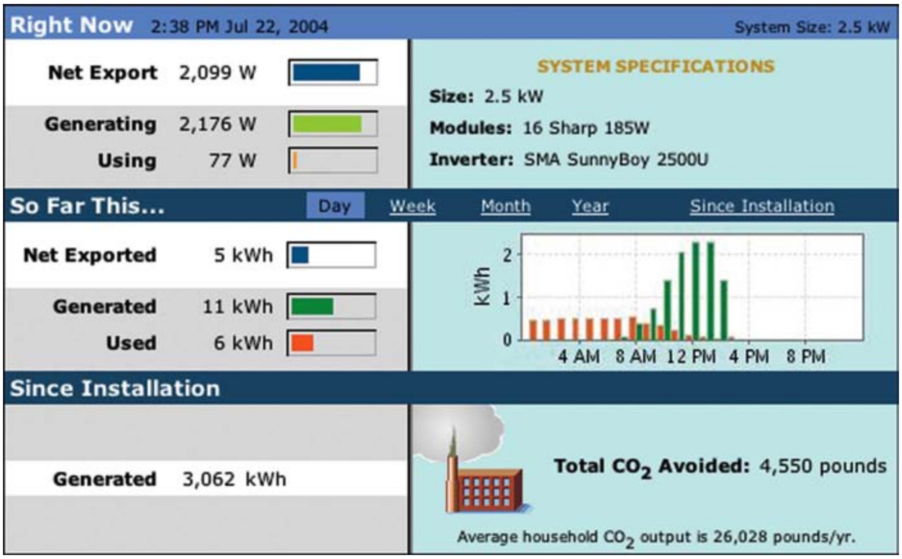
Another great feature PV2Web offers is automated alerts that let my installer know when my solar-electric system is not functioning to its capability. Akeena Solar is able to monitor my system remotely and immediately identify problems. This capability allows me to save on travel and service charges, and allows my installer to take immediate action to fix any issues I might be having with my system.

Cost

The overall cost of an FST system seems high, but to me it didn't look that bad when I looked at my total cost, and the very real benefits of the system. The total cost of our PV system was US$27,000. However, we got a US$11,700 refund from the state, as well as a tax deduction, which brought down the total out-of-pocket costs for us to about US$12,000.

I work in the software industry and love technology, so I was very interested in all the monitoring capability Fat Spaniel provides. Adding usage monitoring enabled me to actually see how much the refrigerator, washer, dryer, Jacuzzi, and other appliances contribute to our electricity consumption.

Real-time PV2Web display of Horst Wend's photovoltaic system.



Fat Spaniel Monitoring System Cost

Item	Price (US$)
Basic PV2Web monitoring system	$1,428
Optional irradiance & temperature monitoring	400
Optional building demand monitoring	338
Channel for one additional inverter	275
Total	$2,441

Increase Awareness & Control Costs

PV2Web is powerful yet simple to use, and provides easy-to-understand, real-time insights into my energy system. It's easy to work with because there is no software for me to install or maintain, and I can view my data from any Internet-enabled device. I have enjoyed being able to show my friends how well my system is performing.

I have been able to increase my awareness of electricity use, and I make more energy efficient decisions. For example, I know that when I use our washer and dryer, they draw several KW for about an hour (mostly the dryer). The monitoring system raised our awareness, so we now make sure the washer and dryer are fully loaded before we use them instead of doing smaller loads. Also, I saw after I filled the Jacuzzi in March that it used an enormous amount of electricity for two days to heat it up. Next time, I'll fill it from our hot water supply, since this is more cost effective.

I was able to improve my net metering results by maximizing energy export and load shifting, and reducing my electricity bill through tighter management of my energy production and usage. The PV2Web data allowed me to control my energy costs by taking advantage of inexpensive, off-peak rates.

By shifting my energy usage and producing electricity during peak hours, I've been able to reduce my electricity consumption significantly, and I've reduced my electricity bill by 50 percent! Based on the PV2Web data, I'm also considering expanding my system to gain the maximum energy production for my specific use, and to maximize my savings as well.

What I've learned is that installing a grid-tied solar-electric system is just one step in smart energy management. An even more important step is making efficient changes to your energy production and usage through monitoring of your renewable energy system.

Access

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Fat Spaniel Technologies, Inc., 648 S. 12th St., San Jose, CA 95112 • 408-279-5262 • Fax: 408-516-9111 • info@fatspaniel.com • www.fatspaniel.com

Akeena Solar, 605 University Ave., Los Gatos, CA 95032 • 888-253-3628 • Fax: 408-395-7979 • info@akeena.net • www.akeena.net

Other monitoring systems:

Sunny Boy's system can publish data to the Web • www.sma-america.com

OutBack Power Systems is working on this capability • www.outbackpower.com

Fronius has data collection, and soon a networkable display • www.fronius.com

SolarQuest • http://data.solarquest.com

Northwrite • www.northwrite.com/monitoring.asp

Draker Solar Design • www.drakersolar.com

WinVerter-Monitor • www.righthandengineering.com

The First Small Wind System in Lassen County

Leslie Morán

Top: Raising the 84-foot tower with the Proven WT2500 for the first time—keep clear of the fall zone.

Above: Almost ready for raising—the Proven WT2500 weighs more than 450 pounds.

"I've always liked the idea of a property paying for itself," says Paul Thomas, who with his wife and family, own 77 acres in Litchfield, California. Ever since Paul graduated from high school in the mid-seventies, he has wanted renewable energy in his life. He credits his mother with instilling a vision in him for being self-sufficient.

After construction on their home was completed, Paul began his research. A *Home Power* article—"Apples and Oranges" by Mick Sagrillo—explained the basics about small wind turbines. On the Internet, he found information on the rebate program offered by the California Energy Commission (CEC) for customers of Lassen Municipal Utility District (LMUD), and he picked up a copy of the Lassen County ordinances. Paul also found my husband Chris Worcester's company, Solar Wind Works, online. He called and spoke with Chris.

Chris first visited the Thomas homestead in May 2002. At an elevation of 4,050 feet (1,234 m), the only trees visible grow along a few scarce waterways, or had been planted at farms, ranches, or homesites. In the summer, it is hot and dry, while during the winter it can snow and get as cold as -20°F (-29°C), with the mercury often hovering just above zero.

As options for the site were discussed, the presence of a significant prevailing wind spurred Paul and Chris to quantify the wind resource. Several months later, maps, documents, and information had been compiled from a variety of agencies. After reviewing the often-conflicting material, it was determined that the property sat in a Class 2 wind designation, a usable resource for a small wind turbine.

California Energy Crisis Hits Home

Originally, Paul had planned to pay for up to 50 percent of the wind turbine installation through the CEC rebate program. Unfortunately, the original program ended in December 2002, just as Paul was getting ready to apply for the funds.

This could have brought their renewable energy project to a standstill. But Paul's wife Carrie wanted to keep her husband's dream alive and encouraged him to, "Go for it!" She liked the idea of having uninterruptible power when winter storms take out the overhead utility lines and leave the rest of their valley in the dark.

Together they reviewed their finances and found a way to keep the project moving forward. This hurdle caused the system to be downsized from a Proven WT6000 to the WT2500 wind turbine.

Answering to the County

In April 2003, the application package was submitted to the county. This was the first small wind turbine permit submitted in Lassen County. The planning department handed Paul a long list of items they wanted justified, and Chris began gathering answers. The county wanted proof that the wind turbine would not interfere with television and radio transmissions, and they wanted UL or equivalent safety listings on all of the electronic components used in the system.

To meet these requirements, a letter was received from Proven Engineering Products Ltd. of Scotland stating the British standards that their wind turbines and controllers are built to. Next the Electrical Testing Laboratory (ETL) listings for the two OutBack GTFX3048 inverters and the OutBack AC and DC boxes were obtained. A copy of an article written by Mick Sagrillo (see Access) addressed the county's concern, ensuring that operation of the wind generator and blades could not and would not interfere with radio or television transmissions. With this information, Paul resubmitted his package in May.

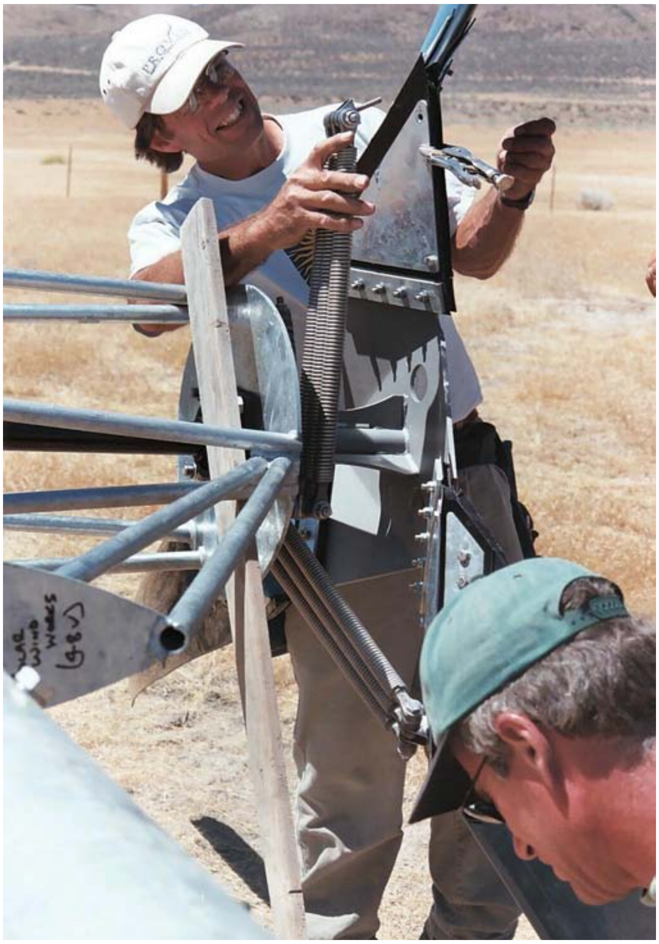
Installer Chris Worcester and owner Paul Thomas attach blades to the Proven's hub.

Preparation

Lassen County issued the permit for the renewable energy system later in May, without any further questions or changes. Meanwhile, Paul had kept busy. After hanging the plywood backing for the power center, he built a vented, insulated battery box consisting of a wood frame with plywood sides coated with fiberglass resin.

The battery box holds sixteen Surrette S-530, 6 V, lead-acid batteries wired in two parallel strings of eight batteries. This battery system stores 800 AH at 48 VDC, enough to run the household's loads for 24 hours, at 50 percent depth of discharge. The box is covered with a hinged, sloping, clear Lexan lid. The automatic vent fan is powered and controlled by a 12 VDC auxiliary output on one of the inverters.

Paul planned to install an anemometer on the wind turbine tower. After reviewing all the options, an NRG Systems Wind Explorer anemometer and data logging system was ordered in July.



Chris attaches a spring pack, which tensions the blade, allowing it to bend back for high-wind governing.

Paul's property sits on an old lake bed, is level, sandy, and treeless, save for a vegetable garden and some young aspen trees. Trenching and digging the foundation footings in such sandy soil proved to be a challenging job. The vertical walls had to be kept wet constantly; otherwise the sandy soil would collapse into the excavated areas and need to be dug out again.

It took Paul two days of backhoe work to complete 180 feet (55 m) of trench and the foundation holes for the tower and four guy anchors. With the trenches open, the schedule-40 PVC conduit runs were laid in. They provide for this turbine installation and for a future PV array.

Power Center

After reviewing the 120/240 VAC loads in the home's electrical subpanel, Chris determined that at least two inverters supplying a combined 5,000 W at 240 VAC, drawing from a 48 V battery bank, would be needed for the power center. When the wind is blowing, wind generated electricity charges the batteries until they reach a full state of charge. Additional energy is first used by the household electrical loads. If more energy is being generated than is being consumed by the loads, excess is fed back to the utility grid via a bidirectional utility KWH meter.

Paul's system contains two, series wired, OutBack Power Systems GTFX3048 inverters for 120/240 VAC. An OutBack X240 AC autotransformer steps AC output up or down to match the load requirements on the individual AC buses at the home's AC load center. The power center also contains the required AC and DC circuit breakers. The system has plenty of room for expansion, including the future photovoltaic (PV) array's charge controller circuit breakers.

The power system also boasts a Hub 4, which is used to connect the inverters to the OutBack Mate. The Mate has a digital display, and coordinates the operation of the inverters. In the future, when the PV array is installed, the Mate will also communicate with the OutBack MX60 charge controller.

A cable tray (or gutter) that measured 6 inches by 6 inches by 8 feet long (15 x 15 cm x 2.4 m) was mounted to the wall. Six conduit nipples extend upward from the gutter, and align with knockouts (punched holes) coming out of the bottom of primary components in the power center. This design simplified the cable runs between the various components in the system, and really made for a clean installation.

The prewired OutBack Power System board weighed in at more than 300 pounds (136 kg). Paul attached a strap to the preassembled power center and let his automotive engine hoist do the heavy lifting. With the engine hoist, the

Tech Specs

System Overview

System type: Grid-tied, battery-based wind

Location: Litchfield, California

Wind resource: 9 to 10 mph (4 to 4.5 m/s) annual average

Production: 420 AC KWH per month average

Utility electricity offset: 25 to 50 percent

Wind Turbine: Proven WT2500/048

Rotor diameter: 3.5 m (11.5 ft.)

Energy Output: 417 AC KWH at 12 mph (5.4 m/s) average per month

Power output: 2.5 KW at 26.8 mph (12 m/s) peak

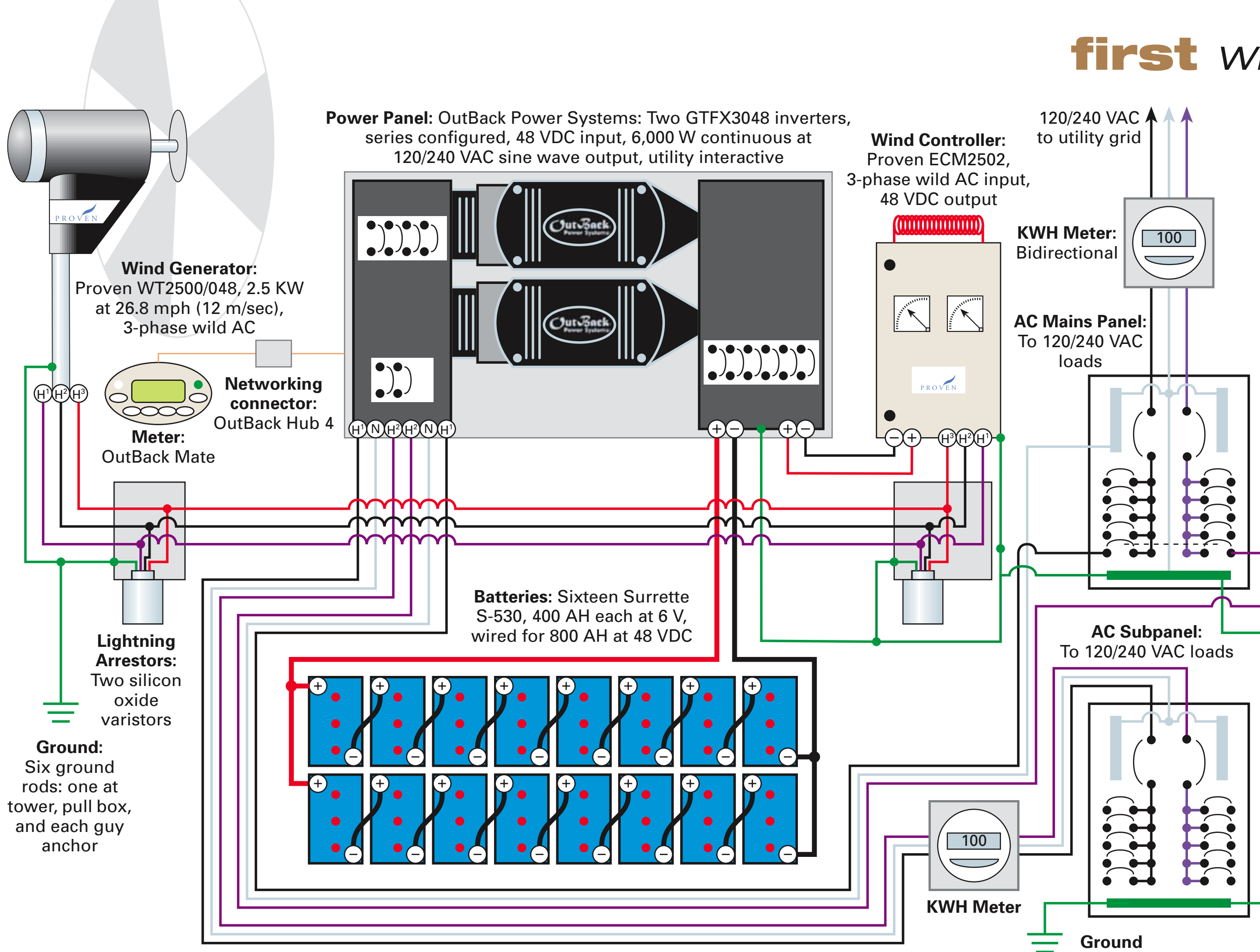
Tower: 84 ft. (26 m) Lake Michigan Wind and Sun, 5 in. pipe, tilt-up

Balance of System

Inverter: 2 OutBack GTFX3048s, 48 VDC input, 120/240 VAC output

System performance metering: AC KWH meter between the inverters and the home's subpanel

Energy storage: 16 Surrette S-530, 6 V, lead-acid batteries wired in two parallel strings of eight batteries for 800 AH at 48 VDC



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

panel was gingerly moved into place and the conduits easily slid into alignment with the knockouts.

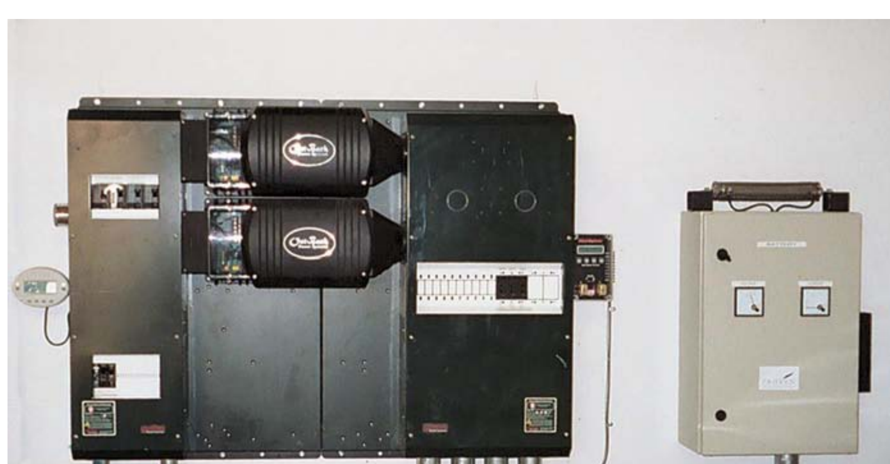
Tower Assembly

The higher off the ground, the faster and less turbulent the wind. Since Lassen County required a variance for a wind turbine higher than 100 feet (30 m), an 84-foot (26 m) tilt-up tower kit was planned. A tilt-up tower is less expensive than a freestanding tower, and makes maintenance easier, but it needs room for the guy wires. The pipe for the tower is a 5-inch diameter, schedule 40, hot dip galvanized steel pipe.

The tower foundation and anchors needed 16 yards of concrete. It took most of the day to complete the pour and finish the concrete. Meanwhile, crew members worked on drilling pipe and laying out the tower kit.

The entire next day was spent assembling the tower, laying out the guy wires, and measuring and attaching them to the turnbuckles and tower. When assembling a tilt-up tower, it's important to pay close attention to the geometry. Keep the distance between the two side guy anchors and the top of the tower equal. This ensures that the guy wires will be the same length, which will allow the tower to be raised and lowered easily.

The OutBack power center with two GTFX3048 inverters, and the Proven ECM2502 controller (at right).



Sixteen Surrette S-530s store wind energy for later.

With each section of pipe weighing 305 pounds (138 kg), the crew aligned and blocked up the tower pieces using cinder blocks and scrap lumber. This gradually increased the height of each section, so that the top piece of pipe would be high enough off of the ground to keep the wind turbine out of the dirt when it was mounted.

Internal Tower Cables

The main electrical cable, which would carry the electricity down through the inside of the tower, and the braking cable had to be installed as the tower was assembled. The electric cable is #2 (33 mm^2) tray cable (a jacketed conductor). The 3/16-inch (5 mm) aircraft cable for the manual brake was taped to the end of the tray cable, and together, both cables were drawn up the inside the pipe tower. The tray cable was then suspended at the very top with a Kellums grip, hung on a 3/8-inch (10 mm) stainless steel bolt. As the tension on the Kellums grip increases from the weight of the cable, it tightens its hold.

The cable comes out the tower base and runs through a liquid-tight flexible metal conduit to a rain-tight electrical splice box near the tower base. At this splice box, it is connected to three #4/0 (107 mm^2) THWN cables using NSI insulated in-line splice reducers. The #4/0 was sized to keep the voltage drop to an absolute minimum. Two Delta, three-phase, 600 VAC lightning arrestors were also wired in, one here and one at the Proven controller's three-phase circuit breaker.

All Proven wind turbines come equipped with a manual braking system so the turbine can be stopped for routine maintenance. This feature fit one of the county's requirements. A mechanical hand brake was installed at the base of the gin pole. A quick flip of a lever at the bottom of the tower activates the caliper braking system in the turbine and stops the Proven's blades from spinning.

Tower Grounding 101

A vital yet often underrated aspect of installing a complete wind-electric system is the grounding electrode system. Six, 8-foot (2.4 m) by 5/8-inch (16 mm) ground rods (grounding electrodes) were used. Ground rods were pounded in next to each guy anchor, at the tower base, and at the electrical pull box near the base of the tower.

After assembling the tower, with all of the guy wires and turnbuckles in place, a stranded #4/0 (107 mm^2) bare copper grounding conductor was bonded to the pivot plate at the tower base and to its respective ground rod. Then #4 (21 mm^2) bare copper grounding conductors were bonded to the ground rod at each guy anchor. Stair-stepping up from the ground rod to each guy wire, they were bonded to each guy wire individually with split bolts.

The guy anchor grounding rods were bonded back to the central tower footing ground rod using #4 (21 mm^2) bare solid copper laid in 30 inch (76 cm) deep trenches. In each of these runs, a 2 foot (0.6 m) long "Z" was bent into the wire. In theory, this will help dissipate lightning into the earth, since lightning likes to follow a straight path.

A ground rod was also installed outside the power center building to provide a close path to ground at the power center. Another bare #4 copper wire went from this ground rod back to the tower grounding system, with two Zs bent along its length. The power panel was then bonded back 90 feet (27 m) through the framing with #2 (33 mm^2) THHN to the building's main electric panel's common grounding electrode.

Tower grounding is critical to prevent electrolysis between metal and earth, which can result in tower failure, and for dissipating the static electric charge buildup that can attract lightning. Proper grounding also provides an equipment ground in the event of a short in the electrical system, providing safety to the workers and the owner.

A Gin Pole for the Gin Pole

The gin pole (the lever arm that lifts a tilt-up tower) was built above and parallel to the lower section of the tower. The front guy wires and turnbuckles were attached to the gin pole. A smaller, lighter-weight gin pole can be heaved into position with muscle power. This gin pole was 32 feet (10 m) long and weighed 460 pounds (209 kg). To lift the gin pole into its proper upright position, a temporary 10-foot (3 m) wooden gin pole was constructed.

Gin pole down, tower up—with careful measuring, the gin pole turnbuckle will come out plumb, making tensioning easier.

The lifting cable was tossed up and over the wooden gin pole and attached to the end of the permanent gin pole that needed raising. Paul's John Deere backhoe provided the muscle, and the gin pole went up without a hitch. Once in place vertically, it was bolted to the tower's pivot plate and the temporary wooden gin pole was removed.

Raising the Tower—The Trial Run

During a test tower-raising, the pulley system and lifting cables are being used for the very first time, without the turbine installed. This trial run also lets the crew clarify communication commands and directions, and is vital to ensure that there are no unforeseen problems with the tower and lifting assembly. Without this trial tower raising, if something goes wrong on the first lift, the wind turbine could be destroyed. It's very important to carefully adjust the tower rigging before mounting the turbine. When being raised for the first time, the guy wires need to be a little loose so the tower will raise without being bent.

This 84-foot (26 m) tower has four levels of guy wires anchored in four directions with sixteen turnbuckles. Using the backhoe to pull on the lifting cable, the gin pole lowered as the pivot plate rotated, and the tower went up effortlessly. This practice run provided the perfect opportunity to plumb the tower to vertical and adjust all the guy wires to their proper tension before adding the additional weight of the wind turbine. The tower lowered as easily as it went up.

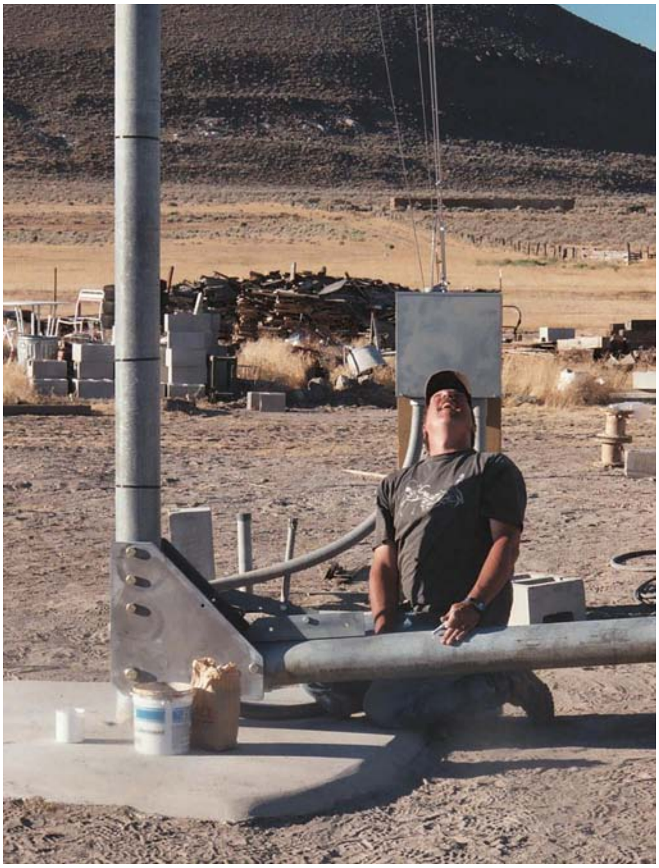
Why a Proven?

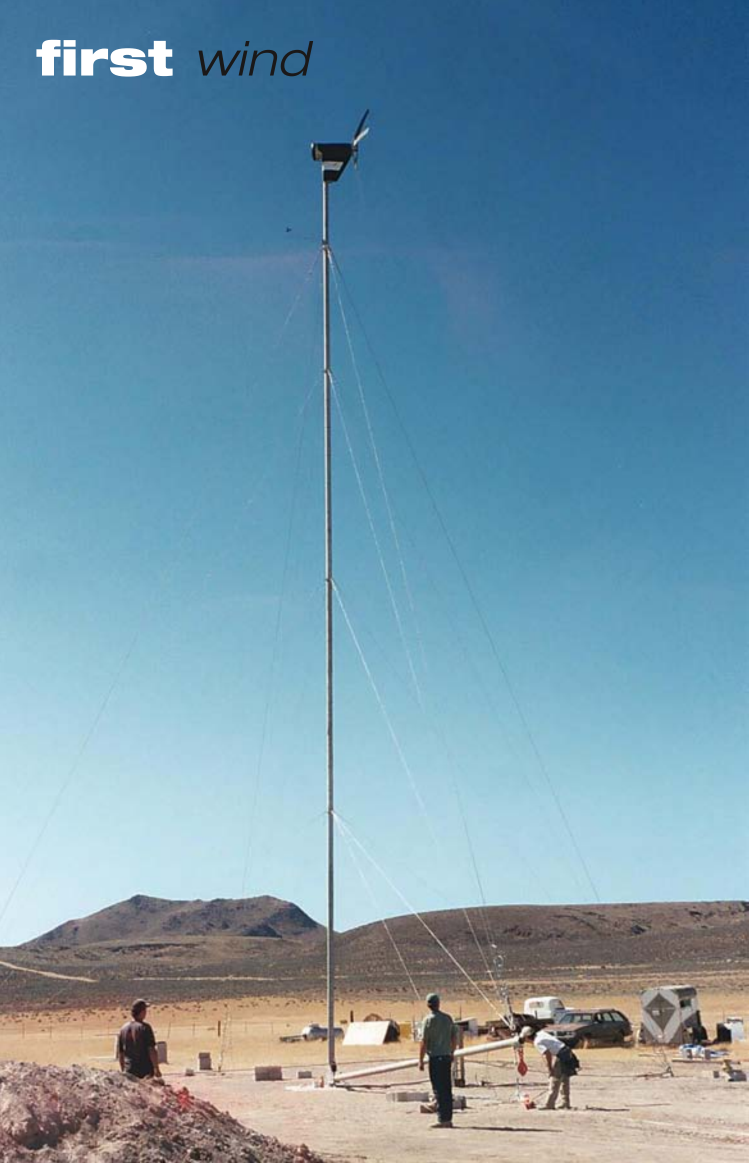
Proven turbines are manufactured in Scotland and known for their industrial strength durability. (They are named after the company owner, Gordon Proven, whose name is pronounced as in "pro.") Provens are considered "heavy metal" small wind turbines. Their heavy weight and low rpm leads to a long service life. The turbine's inherently simple design has few moving parts, and the downwind design means that no tail is needed. The oversized, greasable bearings make maintenance easy.

Thomas System Costs

Item	Cost (US$)
Proven WT2500 wind genny, controller, & tower mount	$9,540
Labor, design, & consultation	6,400
OutBack power system, incl. inverters, transformer, & AC & DC breakers	6,050
Lake Michigan Wind & Sun tower kit & pipe	5,890
16 Surrette S-530 batteries with cables, trays	3,950
Shipping	2,785
Tower engineering	2,500
Tax	2,146
Misc. electrical	1,950
Concrete & rebar	1,400
NRG Wind Explorer wind monitoring system	1,010
Total	$43,621

Grinning from ear to ear, Paul releases the brake and the Proven spins out its first amps.





Success—the Proven WT2500 up and running on the 84-foot tilt-up tower.

The variable pitching blades also prevent the turbine from overspeeding, even when the load is disconnected.

Paul's Proven ECM 2502, 48 V, wind turbine controller has three AC diversion load relays. This controller has four different battery charging modes, including full charge, sequential dump load operation, trickle charge, and complete disconnect. Light emitting diode (LED) indicator lights, a voltmeter, an ammeter, a three-phase rectifier, and a circuit breaker round out the controller's electronics.

Mounting the Turbine

The Proven comes with a mounting shaft, the link between the tower and the turbine. After connecting the three-phase output wiring in the mounting shaft to the wiring in the tower, the mounting shaft was securely bolted into place. The wind turbine head weighs in at more than 440 pounds (200 kg), so the turbine was gently strapped under the tractor bucket. It slipped right onto the mounting shaft.

The bearings inside the turbine were greased, the slip rings and brushes were mounted, and the three-phase wiring in the mounting shaft was connected to the slip rings. The turbine blades and spring sets were attached, the brake cable was secured, and the cover was fastened on. In an hour, the turbine was ready to go! All that remained was lifting the tower and letting her fly!

Saving with Renewable Energy

Several months have passed since Paul Thomas' Proven began flying. Even though last winter was below normal for wind, the family is offsetting their electric bill by as much as 50 percent.

When asked how he feels about actualizing a long-range goal, Paul replied, "It's exciting." Even though he saw the cost per kilowatt-hour of utility electricity double during

Three downwind blades are hinged at the base, allowing them to flex in relationship to the wind speed. The large diameter, direct drive, three-phase AC, permanent-magnet alternator enables full production at a low rpm. The lower the rpm, the longer the turbine will last and the quieter it will be.

With a Proven, the output does not drop off in high winds as it does with many wind generators. As the wind speed increases, the hinged blades cone back, away from the force of the wind, reducing the swept area. The variably pitching blades then spill more wind. This also helps keep the rotor speed constant in high winds. The Proven is warranted to withstand 145 mph (65 m/s) winds, the highest warranted wind speed in the industry.

Paul and Carrie Thomas (far right), with their girls, Katelyn, Breanna, and Heather.

the summer of 2002, he continues, "I'm not doing it for the economic payback. I'm doing this because I want renewable energy to be a part of my life."

Access

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NRG Systems Inc., PO Box 509, Hinesburg, VT 05461 • 802-482-2255 • Fax: 802-482-2272 • info@nrgsystems.com • www.nrgsystems.com • Wind monitoring system

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"Apples & Oranges," wind generator comparison article by Mick Sagrillo, *HP90*

"Telecommunication Interference from Home Wind Systems" by Mick Sagrillo • www.awea.org/faq/sagrillo/ms_telint_0304.html

What the Heck?, "Gin Pole," by Ian Woofenden, *HP99*

"Fishy Business in the Falklands," early Proven wind system article by Clive Wilkinson, *HP55*.

Washing Machine Spin-Off

Maytag Neptune vs. Frigidaire Gallery vs. Thrift Store Model

Linda Pinkham, with Joe Schwartz

Application: Maytag's Neptune washing machine (model MAH6500A) is an Energy Star clothes washer that I purchased in December for our home. With gardening chores, farm animals, and three large German shepherds soiling our clothing with big muddy paws, laundry in our household is a challenge. Our friend Anna had recently purchased a Frigidaire Gallery (model FWT645RH) washing machine, also an Energy Star appliance. Anna is an architect who lives with one dog on a more civilized piece of property. Her laundry needs are more moderate.

System: Energy use and peak power were tested with a Brand Electronics digital power meter (model 20-1850). Water use and water extraction efficiency were measured and calculated by weighing loads of wash and buckets of used water with a Taylor Lithium digital bathroom scale. The same 13-pound (5.9 kg) load of mixed laundry was washed in the front-loading Maytag Neptune, the comparable Frigidaire Gallery front-loader, and an older, Maytag, top-loading machine similar to the one I replaced with the Neptune.

Linda's new Maytag Neptune is Energy Star-rated for electrical efficiency and low water use.

My ancient Maytag washer decided it was time to quit after 25 years of hard service. With the recent installation of our grid-tied photovoltaic (PV) system and our increased awareness of energy use, it was a golden opportunity to replace that appliance with an Energy Star machine.

In my household, Maytag appliances have had a stellar reputation for dependability. In addition to lower electrical usage of the washing machine itself, other advertised features that influenced my purchase decision were lower water use and the machine's Max Extract spin cycles, which the salesperson said would reduce dryer times to about 20 minutes. Since we have both a well and a septic tank, reducing the amount of water needed for clothes washing would reduce use of the water supply pump and relieve our septic tank. Decreasing time for the electric dryer (equipped with a moisture sensor) would offer substantial savings.

Setup & Use

Installation of the Neptune was easy, since the purchase price included free delivery and setup, and removal of the old machine for recycling. The delivery folks hooked up the hoses, turned on the water, and checked that the hot and cold water were connected correctly. They leveled the feet, plugged the machine in, and made sure that it operated smoothly through all of its cycles. The whole process took less than 30 minutes.

Using the machine is very easy, with its clearly labeled and intuitive electronic touchpad controls. It has features and options galore, beyond my imagination of what was possible in the realm of laundry in the modern age. It makes my old machine seem more closely related to my grandmother's wringer washer from my childhood years.

The Neptune has fourteen cycles and options to choose from, including extra rinse, presoak, stain cycle, and delayed wash. Tumbling actions (there's no agitator and subsequently no transmission) range from heavy soil to hand wash. Wash and rinse temperature settings are manual, with an option to use the internal temperature boost to heat water to either the desired warm or hot setting if the household hot water is depleted, or to increase cold water temperature to 65°F (18°C), the temperature required to activate many detergents.

Anna's Frigidaire Gallery used less electricity, but more water than the Neptune. It also has no phantom load when turned off.

At the beginning of the wash load, you put detergent, bleach, and fabric softener into the dispensers in the top of the machine. They are automatically dispensed at the appropriate time in the cycle. In the pre-Neptune era, I did all of these things manually, and they required an acute sense of timing and diligent attention. Since I am not by any means a domestic diva, our laundry results were barely adequate in the past.

One of the biggest bonuses with the new machine is how quiet it is. With the door to the laundry room closed, the only time I can hear it is when it reaches the maximum 1,000 rpm of its spin cycle. As much as showroom comparisons could reveal, I favored the Maytag Neptune over similar products because of its large door opening and its somewhat larger capacity to handle blankets and sleeping bags—a task formerly relegated to an afternoon at the launderette.

Washing Machine Comparison

Model	KWH Used	Total Wash Time (Hrs.)	Peak Watts	Water Used (Gals.)	H_2O left in Laundry (Qts.)	Cost (US$)
Maytag Neptune MAH6500A	0.175	1.2	689	28.9	2.5	$1,000
Frigidaire FWT645RH	0.155	1.0	722	34.8	2.0	650
Maytag LAT8200A (used)	0.172	0.5	775	33.8	3.3	200

The Dirty Laundry on Washing Machines

With all the conveniences of the Neptune, I had to wonder what the sacrifices would be in terms of efficiency. So *Home Power* tech editor Joe Schwartz and I gathered up some of his laundry and used it to test three washing machines. He got the world's cleanest load of laundry, and the tests revealed some surprises.

Features

Maytag Neptune

High Points:

- Energy Star rated
- Superior water conservation
- Easy to use
- Lots of extra wash cycle options for cleaner results
- Good water extraction
- Larger capacity for fewer loads and ability to wash bulky items
- Heavy-duty construction
- Reversible door swing and larger door opening

Low Points:

- Slightly higher energy use per load
- Machine "walks" a little for some spin cycles with bulky items

List Price: US$1,000

Warranty: 1 year, all parts and labor; 2 years, all parts; 5 years, electronics; 10 years, drive motor

Frigidaire Gallery

High Points:

- Energy Star rated
- Easy to use
- Lower energy use
- Superior water extraction

Low Points:

- Higher water use
- Slightly smaller capacity

List Price: US$650

Warranty: 1 year, all parts and labor; 2 years limited, motor, drive pulley, and motor controller

The Maytag Neptune's digital display offers a dizzying array of custom settings.

We found an older Maytag top-loader (purchased at a thrift store)—just like the one that I had replaced—at our publisher's town digs. This was the perfect situation to quantify how the Neptune had improved my home's efficiency and energy use in the laundry appliance category. We tested the thrift store Maytag first, because of all the washing machines to be tested, it had the smallest capacity.

We filled this machine to the brim with 13 pounds (6 kg) of assorted tech editor apparel—everything from blue jeans and socks to a fleece jacket. The machine was set for regular wash, cold wash and rinse, the highest of the two water level settings, and the maximum wash time of 12 minutes. In a whirlwind 30 minutes, the machine was done, but as we pulled the clothing out, we saw that one pant leg wasn't even wet. The test results for water and energy use can be seen in the table.

Next, we brought the laundry load to my house and fit it into the Neptune—with room to spare. We set the machine for cold water wash and rinse, disabled the temperature booster, chose the heavy-soil setting (which adds an extra rinse), and selected the Max Extract faster spin option. The Neptune also has a longer spin option to avoid wrinkles, but for Joe's work clothing, that would be overkill. A little more than an hour later, it had emptied the last of its grey-tinged water and was sporting some fairly clear rinse water in the last round. Plenty of dirt had been left from the first washing in the thrift store Maytag.

While the Neptune was certainly excellent at using less water, it didn't use less electricity than its predecessor. Of course, it worked longer at washing, and certainly did a better job. It did a reasonably good job at extracting water, outperforming the older machine by 3 cups (0.8 l) of water.

The good news is that someone at Maytag listened about the 10-watt phantom load problem that was reported by Tom Markman in *HP92*. These days, the phantom load is 3 watts when all of the display LEDs are lit up. Ten minutes after the cycle is complete, the display goes off and the phantom load reduces to 2 watts. Our next request for Maytag is to eliminate the phantom load altogether.

Then we decided it would be fun to compare the Neptune to another Energy Star front-loader, the Frigidaire Gallery. The Frigidaire has comparable features and conveniences, but a slightly smaller capacity (3.1 ft^3 rather than 3.4 ft^3). Joe and Anna washed the same laundry load one more time at her house.

They set the machine for comparable settings, choosing cold water temperatures, regular cycle and heavy soil, and an extra fast final spin (1,050 rpm). The Gallery has dials for its settings, and is a little less high-tech looking. But both machines use intelligent water optimization features, selecting the amount of water to use based on each laundry load's characteristics.

The Gallery outperformed the Neptune in energy use and water extraction, and was a little faster at completing the task, but used more water than either of the other machines. The additional 50 rpm in the water extraction phase of the Gallery appears to be effective, trumping the Neptune by extracting 2 more cups of water than it, and a sopping 5 more cups than the older Maytag. Another plus is that the Gallery does not have a phantom load. At this point, the load of wash was pristine, so it was hard to say which machine had done a better cleaning job. But all told, there was relatively little difference in performance between the two modern machines.

It's a Wash

As with any test results, many factors are difficult to quantify, and setting up fair conditions between dissimilar pieces of equipment is a challenge. Our test was neither complete in its scope, nor highly scientific. But we wanted to measure some specific data, such as total KWHs used, peak watts, phantom load, and water use and extraction. *Consumer Reports* in its June '04 issue reviews the latest models with a more exacting standard of tests, but unfortunately they do not provide any specific numbers, which were what we wanted to see. However, their conclusions appear to be in line with ours, whereas both of our conclusions differ somewhat from the Energy Star ratings of the Environmental Protection Agency (EPA). The EPA places the Neptune higher than the Frigidaire Gallery for water extraction. But with a different load of laundry, our results would change, so it's hard to point to specific numbers in such a small sample as being conclusive.

While both modern machines have stainless steel tubs that carry a lifetime warranty, the Neptune has a more robust construction, with a porcelain-enameled titanium top that will retain a better appearance, longer. It also carries a longer warranty on its electronics and motor. But it definitely cost a lot more.

Linda multitasks—energy-efficient washer testing and domestic chores.

Tech Specs

Maytag Neptune

Wash Cycles: 14

Capacity: 3.4 cubic feet (0.096 m^3)

Dimensions: 42 1/2 H x 27 W x 28 1/4 D inches (108 x 69 x 72 cm)

Motor Speeds: Infinite (self-selecting)

Spin Speed: 1,000 rpm

EPA Energy Use Estimate: 273 KWH per year

EPA Modified Energy Factor (MEF*): 1.75

Frigidaire Gallery

Wash Cycles: 5

Capacity: 3.1 cubic feet (0.088 m^3)

Dimensions: 36 H x 26 3/4 W x 27 1/4 D inches (91 x 68 x 69 cm)

Motor Speeds: 2 wash and 5 spin (3 selectable)

Spin Speed: 1,050 rpm

EPA Energy Use Estimate: 246 KWH per year

EPA Modified Energy Factor (MEF*): 1.68

*A measure of efficiency that combines tub capacity, energy use, and the amount of dryer energy required to remove remaining moisture content. The higher the MEF, the more efficient the washer.

Because of the heavy-duty laundry needs in my household and my general complacency about doing laundry, I think the Neptune was the right choice for us. At the same time, Anna's choice of the Gallery seems appropriate for her lighter-duty needs. Spending a thousand dollars on a washing machine may not be the wisest thing savvy off-gridders who have small wash loads, use cold water, and dry on a clothesline could do with their money. For the busy urbanite, any Energy Star washing machine is a good bet.

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Energy Star ratings for washing machines and other appliances, and how they are rated • www.energystar.gov/index.cfm?c=clotheswash.pr_clothes_washers

American Council for an Energy Efficient Economy • www.aceee.org • Comparisons of Energy Star-rated washing machines and other appliances

The Winner Is...

Solar Energy Runs Our Chili Booth

Tom Burbridge

Cooking competitively in a remote location requires some degree of skill, the selection of quality ingredients, and if you're lucky, the availability of electricity. "Team Taste the Heat," consisting of my father-in-law Tom Ouellette and me, had decided to test our cooking skills with our own sauce and seasoning recipes. Chili and barbeque competitions in the Texas cook-off circuit sounded like the best venue for us, but we soon learned that electricity would be scarce if nonexistent.

After reviewing some footage from a national cooking channel, we noticed that nearly all the cooking teams used a gas generator. Although a gas generator resolves the remote electricity issue, we realized that using such a beast would be too expensive for what we needed, require an extra fuel source, produce exhaust gases and noise, and demand a high degree of maintenance due to all the dirt and grime it would collect from being run in an open field. We decided that a portable, self-contained, renewable energy system would be the best solution for our needs.

Renewable energy (RE) is not a new concept for me. I have been an avid reader of *Home Power* magazine since 1992, and I have tinkered and played around with various projects for many years. In all the projects that have succeeded, I have applied six basic rules.

Rule #1: Correct Your Thinking

RE is not a hippie-driven concept, but a cost-effective way to provide a valuable resource for everyday life. Do

Remote Event Pro Tips

- The solar window can be very limited, based on booth location, trees, etc.
- Don't count on it being sunny all weekend, because it often won't be. Size the battery bank to ensure enough energy for the event even if there is virtually no sun.
- A simple battery/inverter system is often a good, and less expensive choice. Batteries can be charged beforehand from the grid, or better yet, from an RE system.
- Always have at least an inexpensive analog voltmeter to keep track of battery state of charge.
- Don't undersize the system since it will be in the public eye. Events are a great way to publicize the use of PV, but a system that doesn't work attracts more attention than one that does.

Solar electricity works long after the gas generator fails.

not let the naysayers convince you otherwise until you have experienced RE firsthand. Whether I am cooking brisket at a remote location or at home during a power outage, our system pays for itself in full.

If you're the type of person who needs a financial justification to cross over into renewable energy, you may never have it unless you correct your thinking. The bottom line is that taking that first step into renewable energy is cheaper than buying a new 30-inch TV. Our system uses off-the-shelf, everyday components and cost less than US$250 to build. It's easy to maintain and provides our cooking team with all the electricity needed for a successful competition.

Rule #2: Know What You Need

Having adequate lighting is one of the most important things needed at a cook-off. We generally set up our cooking area, light the fires, and start cooking in the (usually) quiet and dark hours before dawn. Using incandescent lights was out of the question since compact fluorescent (CF) bulbs use about a quarter of the energy for the same amount of light.

Taste the Heat Loads

Item	Watts	Hours	Watt-Hours
Blender	350	0.25	87.5
Meat grinder	250	0.25	62.5
Electric knife	100	0.25	25.0
2 CF lights	15	2.00	30.0
		Total	205.0

The trick for determining our remote electricity requirements was to list what appliances we needed. Our final list of essential appliances boiled down to those shown on the load table. Seldom are two AC-powered appliances run at the same time, nor are they run for longer than 15 minutes per day. Our kitchen uses 205 watt-hours per day, for a weekend total of 410 watt-hours.

Rule #3: Do the Math First

Our system uses four, 3.2-watt solar-electric panels; a garden-variety, 12-volt, 95-amp-hour battery; a 700-watt inverter; and a few other components. The battery, with a capacity of 1,140 watt-hours (volts x amp-hours), is large enough to not be overtaxed by our weekend loads. Under the ideal circumstances usually found here in Texas, the photovoltaic (PV) system is able to replenish the battery over the course of a week, allowing us to compete every weekend during the summer season. Our calculations showed that 12.8 W of PV times 8 peak sun hours (summer only), times 7 days charging, times 0.65 total system efficiency derate (for a battery-based system) equals 466 WH (assuming full sun all week).

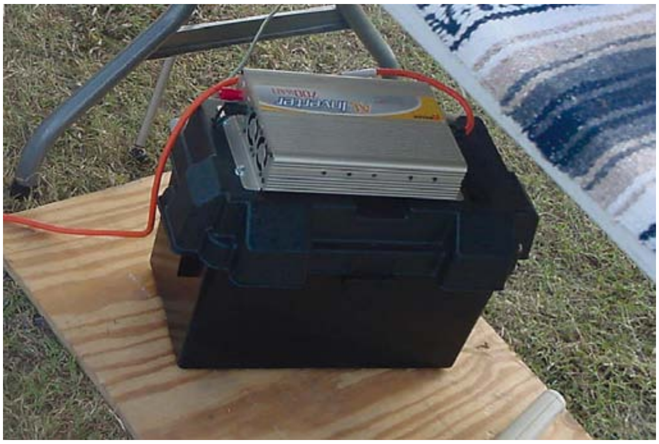
Rule #4: Use Only What You Need

Our PV system narrowly meets our 410 WH requirements. For those rare times when the weather does not cooperate, I put the battery on a trickle charger at home during the week to charge it up.

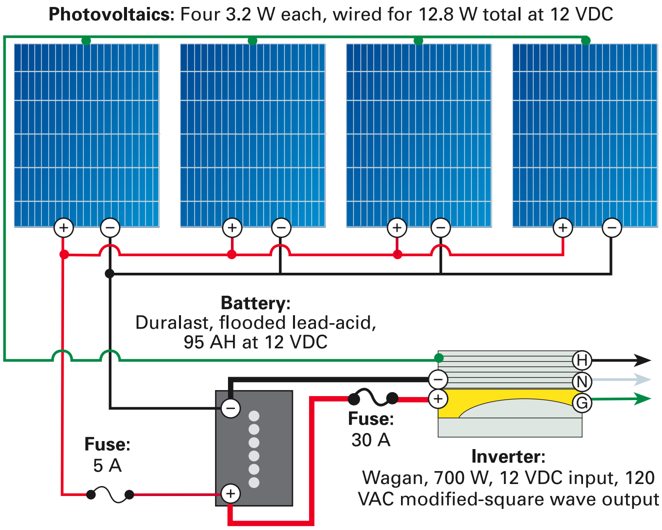
Many of you have probably noticed the lack of a charge controller in our system. Since the PV modules we presently have are essentially operating at the rate of a trickle charger, a charge controller is not entirely necessary in this system. If we ever want to have more equipment at our remote kitchen and decide to add some larger PV modules, we will definitely buy a charge controller.

Rule #5: Go Cheap without Sacrifice

With only my wife's hot sauce manufacturing business for financial support, we set a renewable energy budget of US$250 dollars and prayed for some bargains. After reading



The Taste the Heat solar-electric system in a box.



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

a few thousand stories in *HP*, I thought that I was asking the near impossible.

The battery for our AC loads is a marine deep-cycle battery that we bought on sale. It was originally purchased in case all the Y2K fear mongers were correct. After a checkup with a hydrometer and a trickle charge, it was ready to perform as intended. For our single DC load (the pump for the sink), we use a self-contained JumpStarter battery that I picked up at a discount store.

The Wagan 700 W modified-square-wave inverter for the main unit was found at an electronics store. I managed to get a better deal since the cables were missing.

Despite the falling prices of PVs, they are still expensive if bought new. Fortunately, Volkswagen ships select vehicles with a 3.2-watt solar-electric panel. These panels are not intended to fully charge a dead battery, but to maintain the battery while the vehicle is being transported. I found four of these PV panels on eBay. They will not recharge the battery in a day. But providing there's sunny weather, the panels generate enough energy during the week to recharge the battery for its weekend performance.

Rule #6: Let Your Work Brag for You

When I first introduced my remote RE system to the Texas cook-offs, the reactions from other cooking teams varied. Usually, the only reaction we hear is during early morning setup when the bright lights go on. It was during one of these cook-offs when the serenity of the early morning was shattered by the screeching chorus of multiple gas generators.

One by one, they were shut down as the local law enforcement officers began writing "disturbing the peace" tickets to the cooking teams running the smoking beasts. In the end, we were one of three cook-sites that still had electricity. The other two cooking teams had arrived on location early and quickly plugged into the grid, thus avoiding the US$200 fines.

Seeing Is Believing

When we first started using our modules at the cook-offs, we were met with a lot of skepticism on the practicality of our remote RE system. Several people stated that a generator was better suited for remote use. When I asked how much they paid for their gas-guzzling generators, they hesitated and said, "$2,500."

Another argument was that an RE system is fragile and if one component breaks, the whole system goes down. "That is quite true," I would reply, "But if any one component in *our* system breaks, I just make a visit to any automotive store and replace what broke.

The chili cook-off alley had a noise level of 97 decibels, as measured by the local police. Time to shut down some generators.

PV System Costs

Component	Cost (US$)
4 PVs, 3.2 W	$80
Wagan inverter, 700 W	65
JumpStarter battery	50
Duralast battery, 95 AH	45
Battery box	8
Total	$248

And since the *whole* system cost less than US$250, I will probably be up and running before a mechanic can look at and repair a generator."

Most of the cooking teams appreciated our approach to the cook-offs. A number of teams have asked me how they can build a similar system for their own use. I soon learned that many were having trouble with their gas generators, and wanted something that was more convenient, portable, and easy to maintain.

Winning Strategies

Oh yes, and the winner is...Team Taste the Heat. So far, we have won several awards, including: First Place Salsa, Second Place Brisket, Third Place Margarita, plus six top-ten awards in a variety of categories, three international awards for sauces and seasonings, and one regional award for hot sauce.

For those of you who want to start using RE, but do not wish to make a huge investment, take my advice. Start small and work up to your goal. Buying and using RE is simple, cheap, and pays for itself the moment you bring forth light when others have none.

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How to *Finance* Your Renewable Energy Home

Allan Sindelar & Phil Campbell-Graves

Financing renewable energy (RE) has been a barrier for as long as RE technology has existed. While a growing public awareness of RE systems is slowly and continually breaking down this barrier, obtaining mortgages for off-grid homes and RE systems continues to be difficult. The good news is that several national lenders have recently been granting loans with some caution. RE homes can be used to secure favorable loans, but certain tricks of the trade can facilitate the process.

Mortgages & RE Financing

Financing a home is different from financing a renewable energy system. The former is part of a mortgage, while the latter is an improvement to an existing home. Obtaining a loan to buy, build, or refinance an RE home is tricky, especially when the home is off-grid. A few lenders are willing to make these loans. These lenders are concerned with the ability and willingness of the borrower to repay the loan and with the quality of the collateral securing it.

Your loan officer is often the key to your success. Loan officers make the case for loans. Underwriters make the decision to accept loans. For loan officers and underwriters, comfort rests in sticking to the familiar. Off-grid homes are anything but familiar.

Loan guidelines also matter, particularly with off-grid homes. A loan officer's choice of loan programs can determine results. If a challenging submission does not fit the lender's guidelines, the loan will be rejected.

The process is simple in theory. Four loan elements drive decisions: income, debt, assets, and credit. With home mortgages, a fifth element, collateral, is important as a fallback position for the lender.

While "lack of utility services" may be the reason given for a rejected loan, the failure more often results from how well the loan elements come together. For that reason, planning the loan is as important as planning the power system.

For most of us, the long-term cost of buying a home is two to three times higher than the selling price because of interest. The four loan elements not only win loans, but also determine interest rates. Improving the way in which these

Off-Grid Financing Tips

Seven planning tips should improve your off-grid financing results.

Provide a list of recent sales of off-grid homes in your local area for the appraiser and your lender. Called comparables, these figures establish relative value and indicate to lenders that an off-grid home can be sold within a reasonable time. Without them, lenders will not approve a loan.

Stick to construction and designs common to your region. For example, in the Southwest, adobe and rammed earth are common. Elsewhere, they may limit market and lending opportunities.

Avoid manufactured homes. The mortgage industry has moved away from financing these structures. Remaining loans tend to be restrictive and costly, complicating off-grid financing.

Include a working backup power system. A fossil-fueled engine generator is the simplest option. Even if you will never need it, lenders likely will require some form of backup power.

Think energy efficient, not off-grid. The term "off-grid" is unfamiliar to people outside the renewable energy industry, and may have undesirable connotations.

Find a loan officer who understands off-grid technologies. Experience and knowledge can turn borderline loan situations into solid loan submissions.

Choose an appraiser who knows both the technology and your market. An experienced appraiser often can find comparables that support value. An experienced loan officer can help select the appraiser and guide the process.

elements come together is the planning goal. Let's take a closer look at the roles of income, debt, credit, collateral, and the importance of advance planning for loans on off-grid homes and RE systems.

Income & Debt

Lenders use tax returns to measure income, especially for self-employed individuals. The relationship between debt and income (debt ÷ income) is called a "debt ratio." Debt is the sum of all monthly payments for credit cards, installment contracts, and other debts, plus your proposed mortgage payment, property taxes, and insurance. Income is the number reported on a W-2 form, plus taxable income from business, investments, and similar sources.

Buying a home is rarely an impulse purchase. Plan for a debt ratio that falls below 45 percent, and if possible, below 35 percent. Above this level, lenders tend to place the loan in higher risk categories, meaning higher interest rates. Notice that the proposed mortgage payment varies with its interest rate, which affects debt ratio.

If you are self-employed, reduce your business expenses or delay business investment in the year or two leading up to a home purchase. For self-employed borrowers, lenders will ask for two years' tax returns plus the year-to-date profit and loss (P&L) statement for your business. Of these documents, your P&L statement and most recent tax return weigh most heavily in determining your income level. With good planning, you can save thousands of dollars on a home through lower interest rates.

Whether you are self-employed or not, you should try to reduce monthly debt. Depending on when you plan to buy, you may be able to improve your debt ratio and loan options. The goal is to bring your debt payments below 45 percent of your income; the lower the better. A dollar reduction in monthly debt is worth more than a dollar in improvement in monthly income. Although the net effect on pretax income is the same, the effect on debt ratio is noteworthy. For the example in the sidebar (above right), a US$100 reduction in monthly debt expense has the same effect on debt ratio as a US$222 increase in monthly income.

A Lesson in Better Planning

If you are self-employed, you may have flexibility that others lack. For example, the self-employed can control business expenses that affect taxable income and an important loan-related ratio.

Consider a self-employed borrower who implemented an advertising campaign the year before buying a home. Predictably, increased sales lagged behind ad spending, and the increased revenues from advertising did not occur during the tax year. The expense of the ad campaign reduced taxable income, saving the borrower some US$4,400 in income taxes that year. Unfortunately, the savings came at a cost.

The ad campaign not only reduced income, but it increased the borrower's debt ratio from 45 to 56 percent and resulted in a 2 percent increase in the loan's interest rate. For a twenty-year loan on US$234,000, the higher interest rate increased the loan payments by US$31,519 over the next decade and US$63,038 over the term of the loan. By planning the home purchase more carefully, this borrower could have delayed commencing the advertising program for a few months and saved a great deal of money.

Assets

The term "liquid assets" means the money quickly available to meet your emergencies, obligations, and down payment. Liquid assets include bank accounts, stocks and bonds, mutual and money market funds, and a portion of retirement funds (401Ks, IRAs, etc.). While assets also include real estate and improvements, liquid assets weigh more heavily in loan decisions.

Success Story #1

Michelle Hermann helped her appraiser find comparables for her new "energy efficient" adobe home inside the city limits of Santa Fe, New Mexico. The house has a photovoltaic (PV) system (battery-based with grid backup), solar hot water, passive solar space heating, solar in-floor radiant heating with woodstove backup, rainwater catchment, and other progressive features. Her willingness to assist her appraiser helped obtain a larger mortgage that covered the cost of the RE elements.

Lenders sometimes require "reserves"—liquid assets that exceed the amount of a number of mortgage payments required to purchase your home. Reserve requirements often are expressed in months, with one month of reserves equaling your monthly mortgage payment (with property taxes and insurance) and all monthly debt payments. Having assets in reserve may turn a marginal application into a viable loan. As part of your advance planning, maximize your assets by turning unwanted items of value into cash. A good number to shoot for is six to eight months of reserves.

Credit Scores

Credit scores are a pivotal element of a loan application. A credit score, sometimes called a FICO (acronym for the Fair Isaac Corporation credit scoring model), is a measure of how well a borrower manages money. All three national credit bureaus use FICO systems. In the finance game, FICO is the score, so the rules are worth learning.

FICO credit scores range from about 300 to 850. Higher scores indicate lower loan risks. They define thresholds to favored lenders, loan programs, and interest rates. Lenders generally believe that someone with a high credit score can manage money, requiring less lender oversight of the borrower's financial affairs. A high score will do much to compensate for a perceived weakness elsewhere in your application.

A higher credit score enjoys far more borrowing power. A score of less than 620, for example, falls below typical minimum limits to qualify for a loan with the best interest rate. It may attract a loan that is 2 percent higher than for someone with a score above 720. This means that over time, a person with the lower credit score will pay 30 percent more for the same house. It also means that someone with the higher score can buy a home that is valued 30 percent higher for the same monthly mortgage payment. And that's not the only benefit.

Improving FICO Scores

In most cases, a FICO score may be easily improved. Here are tips on how to improve your credit score.

Keep credit card balances below 50 percent of your credit limit. If you can't pay down your credit cards, spread out credit card debt between several cards, rather than maxing out one card.

Pay your rent or mortgage on time. This is your single most important payment. One late payment can disqualify a borrower from better loan programs.

Pay your current credit cards on time. Credit scores weigh current history more heavily than past problems.

Pay off problem accounts. Paid collection accounts score higher than unpaid ones.

Challenge credit problems that are not yours. Credit bureau mistakes are common.

When you apply for a loan, you want the highest possible FICO score. For this reason, pull your scored credit report from all three credit bureaus. Use this report to identify and correct mistakes that adversely affect your FICO score and to restructure debt to create a higher score. Some credit bureaus have FICO simulators to test restructuring ideas.

For a fee, you can order and view online a single report for all three bureaus (called a "tri-merge") from any of the three credit bureaus. Go to www.myfico.com, www.equifax.com, www.experian.com, or www.transunion.com for details.

Success Story #2

Albert and Susan Robinson of Santa Fe, New Mexico, are Quakers and peace activists. They wanted their home to reflect their values in action. They used equity from a larger former home to pay for their modest new home. But they needed to finance their RE systems. Their home equity secured a loan to purchase a US$19,000 grid-tied PV system and single-panel solar hot water system. The Permaculture Credit Union in Santa Fe gave them a 0.75 percent interest rate discount for an RE-related loan.

Success Story #3

John McAndrew found a simple way to finance his 980-watt PV system near Santa Fe, New Mexico. He took part of his retirement savings out of the stock market and put it into the Permaculture Credit Union (PCU) as a certificate of deposit (CD). He then took out a share-secured loan at an interest rate of 3 percent more than what he was being paid by the PCU for his CD, and used the loan to buy his PV system.

"By putting some of my retirement savings in the PCU," John says, "I was able to support the credit union, put PV on my home, and finance my system at a low rate, all while making my investments more socially responsible. This arrangement let me put the PV system to work now, rather than waiting for years until I had saved the money for it."

With a higher credit score, you also may be able to simply declare your income, without having to produce a P&L and tax return. Stated-income programs are available only to borrowers with FICO scores around 720 and above, and some programs are restricted to self-employed individuals.

Lenders also may relax debt ratio requirements for individuals with higher credit scores. Someone with a 620 FICO may be required to have a debt ratio below 45 percent; above 720, the same lender may allow a 50 to 55 percent debt ratio.

You can easily improve your credit score in the months leading up to your home purchase. We have seen 80-point jumps in credit scores through debt restructuring. The FICO sidebar offers tips on how to do this. The results are worth the effort.

The goal with credit scores is to increase them—the higher the better. Several important thresholds define loan program options. A FICO above 720 places borrowers into the best loan programs. Above 620 usually qualifies borrowers for conforming loans—loans that meet mortgage industry standards and have lower interest rates, lower costs, and other favorable terms. Below around 620 usually places borrowers into sub-prime loans or restricts borrowers to certain government-guaranteed loan programs.

The Fifth Element–Collateral

Collateral allows borrowers to reduce loan risks for lenders, and this often results in lowering interest and other loan costs. A home is the collateral for a mortgage loan. Similarly, borrowers can secure loans with liquid assets,

Success Story #4

Coauthor Allan Sindelar's off-grid home near Sante Fe, New Mexico, was refinanced last year at a low interest rate for a 15-year term, instead of the original 30-year term. This will allow him to pay off the home in half the time with nearly the same mortgage payment.

Northern New Mexico has an established history of off-grid homes and innovative building techniques in the high desert and mountains, so comparables are relatively easy to find when seeking financing. In other areas, "lack of comparables" may be the single toughest barrier to obtaining a loan. Sometimes an experienced loan officer from another part of the country can succeed where a local lender can't.

Financing RE Improvements

Financing needs differ when you are installing an RE system enhancement to an existing home, such as for a grid-intertied PV system. System installations often are financed through signature loans and secured lines of credit, with the latter usually giving a lower interest rate.

The two most common choices of secured loans are to use the equity value in a home (a HELOC, or home equity line of credit) or to use liquid assets, such as a certificate of deposit. Of these choices, the use of liquid assets usually has lower loan costs and low, fixed-interest rates. In comparison, a HELOC may have closing costs (fees associated with the loan) and often has variable-rate features.

With a good credit score and good security, a loan for an RE system is not very different from a loan for any other purpose—it doesn't matter to the lender what the money is used for. While many lenders will finance RE projects, one national lender actively seeks to finance RE projects for individuals—the Permaculture Credit Union (PCU).

The PCU is a member-owned, not-for-profit financial institution that finances sustainable, environmentally responsible projects. Membership is open to people who have completed a Permaculture Institute-recognized design course, are members of an affiliated regional permaculture institute, or subscribe to permaculture ethics. Some day we may see RE equipment manufacturers, distributors, and dealers routinely offering financing programs.

such as a certificate of deposit. Collateral in the form of a home is a bit trickier to manage.

Even if you plan well for a new, off-grid home purchase and have maximized your borrowing power by reducing debt ratio, increasing reserves, and obtaining a high 700s credit score, you may still receive a rejection letter. While the reason likely to be given will be "lack of utility services," a more experienced loan officer may have better results. By repackaging the loan, the loan officer can receive a prequalifying approval to use the same home as collateral for a loan from the exact same lender that rejected the first loan submission. Baffling? Not really.

While a prequalifying approval is not a loan, it is an agreement that the lender will consider a loan using the off-grid home as collateral. The loan elements and collateral still must otherwise meet lender guidelines. Lenders often misunderstand the qualities of an off-grid home, a distinction credited for turning many loan submissions into loan rejections. To a lender, collateral is worst-case planning. Lenders do not want a piece of collateral that can't be resold if the borrower defaults on the loan. All too often, "off-grid" suggests sales problems.

Although some off-grid designs and funky systems may hinder sales, this is usually not the case. Recognizing this distinction, a good loan officer's submission will avoid describing anything as off-grid, preferring instead to explain energy efficiencies: "The home is so energy efficient that it does not need to be attached to the grid." Instead of being a sales problem, the home's design becomes a potential sales benefit.

Fair Market Value

If a lender agrees to use an off-grid home as collateral for a loan, the lender will try to determine its fair market value. This is where "comparables" and "appraisals" enter the picture.

Comparables are sales of homes of similar size, structure, and location that serve as the basis for determining the value of a home for lending purposes. A grid-tied home is comparable to most homes of the same structure and location. An off-grid home is comparable only to other off-grid homes. Comparables give lenders a basis for measuring a home's marketability and value, and are an integral part of a home's appraisal. Lack of comparables can make financing an off-grid home difficult.

Unfortunately, appraisals often fail to reflect the costs of energy efficiency and renewable energy upgrades. The reason is that many appraisers lack the experience and skills to evaluate these improvements.

An appraiser is a certified professional who determines the market value of a property. Appraisers usually follow statistical guidelines like those found in the *Marshall & Swift Residential Cost Handbook*. Energy-efficiency improvements fail to gain statistical significance in many markets, leaving appraisers to their own resources to find acceptable adjustments. An appraiser may use several methods to determine value. A market assessment, based on comparables, may fail to adequately reflect the value of improvements. A cost approach that includes the depreciated value of improvements may be discarded by a lender.

Here again, loan officer experience pays. The term "energy efficient" has specific meaning within the mortgage industry. Few loan officers, appraisers, and underwriters have experience with energy-efficient and off-grid homes. For that reason, an experienced loan officer plays a heightened role in attracting favorable financing for RE, and especially off-grid homes.

Choices made early in the planning process may improve or limit RE financing options. The tips in the "Off-Grid Financing Tips" sidebar (on page 94) discuss areas that you will want to address if selecting an off-grid home. In all cases, an experienced loan officer will know how to present unconventional situations in the best possible way.

A home may be the single largest investment that you will make. It builds wealth, locks in a reasonably predictable housing expense, and can reduce living expenses in retirement years. A great deal of thought and effort goes into selecting and buying a home, off-grid or otherwise. Increasingly, lenders are willing to recognize the value of RE improvements and to consider loan applications using off-grid homes as collateral. Early planning will help you pull the pieces together for the greatest chance of obtaining favorable financing.

This introductory article (adapted from a consumer guide by coauthor Phil Campbell-Graves) has focused on how to create loan packages and attract more favorable financing for RE homes and systems. A subsequent article is planned to address where to get financing, and identifying programs and lenders that are likely to provide the most favorable loans for RE homes. The authors welcome stories of successes and failures, and unusual financing methods and resources for possible inclusion in a future *Home Power* article.

Access

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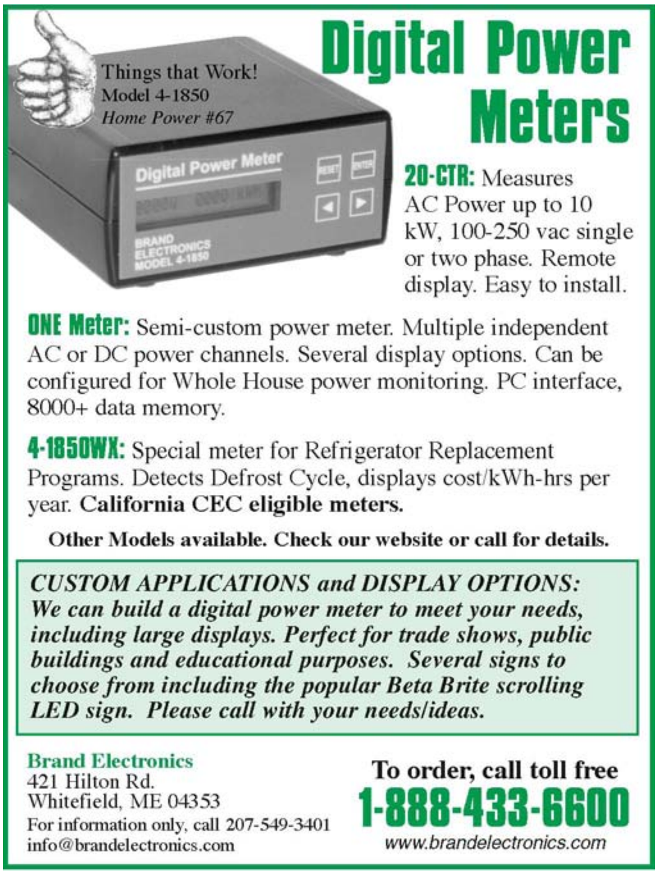
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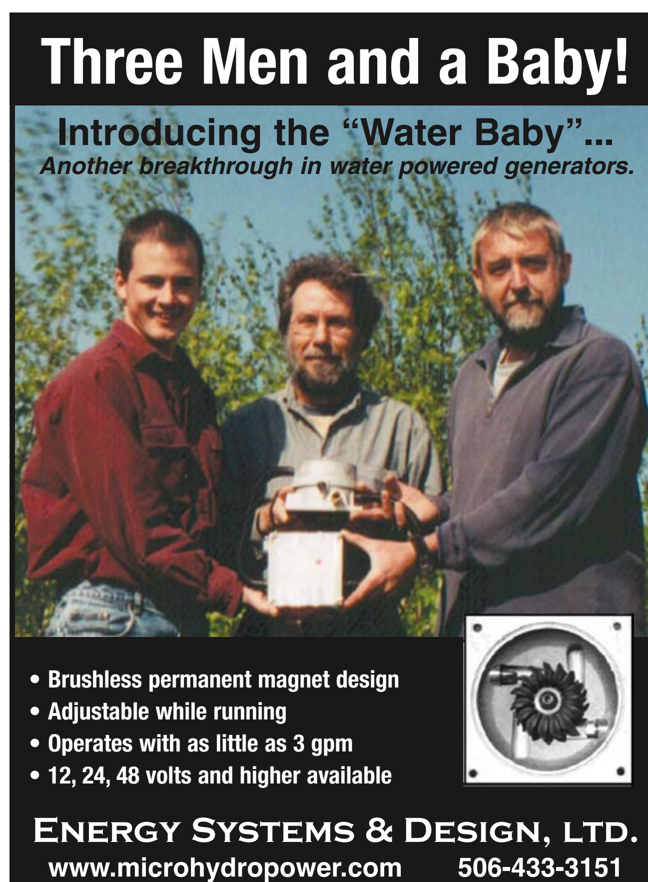
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PV & EV

Photovoltaics & Electric Vehicles

Mike Brown & Shari Prange

An electric "Voltsrabbit" in front of the 3 KW solar-electric array needed to provide it with a 25-mile average daily range.

When the inspiration to build an electric car conversion strikes, it is often followed by a second inspiration—to charge the car with solar-electric panels (PVs) on the vehicle's roof. Solar energy and electric cars are made for each other—right? Well, yes and no.

Capacity

It's not effective to mount PVs directly on an electric vehicle, for a couple of reasons. First, you simply can't get enough PV capacity on the roof of your vehicle to provide a significant amount of charge. Let's look at some numbers to see why this is true.

A typical conversion uses about 0.4 KWH (400 watt-hours) of electricity per mile (250 WH per km). If you only drive 25 miles (40 km) a day, that's 10 KWH. Your PVs won't put out their full rated capacity sunup to sundown. Realistically, you will have maybe four to five hours of prime sun striking the panels each day (referred to as average daily peak sun hours). With five sun hours, you'd theoretically need 2 KW of PV output to cover your 25-mile day.

Taking into account decreased PV output at high temperatures and efficiency losses throughout the system, roughly speaking, you would actually need an array rated for 3 KW. That would be twenty panels rated at 150 W each. At about 270 square feet (25 m^2), even a Hummer doesn't have enough roof for that! (And a Hummer would take more than 0.4 KWH per mile, too.)

Another way to think about it is to look at a cross-country solar race car. These vehicles are essentially big rolling solar-electric arrays. They maximize their flat surface area, and cover every inch of it with solar cells—often very expensive satellite-grade cells. And for all of that, on a sunny day at noon, the car's array produces maybe 1 KW, which is just enough to power a flyweight car of a few hundred pounds.

Battery Health

Another problem with roof panel charging is the batteries. Vehicle-mounted PVs will not necessarily get full sun for enough hours each day to give your batteries a proper, full charge. Siting, orientation, and the variable nature of sunshine will all be problems.

Each type of battery needs a specific charging profile for good health. To get this, the pack should be brought to full charge using a charger that is programmed with the appropriate charging profile. If a pack doesn't get this full, proper charge often enough, the batteries will get out of balance with each other. This means that some will be a little more "full" than others. Prolonged operation with an unbalanced pack will shorten battery life, and may cause some battery failures. Equalizing charges will resolve this problem, but PV arrays are often too small to effectively equalize a typical battery bank.

Solar EVs

That's the bad news. The good news is that solar energy still has a place for use with electric cars. A large, stationary solar-electric array installed on your house or garage can be used to either completely or partially charge your EV. So you can provide some or all of the energy needed to run your EV with PV. You just need to do it at home, not on the road. (See the article by Ed Witkin on page 30 of this issue.)

Small solar-electric panels can have other uses on an EV. You can use them to operate accessories, or to power a small fan to keep the interior cooler when the vehicle is parked.

So don't let reality dampen your inspiration. Go ahead and build your electric conversion. Then install a PV array at your home. A journey of a thousand miles begins with the single step.

Access

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See "Solar Trailblazer: PV Charges EV in Palo Alto, California," by Will Beckett in *HP78*

What the Heck? 15

Combiner Box

The OutBack Power Systems PSPV combiner box (shown with its cover removed) can support as many as twelve series strings of PV modules and can feed up to two charge controllers.

Used In: Solar-electric/photovoltaic (PV) systems

AKA: Junction box, terminal box

What It Is: A weatherproof enclosure with wiring bus bars and breakers or fuses used for combining multiple PV inputs.

What It Ain't: A tool box that's been flipped upside down, your kitchen junk drawer, or the bed of my pickup truck

In many PV systems, a combiner box is required to bring together the outputs of multiple series strings of PVs, and to provide overcurrent protection for each series string in the array. Inside the combiner box, positive and negative bus bars are used to parallel the output of these individual series strings. These boxes also allow you to transition to the larger wires between the PV array and the batteries or inverter to minimize transmission voltage drop.

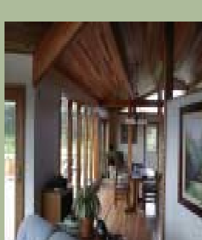
In almost all applications, the *National Electrical Code (NEC)* requires a breaker or fuse in the positive lead of each series string of PV modules for overcurrent protection. Series fusing prevents the possibility of individual series strings of PVs backfeeding another paralleled series string that develops an electrical short circuit.

These DC-rated breakers and fuses are typically rated at 5 to 20 amps, depending on the type of modules you're using. PV manufacturers provide a specific series fuse amperage rating for each of their PV models. The series fuse information is typically printed on the label on the back of the module.

Using a combiner box results in a code-compliant and organized PV wiring network that is easy to troubleshoot and maintain, and provides the required series fusing.

Joe Schwartz • joe.schwartz@homepower.com

2004 Oregon Tour of Green and Solar Homes



Portland Tour:	September 18th in conjunction with the Build It Green Tour. Contact (503) 823-7725.
Salem Tour:	October 2nd. Contact (503) 378-8325.
Eugene Tour:	October 2nd. Contact (541) 744-7448.
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Bend/Redmond Tour:	October 2nd & 3rd including a Green Building & Renewable Energy Fair at the Bend Fall Festival. Contact (541) 617-9013.
John Day Tour:	October 2nd. Contact (541) 575-3633.
Roseburg Tour:	September 25th. Contact 496-3987.
Grants Pass Tour:	October 2nd. Contact (541) 476-4200.
Klamath Basin Tour:	October 2nd. Contact (541) 883-8410.

For more information on the tour check out the website:

www.energy.state.or.us/renew/Solar/2004Tour/TourHome.htm

Be looking for the 2004 **Green and Solar Homes Oregon** magazine! It is chock full of great information.

PV Grounding

Continued

John Wiles

Sponsored by the Photovoltaic Systems Assistance Center, Sandia National Laboratories

Grounding PV modules was covered in *Code Corner* in *HP102*. In this column, the terminology used in grounded systems and some of the grounding methods will be covered.

The subject is quite complex. Grounding photovoltaic (PV) systems with both AC and DC sides is even more complex. Everyone involved in PV installations is encouraged to get a copy of the *National Electrical Code Handbook* for the additional details it provides on grounding.

Equipment-Grounding Conductors

In a grounded electrical system, several terms with the root term "ground" are used. If these terms are used improperly, it can be confusing and possibly unsafe. A "grounded" system is one that is connected to earth. (Europeans use the term "earthed.") All exposed metallic surfaces that could accidentally be energized (come into contact with an electrically "hot" or "live" conductor) must be connected to ground with "equipment-grounding conductors."

The requirement for equipment-grounding conductors applies to PV module frames, module mounting racks (if exposed, single-conductor cable is routed along them), switchgear enclosures, overcurrent enclosures, metallic conduit and raceways, inverters, charge controllers, and the like. A PV system at any voltage (even a 12-volt, off-grid system) should have a network of equipment-grounding conductors linking all of these exposed metal parts to each other and to the earth.

Equipment-grounding conductors do not carry electricity on a continuous basis. They are only intended to do so under ground-fault conditions (unintentional electrical circuits to ground). They represent one of several lines of defense against fires and shocks from electrical systems. First, the metal surface is connected to earth, and if it comes into contact with an energized conductor, any dangerous voltages will be reduced significantly in magnitude as energy is diverted into the grounding system. The equipment-grounding system is designed and connected so that most ground faults (where an energized conductor contacts an exposed metal surface) result in an overcurrent device (fuse or circuit breaker) opening and stopping the fault current.

The equipment-grounding conductor can be a bare conductor with no insulation, an insulated conductor with green insulation, or a conductor with green insulation and yellow stripes. Equipment-grounding conductors in DC, PV source and output circuits must have an ampacity at least 1.25 times the short-circuit current (I_{sc}) from the PV sources at that point in the circuit.

The ampacity of these conductors is calculated from Table 310.16 in the *NEC*. The insulation temperature rating used for the ampacity determination should be equal to the insulation temperature rating of the circuit conductors, even when the equipment-grounding conductor is bare.

Equipment-grounding conductors in other DC circuits and in AC circuits are sized according to Table 250.122 in the *NEC*. This table is based on the rating of the overcurrent device protecting the circuit. The table is used to determine the size of the equipment-grounding conductor in circuits *other* than DC, PV source and output circuits. If the circuit conductors have been oversized for voltage drop, then the equipment-grounding conductors from Table 250.122 must also be oversized proportionately.

Grounded Conductors

A "grounded conductor" is a circuit conductor that is normally electrified and is connected to earth. The connection to earth should be made at only one point in the DC part of the system and at only one point in the AC part of the system. In utility-interactive systems, the connection between the DC grounded conductor (usually the negative conductor from the PV array) and the rest of the DC

Equipment-Grounding Conductor Size

Overcurrent Device Rating (A)	Minimum Equipment-Grounding Conductor Size (AWG)
15	14
20	12
30	10
40	10
60	10
100	8
200	6
300	4

From Table 250.122 of the *NEC*.

grounding system is frequently made inside the inverter as part of the ground-fault protection device.

The insulation on a grounded circuit conductor is white for #6 (13 mm^2) conductors and smaller. If the conductor is larger than #6 (normally available only in black), the conductor must be marked with white tape or paint at each splice and termination. The code allows manufacturers to use three longitudinal white stripes on any colored conductor (except green) to indicate a grounded conductor. If exposed, USE-2 (normally available only in black), single-conductor cables are used for PV module interconnections, the grounded conductor must be marked with white tape or paint at each termination, even when the conductor is smaller than #6.

Main Bonding Jumper

In *NEC* language, the word “bonding” means to connect electrically. Equipment-bonding conductors and devices connect various parts of the equipment-grounding system together. For example, the green grounding screw on an AC switch or outlet is used to connect the equipment-grounding conductor. The main bonding jumpers connect the grounded circuit conductors (one for the DC sections of the system and one for the AC sections of the system) to the equipment-grounding conductor(s) at the main disconnects or main bonding points.

In the AC parts of PV systems (both utility-interactive and stand-alone), the main AC bonding jumper is usually installed in the main load center of the building where the AC service disconnect is commonly installed.

In a utility-interactive system, the main DC bonding jumper is frequently (but not always) internal to the inverter and is part of the internal ground-fault protection system required by the *NEC,* Section 690.5. Since utility-interactive inverters are frequently used on dwellings where the PV arrays are on the roof, many inverter manufacturers include the ground-fault protection device in all inverters.

In stand-alone systems where the modules are not mounted on the roof of a dwelling, the main DC bonding jumper can be installed anywhere on the DC circuits. It is frequently a large grounding block mounted in the DC disconnect enclosure between the inverter and the batteries. If the PV array is mounted on the roof of a dwelling, the main DC bonding jumper will be part of the *NEC* section 690.5 ground-fault protection device that will usually be mounted external to the inverter.

Grounding-Electrode Conductor

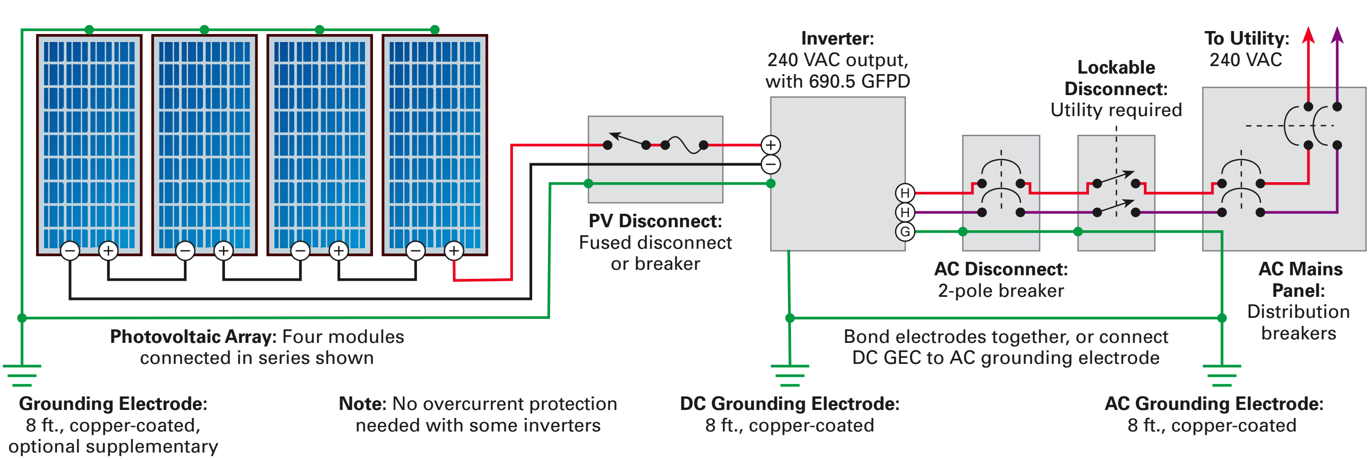
Because most inverters have transformers that isolate the DC grounded conductors from the AC grounded conductors, two grounding systems are usually required. Conductors are routed from a single main bonding point in the DC system and a single main bonding point in the AC system to grounding electrodes (the part of the grounding system that is in physical contact with the earth, such as a ground rod). The conductors from these main bonding points to the grounding electrode(s) are called the “grounding-electrode conductors” (GECs).

There will usually be a DC grounding-electrode conductor and an AC grounding-electrode conductor in systems with an inverter. In a PV installation where there is an existing AC electrical system, the AC grounding electrode is already installed. The DC grounding-electrode conductor may be connected to the AC grounding electrode or it may be connected to a new DC grounding electrode. This new DC grounding electrode must be bonded to the AC grounding electrode.

Grounding-electrode conductors may be either bare or insulated. No color is specified for this conductor (if insulated), but conventional practice suggests that it be black and not white, green, or green with yellow stripes. The smallest allowable size is #8 (8 mm^2); however, a grounding-electrode conductor this small must be installed in conduit for physical protection.

Many inspectors allow a #6 (13 mm^2) grounding-electrode conductor to be installed without conduit if it is attached to a building surface. The #8 and #6 conductors are normally allowed when the GEC is connected to a ground rod. When other grounding electrodes are used, the size of the required GEC may be larger. If a concrete-encased electrode in the

Grounding for a 240 VAC, Grid-Tied PV System



building slab is used as the grounding electrode, a #4 (21 mm^2) GEC is required.

The GEC must be unspliced (or spliced with irreversible splices—for example, exothermic welds or crimp-on splicing devices) from the bonding point to the grounding electrode or grounding-electrode system.

Grounding Electrode

The "grounding electrode" can be a number of different devices. In many places, the commonly used electrode is an 8-foot (2.4 m) long, 5/8-inch (16 mm) diameter copper-coated steel rod driven into the earth. The entire length of the rod must be in contact with the earth, so the top is usually flush with, or buried slightly below the surface. Clamps rated for direct burial are used to connect the grounding-electrode conductor to the grounding electrode.

The code requires that the resistance from the rod to the earth be 25 ohms or less. This measurement is difficult without specialized equipment. To do it accurately, you have to use instruments that cost hundreds of dollars.

If the measurement is greater than 25 ohms, a second rod must be driven at least 6 feet (1.8 m) away and bonded to the first rod. The bonding conductor must be the size of the grounding-electrode conductor. The rods may be driven up to 45 degrees from the vertical in rocky soils or buried in a trench horizontally at least 30 inches (76 cm) deep.

Sometimes, a 20-foot (6 m) length of #4 (21 mm^2) bare copper conductor is buried in the concrete footer or slab for the house, and serves as the grounding electrode. Connecting the grounding-electrode conductor to grounded water pipes, well casings, or grounded building steel is also allowed in some cases. These requirements are code minimums. If the installation is in a high lightning area, much more extensive grounding systems will be beneficial.

Ground-mounted PV arrays should have an additional grounding electrode at the array location. It is connected to the equipment-grounding system for the module frames and the array structure. Not only is this a code requirement (due to the location of the PV array away from the inverter), it will enhance the ability of the system to deal with lightning surges. This supplementary DC grounding electrode does not have to be bonded directly to the main DC grounding electrode. It is connected indirectly to the main DC grounding electrode through the equipment-grounding conductors.

Grounding is a complex subject, and the information here covers only the high points. For more information, see the suggested references in Access.

Access

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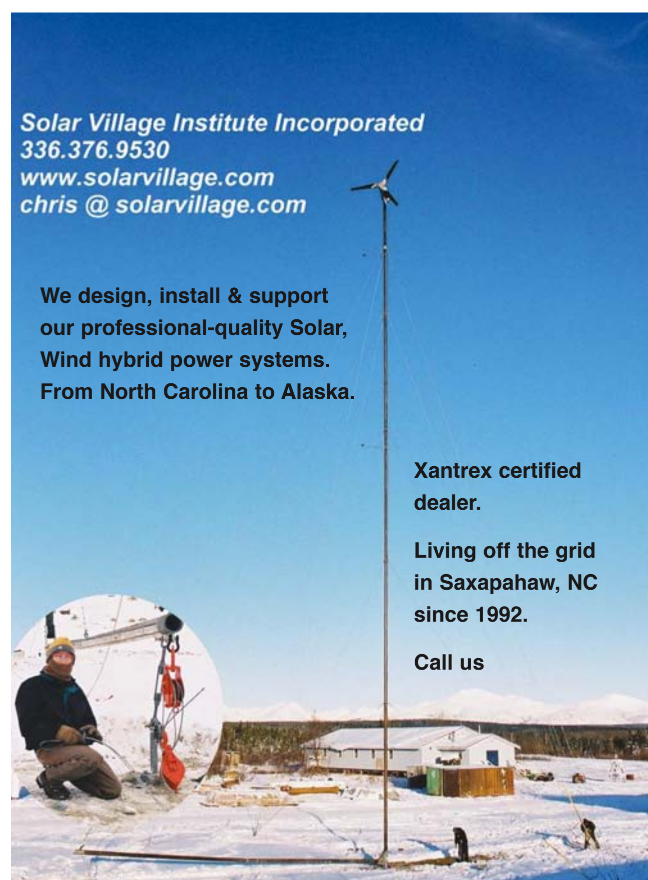
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Feeling the Insurance Squeeze

Don Loweburg

Like many small businesses these days, renewable energy (RE) installers are experiencing an upsurge in insurance costs. But in addition to the difficulties shared by all small businesses, RE installers also are facing some additional problems related to the perceived novelty of the RE trade.

To better understand the extent of the problem, I surveyed a number of professional RE installers for their experiences purchasing insurance. The response, though statistically small, provides a good sampling of insurance issues that plague RE installers.

Say It Isn't So

In addition to the generally high cost of insurance, a common problem is that RE companies (especially new ones) are often denied coverage at *any* price because the insurance carrier does not recognize any work classification for RE installation. When I asked respondents to comment on their experiences obtaining liability insurance, here's what they had to say.

From Oregon: "I let my liability policy lapse last year, and the timing could not have been worse—scams and liability insurance lawsuits were beginning to screw things up. When I decided to get back into the game part-time, I found that if I could get the insurance at all, it was going to cost me three to four times as much as before. It was very disheartening."

From Massachusetts: "It has not been fun! When I described our business, and said we only install tilt-up towers and subcontract the roofing, insurers said, 'No problem.' But months passed, and they finally told me they could find no 'markets' to cover us. When I asked if the process of trying to obtain insurance had blacklisted us, they said, 'Yes'! To get insurance coverage, I had to promise to install only roof-mounted systems—no wind, nothing else. Recently I took a job with another company; the insurance issue is on hold for my personal business projects. My experience trying to obtain insurance as a sole proprietor was definitely a factor in deciding to take a job with someone else!"

From Washington: "I'm a small-scale installing dealer (one employee) in western Washington. I have a specialty contractor's license in Washington State (we aren't required to have a solar license here). Last year, I was cancelled from my insurance. The company just stopped offering liability insurance to contractors. At the time, my premium was about US$900 per year.

I had a heck of a time finding a company that would even give me a quote. I finally found an independent agent in Spokane who offered me a policy. With fees, the premium was US$2,100. I'm now up for renewal with the same company and my premium will be US$2,400. Insurers don't seem to know what category to put RE dealers/installers in. We work with electricity. We work on rooftops. We work on towers. That doesn't sound good to an underwriter. Yet, the reality is that I spend no more than 20 percent of my time in those situations—the majority of my time is spent in the office, on site assessments, and working on business development."

From California: "Last year when my insurer went belly-up, I had quite a struggle getting liability insurance again. When I did, the price went up from the US$960 I had been paying to US$1,912. My biggest problem was having to mention the dreaded 'solar' word. For some reason, insurance companies consider this a liability; it appears that they do not differentiate between solar thermal (i.e., plumbing, hot water systems) and solar electricity (what I do). I have a small business installing residential photovoltaic (PV) systems. I would estimate my gross income is around US$50,000 to US$75,000 in a good year. The fact that I have to pay this much for liability insurance—having never had any claims—to allow me to sleep better at night is absurd."

From Vermont: "I have a very small shop—just me and a subcontracted electrician when needed. I've had no problems with liability insurance yet. I'm paying a yearly premium of US$818—US$507 for commercial property coverage, US$294 for liability coverage, and US$17 for 'terrorism risk' coverage."

Also from Vermont: "We have not had any real problems getting insurance. I know we now have a US$2 million policy (as required to do work under New York's programs).

We pay a lot for insurance. We have contractors' insurance, professional liability insurance (we're both physical engineers), workers' compensation, and health insurance. The workers' comp has probably been the hardest, since 'PV installer' is not a category insurers classify. Because of this omission, many insurance companies try to put us into the worst or most expensive category: 'You're on a roof, therefore you're a roofer.' We actually were classified under 'Cable Installer' for a while, which gave us a decent rate. I think the cardinal rule is to shop for the right agent, and then make *them* shop for the right policies and classifications."

From Hawaii: "We pay for US$2 million liability insurance. Based upon our payroll, this insurance costs us about US$4,000 per year. We are a small company with ten employees. We do residential, commercial, institutional, and PV (wish we did more). Insurers perform annual audits and determine rates based upon your business' volume."

From California: "We have had a lot of trouble getting insurance. Virtually all the carriers tell us that they won't insure any kind of solar work. But because we have a general license, we can get insurance (as long as we avoid the word 'solar'). A big, stupid pain in the butt."

From New York: "I install wind systems and it seems like no insurance agent wants to speak with you if you climb higher than two stories off the ground! The agent who did listen came up with a US$12,000 per year premium for US$1 million in liability coverage. I currently pay US$2,200 for US$1 million of general liability coverage."

Identifying the Issues

From the responses I received, three issues stand out. The first is cost. No matter what job classification you might have, liability insurance is expensive. There also has been a general upward trend for the amount of insurance coverage required. Currently, contractor liability coverage of US$1 million is standard, but insurance agencies can require more. In terms of contracted work, some companies may require that installers obtain greater coverage in order to do business with them.

A second problem many RE installers encounter is that an insurance company may cancel or refuse to renew a policy. Often the reason given is that the insurance company is reorganizing and is no longer offering a specific coverage. Whatever the reason, the contractor now must find a new carrier. But new policies often are more expensive, and previously insured contractors may have difficulty finding a new carrier that they can afford.

A third problem, specific to RE installers, is that many insurers are unfamiliar with and averse to any job title that includes the word "solar" or "wind." They still perceive renewable energy as exotic, untested, and risky. Changing insurers' perceptions of what RE work involves requires education. Fortunately, we don't have to start from scratch.

Making Inroads

Among the responses to the question I posted to the installers, I received information from several individuals in the eastern United States who have been working on insurance issues.

Led by consultant Chris Sinton and funded by the New York State Energy Research and Development Authority, the Renewable Installer Insurance Assistance Program seeks to "increase the level of understanding related to insurance issues for renewable energy (PV and small wind) installers, homeowners, and insurance agents, and ideally increase the availability of affordable insurance for installers." The program's specific goals are to document insurance costs and the issues facing RE installers; develop educational materials for insurance providers; determine the impact of RE training and certification on insurance premiums due to reduced risk and liability exposure; and figure out equitable insurance coverage and rates for installers and agents. They also are trying to determine the feasibility of organizing a group insurance program for RE installers, which would pool resources and help achieve greater bargaining power.

Teamwork

Collaborating with Sinton are Roy Butler, member of the North American Board of Certified Energy Practitioners and owner of Four Winds Renewable Energy; Joel Gordes, Executive Vice President of the New York Solar Energy Industries Association; and Kathy Weinheimer of Independent Insurance Agents and Brokers of New York. Each partner brings a specific focus to the project. As a "wrench" with RE installation experience, Butler understands firsthand the trials and tribulations of obtaining insurance. For the past four years, Gordes has been working on RE insurance issues as a consultant. He recently presented this issue to the Solar Energy Industries Association and their state chapters. Weinheimer represents independent insurers. As an insurance industry member with an understanding of RE businesses, she lends credibility and standing in that arena. (See Access for contact information.)

The Long & Short of It

In the long run, I am confident that the RE trades will become accepted by the insurance industry. Projects like the Renewable Installer Insurance Assistance Program are breaking the ice, and I expect that once some insurance companies understand the RE "market," others will quickly follow.

In the meantime, RE contractors need coverage and cannot wait for the insurance industry to understand the business. We must have insurance to protect both our customers and ourselves. How do we accomplish that in the short term?

Finding specific solutions to the problems of cost control and coverage cancellation can be difficult. Consider joining associations that can command group rates, and participating in political and legislative actions pertaining to RE insurance issues. When shopping for insurance, RE contractors must understand that for an insurer, novelty equals risk. In fact, it's this perception that often initiates problems getting coverage. Contractors also must understand that how they are perceived depends on their presentation—their dress, phone manner, and general professionalism. When you're shopping for insurance, remember to put your strongest qualifications up front, and keep the interaction cordial. If you are an electrical contractor, seek coverage for that particular work classification. Even if you are turned down, take notes: you may learn something to apply to a future interaction.

Access

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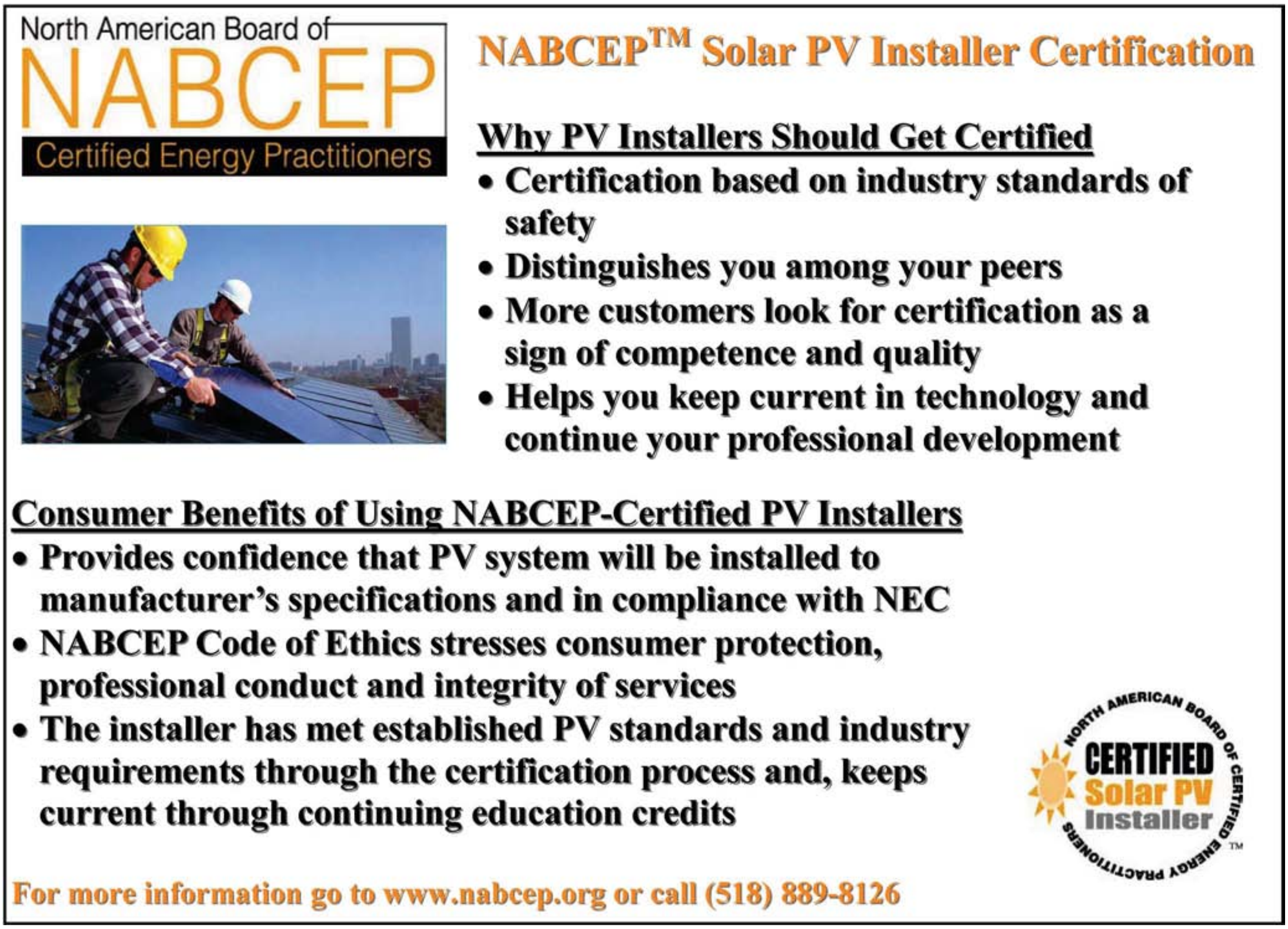


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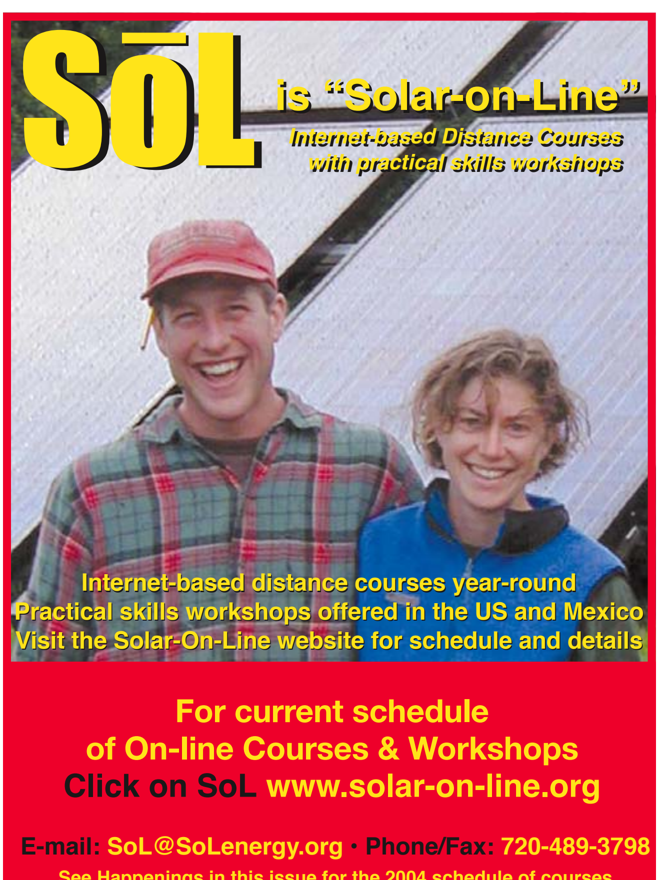
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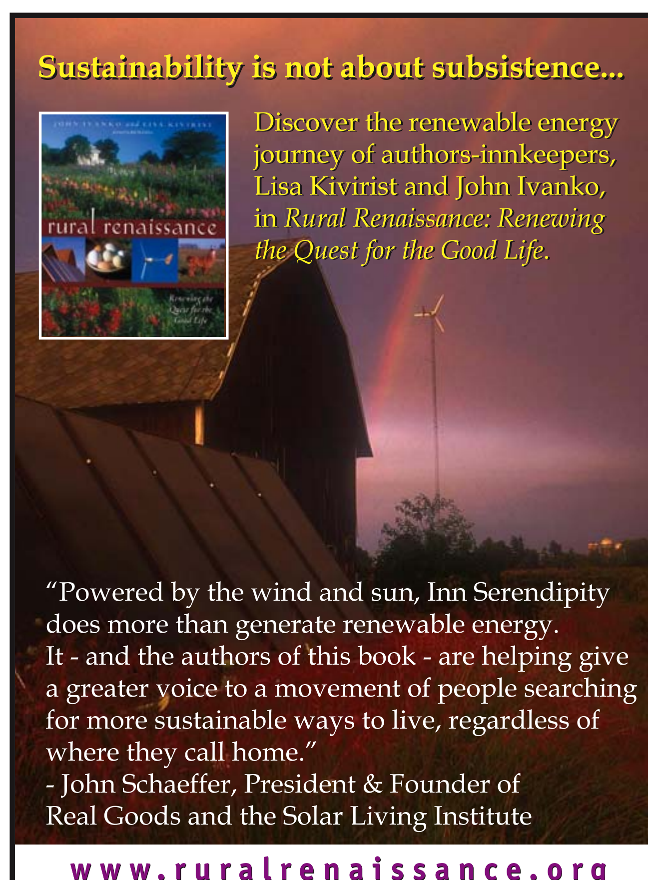
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Nuke Waste

in the Courts

Michael Welch

In 2002, the U.S. Congress and President Bush approved Yucca Mountain, Nevada, as the final resting spot for our nation's commercial and other high-level nuclear waste. This was despite the site's many flaws (see *HP96's Power Politics* column about this really bad idea). The approval provided an opening for legal challenges, and as might be expected, a bevy of lawsuits were aimed at derailing the project.

To expedite things, the federal court handling the cases combined most of the lawsuits against the government into one case, and heard arguments in January 2004. On one side were the State of Nevada and several other interested parties. On the other side were the Environmental Protection Agency (EPA), the Department of Energy (DOE), and the Nuclear Regulatory Commission (NRC). On July 9, the court issued its rulings and, almost immediately, both sides declared victory. Each side won part of the decision. It remains to be seen whether either or both sides will appeal to the Supreme Court.

Constitutionality

First, the State of Nevada's case included a challenge to the constitutionality of the original siting by Congress for the nuclear waste repository at Yucca Mountain. In past columns on this subject, I've decried the fact that siting the repository in Nevada was a political one—not based on sound science.

Quoting from the court opinion:

Nevada asserts that the Constitution requires Congress, when it decides to use federal property in a manner that imposes a unique burden on a particular state, to choose the relevant site on the basis of facially neutral criteria that are applicable nationwide. The resolution runs afoul of this "equal treatment" requirement, as Nevada styles it, because Congress approved the Yucca site based on site suitability criteria that are applicable only to Yucca and that allegedly "reduce[d] to a virtual irrelevancy the actual geologic characteristics of the site."

Nevada's claim was not based on a specific provision or amendment of the Constitution that required this fairness of Congress, though it found support in several clauses, but "rather on principles of federalism ostensibly inherent in the Constitution as a whole."

Unfortunately for Yucca Mountain, the State of Nevada, and all the people and places along the nuclear waste transport routes, the court ruled that Congress had the right to designate those lands when it passed the Nuclear Waste Policy Act (NWPA) twenty years ago, since it has all authority over the use of public lands, and the political process involved was within its mandate. As you might imagine, the court opinion is much more complex than this, and is available to legal beagles at: http://pacer.cadc.uscourts.gov/common/opinions/200407.htm. So the EPA, DOE, and NRC prevailed on that part of the argument.

Design Lifetime

The other big decision in this case involved whether or not it was OK for the EPA to decide that the Yucca Mountain repository needs to last 10,000 years, and that is all they need to design for. This was the only court challenge to the Yucca Mountain repository that was successful, and it is a big one. High-level nuclear waste is dangerous for a lot longer than 10,000 years. Some of it lasts for millions of years. Plutonium, the most dangerous substance known to humans, has a half-life of a quarter-million years.

The NWPA specifically states that the compliance period for making sure radiation does not escape from the repository should be based on and consistent with findings of the National Academy of Sciences (NAS), the federal government's scientific advisor. Independently, the NAS found that, "compliance assessment is feasible for most physical and geologic aspects of repository performance on the time scale of the long-term stability of the fundamental geologic regime—a time scale that is on the order of 10^6 [one million] years at Yucca Mountain."

But the nuclear industry and its EPA cohorts knew that this would be an impossible task, so they arbitrarily chose 10,000 years as the time frame for keeping the repository from leaking. The testing and design of the repository has been based on this.

Nevadans are celebrating this ruling, and some feel that this eliminates Yucca Mountain as a repository before a single, irradiated, fuel rod shows up. According to the Environmental News Service, Nevada Senator Harry Reid said, "I've never believed Yucca Mountain would open, and today it could not be more clear that that's true. The court's ruling is a significant blow to the Department of Energy and the Yucca Mountain project and I believe enough to effectively kill the project."

I also have held strong faith that the Yucca Mountain repository would never open, but I think Reid's optimism may be a bit premature. Already the Bush administration and the EPA are discussing doing an end run around the National Academy of Sciences by legislating the 10,000-year compliance period. They are also looking for ways to do this within the EPA, without having to go to Congress.

My own opinion is that even if the administration finds a way around this court ruling, the amount of money the repository is going to need from the treasury is so monumentally huge that Congress may never find a way to appropriate the funds needed. Before this court ruling, the plans were to complete Yucca Mountain by the year 2010 at a cost of about US$15 billion. But I and others who have been observing the nuclear industry for the last thirty years feel that the project will be subject to the same kinds of cost overruns that have plagued the industry since the beginning, and that the final price tag could top US$100 billion or more—a truly staggering figure. I hope our representatives can see the writing on the wall, and stop wasting our tax dollars on the Yucca Mountain project.

Shoshone Land

One other unresolved issue related to Yucca Mountain is that it and the encompassing Nevada Test Site were recognized as tribal lands as part of an 1863 U.S. government treaty signed with the Western Shoshone Nation. A large majority of Western Shoshone tribal members do not want the repository to be built, and they do not want more nuclear weapons tested on their lands. They believe the land and the water beneath it to be sacred, but the DOE, EPA, and Congress are still trying to take it away once and for all, and continue poisoning the land.

The latest attempt is the Western Shoshone Claims Distribution Act (H.R. 884), passed by the House in June 2004. This bill authorizes payment of a one-time land claim settlement that amounts to about 15 cents an acre. In return, the government would continue to treat Western Shoshone territory as public land, which gives the military and nuclear industry the right to irradiate it. For more info on this and other sacred native lands, see: www.sacredland.org.

Access

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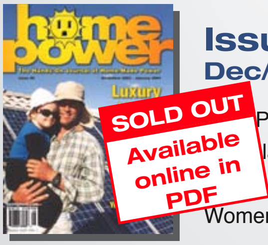

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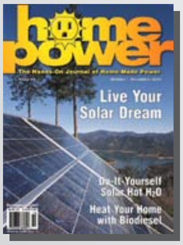

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Free Energy

Not Pie on the Plate

Ian Woofenden

Derivation: From Old English freon, *to set free, and Greek* energos, *active.*

"There ain't no such thing as a free lunch" (TANSTAAFL) is a good phrase to live by, and a good way to look at energy, too. But over the years, countless people have held onto the dream of "free energy."

It's a nice dream. It would certainly make our lives easier if the energy we use didn't come with a price. But so far, everyone I know is still paying for gas for their vehicles, electricity for their appliances, and fuel to heat their homes.

Of course, renewable energy can be considered "free," but only once you pay for it. The equipment to harvest the renewable energy found in sunshine, wind, and falling water costs money, and so does maintaining the systems. You can pay for it up front, and it's a great deal, but it's not "free."

"Free energy" advocates generally aren't referring to photovoltaic (PV) panels or wind generators. They talk about energy from magnets, energy from space, and energy from black boxes that are too secret for us to get a look into. Windmills that blow wind to make themselves go, waterwheels that recycle the water, and other perpetual motion machines have been talked about for centuries. There have been claims of machines that run on gravity, water, air, or ammonia; vortex energy machines; and even little green pills that turn water into gasoline.

I'm a skeptic and a realist. My job asks me to look critically at text, and my conscience asks me to carefully examine claims about any new energy-producing device.

At the same time, I try to remain open to new ideas. PVs once were new, and folks were skeptical about them then—some still remain skeptical today. We have to find a balance between skepticism and openness. Just don't be so open-minded that your brains fall out.

The promoters of free-energy devices must prove themselves. I can't see spending much time with it until they do. When a real, viable technology comes along, you'll be able to buy it. In the meantime, if you want to try to sort the wheat from the chaff, here's an edited version of science maven Bill Beaty's list (www.amasci.com) of things to consider when looking at "free energy" schemes.

So how can you tell a "free energy" (FE) scam from a legitimate technology? Here are some symptoms of a scam:

- *The company wants your money. It wants investors to buy stock, it wants to sell "dealerships," it wants individuals to make large "donations," or sometimes it wants to sell you high-priced books or extremely expensive plans. In any scam, the* whole point *is to separate the victims from their wallets.*
- *The invention is unproven, and has not been publicized in the mainstream press.*
- *Either the inventor keeps the device secret, or the patent lacks some critical information, and nobody can build a working copy based on the patent.*
- *The company shows no interest in demonstrating that the invention works. Scammers will give you all sorts of reasonable-sounding excuses for not providing evidence that their discovery is real. Honest companies will prove their claims beyond any doubt* before *soliciting investors.*
- *The company performs public demonstrations, but something always goes wrong.*
- *The inventor doesn't publish peer-reviewed scientific research papers.*
- *The inventor uses conspiracies/suppression as an excuse for the technology's lack of development and success.*
- *The inventor doesn't give out working copies of the invention to independent labs for testing—the hardware stays secret and untested.*
- *The invention violates current laws of science. (Well, that's OK, since historical inventions often violated contemporary science of their time. But if many other listed symptoms are present as well, then it's probably a scam.)*
- *The inventor hasn't tried winning any of the FE device prizes. Back in the days of flying machines, the genuine inventors were all questing after several major prizes. They didn't disdain the prizes and make excuses. But scammers sure do!*

Ask FE hobbyists. They'll quickly set you straight about who is a rip-off artist and who is a legitimate experimenter or inventor.

I'll be first in line to purchase new, clean-energy technologies that actually work. But I'll remain skeptical of all schemes and scams that aren't functioning products for sale, or at least ready to be tested in independent circumstances. Until then, these free-energy dreams are just more pie in the sky. And as *HP* publisher Richard Perez says, "We report only about pie on the plate…"

Access

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Catching the Wave

Kathleen Jarschke-Schultze

When I lived in town, my friends and I would wave at each other. Stopped at a stoplight, a few cars back on the opposite side of the intersection, an arm would be extended in an energetic, loose-armed, floppy wave. This was often from some model of Volkswagen.

Locals Wave

Country locals always wave. This is not a phenomenon of my county or even my state. I have discussed this with friends from all over the United States and Canada. If you are driving in a rural setting, locals always wave.

In an urban, or even suburban setting, it is possible not to know your closest neighbor. Maybe there are just so many people that you can't wave to all of them. Maybe it's best not to act too friendly in the city. For whatever reason, city folks don't wave.

Kathleen and her niece Tessla decorate their hands with henna for some extra-fancy waves at Oregon Country Fair.

Permanent Waves

Waves come in a variety of styles. Several styles are recognizable and widely prevalent across this continent. Others have been adapted for specific purposes and are quite regional. Here are some of the more common types of waves.

Piano wave. The arm is raised to face level, and the fingers are wiggled as if playing a piano.

Goldie Hawn wave. If you've ever seen Goldie Hawn on a red carpet, you've seen this wave. One arm is fully extended upward and the whole hand is flapped between straight up and a 45-degree angle.

Parade wave. This one was made popular by parade princesses and royalty. The arm is extended out to the side, elbow bent, with the arm in a "V" shape. The hand is held in an upright position. The wave begins with bending the elbow back and forth, and then as the elbow is held still, the hand is waved by bending the wrist. So it goes: elbow, elbow, wrist, wrist. It takes a bit of practice, but it keeps your arm from being too tired to hold up on a long parade route.

Wave wave. I've only seen this on TV in sports stadiums. You must have many people to do this one. A really big crowd is better, and it's best if they are on bleacher seats. The wave starts at one end of the seats and ripples along the crowd in sequence. The first group of people at one end stands up and fully raises their arms overhead. Then the arms are dropped, and at the same time, the waver retakes his or her seat. As those participants sit down, the next people on the bench stand up and wave, creating a wave of wavers. It is quite impressive if you have a cooperative crowd.

Kama'aina wave. In Hawaii, the locals, or Kama'aina, have their own wave. It is also known as the "hang loose." Extend the arm, elbow slightly bent. Fold index to ring fingers into your palm, leaving thumb and pinkie extended. Waggle the whole hand back and forth.

When Bob-O and I went camping on the big island of Hawaii, Bob-O's friend loaned us his car. It was older, slightly rusted, and had Hawaiian license plates. Everyone waved at us. We were quickly reciprocating with the Kama'aina wave. We felt like locals. Then we had to return the friend's car and drive a rental car for the last day to get us to the airport. Nobody waved at us; there were no smiles, no nods. We would wave, but no one would wave back. We felt shunned.

Steering Wheel Variations

When locals wave at you, it is usually while you are driving along country roads. This means there are several wave variations related to driving.

Steering wheel wave. For this wave, the hands never leave the steering wheel. It can involve one, two, three, or all four fingers held upright, but with your hands anchored to the steering wheel by the thumb. Usually this wave is done with the right hand, although the left hand has been seen.

Nodding acquaintance wave. On blind corners, since both hands are on the wheel, you usually get "the nod." The face is inclined upward and then back down at the same time as the eyebrows.

Window wave. This wave is performed with an open driver-side window and the elbow resting on the sill. The hand is raised and brought towards the driver's head in a casual mock salute. Or maybe it is an indication of the old-fashioned politeness of doffing one's hat.

Flat hand wave. The driver or passenger raises a full, flat hand, with the palm presented outward and tilted slightly upwards towards the windshield. There is usually no other movement of the hand, although a slight wave sideways is an uncommon variation.

Why We Do It

Why do country locals wave? It is like hat doffing. Everybody used to do it. Then it became complicated in heavily populated places. But in the country, you are not speeding down the road. You are taking it slow because animals can and do jump out into the road. Corners can be sharp and blind. The scenery is better in the country. You feel like waving. I don't know most of the regulars I wave at on the fourteen-mile journey to the freeway from our house. It doesn't matter—not to me, not to them. We wave.

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Kathleen Jarschke-Schultze is juicing apples and crushing grapes at her home in northernmost California. c/o *Home Power* magazine, PO Box 520, Ashland, OR 97520 • kathleen.jarschke-schultze@homepower.com

Online Courses

Solar Energy International's PV Design & Solar Home Design

Reviewed by Linda Pinkham

Four years ago, I thought "RE" was an abbreviation for real estate, not renewable energy. Today, I have a 2.1 KW, grid-intertied photovoltaic (PV) array in my backyard.

When *Home Power* hired me as an editor, I had an extensive background in the publishing industry, but my knowledge of renewable energy was limited. While words are words, I found that it was impossible to even correctly punctuate some sentences if I wasn't familiar with the topic.

PV Design Online

I needed to come up to speed quickly, but my work schedule seemed to continually overlap the hands-on workshop opportunities available. The solution was to sign up for Solar Energy International's (SEI) PV Design Online course. The six-week course covered all the basics for PV system design, including basic electrical principles, solar site analysis, electrical load calculation, how to select equipment, and sizing a PV system.

The course is designed to let people work on their own schedule via the World Wide Web and through e-mail. It is a good choice for anyone who wants training for a professional career in the solar energy industry, as well as for people who want to install solar-electric systems on their own homes.

Course materials included a textbook, *Home Power* CDs, articles and reading materials on the SEI Web site, and access to a bulletin board forum for questions and discussion with course instructor Justine Sanchez and fellow class members.

Weekly lessons, posted on the course Web site, consisted of reading assignments, homework exercises, and a quiz at the end of each section. Quizzes were promptly graded by Justine and accompanied by lengthy explanations for any incorrect responses. The course is paced to cover two sections each week.

The only thing the course can't provide is hands-on experience, but online students receive a discount to attend hands-on courses. For me, the course covered exactly what I needed, since my job doesn't involve wrenches and screwdrivers, but a red pen and a computer keyboard. For aspiring installers, the PV online course counts for sixty hours towards North American Board of Certified Energy Practitioners (NABCEP) certification.

The only reservation that I had about the PV design course was the textbook, which through numerous revisions had become choppy to my editor's eye. I am delighted to now say that the best and most comprehensive textbook on PV system design has undergone a complete facelift and revision.

The table of contents Web page from SEI's Solar Home Design Online course.

Solar Home Design Online

The PV Design Online course was so useful that when the *Home Power* crew decided to increase the number of green building articles published in the magazine, I immediately signed up for the Solar Home Design Online course taught by Rachel Ware.

The text materials for the solar home design course are located almost entirely online in a well designed, attractive, and user-friendly Web interface. The graphics embedded in the course materials are interactive, and key terms are hyperlinked to an online glossary. Supplementary, hard-copy reference materials from various sources are included in a three-ring binder.

The six-week course covers solar home design strategies, principles of heat transfer, site analysis, building envelope construction techniques, ventilation, heating and cooling, super-insulation, natural and healthy building materials, energy efficiency, and more. Weekly assignments included reading the text and supplementary assignments, and answering one of two thought-provoking essay questions each week.

Our class decided to post our homework essays on the bulletin board so that we all could learn from each other's ideas and Rachel's insightful responses to the essays. Not only was I able to apply the textbook knowledge to my own circumstances, but I also vicariously experienced everyone else's plans and dreams for a solar home. Once again, the hands-on component was missing, but the same offer for a discount applies to online students who attend a hands-on workshop.

Get Moving into RE

Getting an RE education is a big job no matter how you do it. If you want to move towards a more sustainable lifestyle quickly, and understand more about RE and what's in the pages of *Home Power*, SEI's online courses are a good place to start.

Access

Solar Energy International, PO Box 715, Carbondale, CO 81623 • 970-963-8855 • Fax: 970-963-8866 • sei@solarenergy.org • www.solarenergy.org • Online courses & *Photovoltaics: Design & Installation Manual*, 2004, published by New Society Publishers, US$60

Linda Pinkham, c/o *Home Power* magazine, PO Box 520, Ashland, OR 97520 • linda.pinkham@homepower.com

Antarctic Straw?

I read with great interest Chris Magwood's article, "Straw Bale Building on the Cusp of the Mainstream," in *HP101*. I plan to build a small straw bale house. The article did not offer much I didn't already know. However, it gave me a few tools I can use when defending my choice to build with straw. Thank you!

Chris made a statement in the article that caught me off guard. He said, "In fact, there are bale buildings on every continent." I am quite interested to learn more about the bale building projects in Antarctica. Please tell me more! I am most interested in the source of the straw. Jim Green • jagreen3@facstaff.wisc.edu

Jim, OK, I'll admit it—I'm a continentalist, a practicer of continentalism, or some such thing! Of course, there are no straw bale buildings in Antarctica (although they might offer some uniquely suitable properties). I simply exaggerated the fact that bale buildings exist on all the regularly populated continents! I'm glad you enjoyed the article. Cheers, Chris Magwood • cmagwood@kos.net

Small Systems

I've been meaning to write for a while. Now that we have published two articles in *HP*, I wanted you to know what I've heard from readers. In response to the first article, about our small photovoltaic (PV) system, we got tons of e-mails and letters—one from South America, and even one from a man in jail in Salt Lake City. We got calls from people wanting to get started in this business, who kept writing back. Mainly they were trying to break into the technology, but didn't know how, and a small system was something they could tackle. We also heard from lots of people with remote property on which they had been camping, but now want to improve or build a cabin some day. Another guy wants to move into an old school bus on his property in southern Utah and wants electricity. My installer, John Heiss of Northwoods Energy Alternatives, got some referrals too.

In our second article, about our large household-sized system, we have heard several times from a college professor who moonlights as a survivalist and resident lunatic. That's it. I don't know what you all are hearing from readers, but nobody is interested in picking my brain on the household-sized renewable energy plan—everyone I hear from wants to go small. Most of the articles *HP* publishes are on the bigger plans, including household-sized, high-tech domestic hot water, wood heating, and so on. I just thought this might be food for thought at your next meeting, or you can pass this on to anyone who might want to read it. Take care, Rudy Ruterbusch • the4rudys@aol.com

Hi Rudy, We hear from readers about all sizes and types of systems. And we try to keep a good mix in the magazine, though we can always use more submissions on high-quality small systems. Thanks for the feedback. Ian Woofenden • ian.woofenden@homepower.com

$900 Million for Nukes

I am a fairly new subscriber to your magazine. Although I've always been interested in renewable energy, I have taken a more active interest since the blackout last year. I live in Ontario, Canada, and I thought you might find it interesting that our provincial government has just decided to reopen an old nuclear plant that was shut down in 1996. The estimated cost of the restart is about US$900 million.

It just sends me around the bend that they would not even consider any kind of renewable energy sources (wind or solar). I would think they could get quite the system for the same amount of money, and after the initial layout, the upkeep has to be much cheaper than trying to keep a nuke plant going. They also figure it will take 15 to 18 months before the system is even on-line. Keep up the good work. I look forward to each new issue. Jeff Soley • jsoley8207@rogers.com

Hello Jeff, Welcome aboard! Nine hundred million dollars would buy a heck of a big wind or solar-electric system. Considering that utilities worldwide are installing more wind farms than any other electricity source, the decision to put a nuke plant back on-line seems unwise. Add to this the fact that Ontario has good wind potential, and I think that your provincial government has made a big mistake. Richard Perez • richard.perez@homepower.com

Hydrogen Debate

Dear Editor, I recently picked up a copy of *HP101*. As a first-time reader of your publication, I found it to be an excellent source of technical information, and I read it cover to cover. I was however struck by the narrow-minded focus of the hydrogen debate. While there are certainly many pros and cons that will continue to be debated for a long time to come, I believe that this is a prime example of the blind men studying the elephant. While math, physics, and engineering skills are absolutely fundamental in the analysis of weighing the advantages and disadvantages of a future hydrogen economy, neither Richard Engel nor Dominic Crea seemed to be aware of a whole field of research based on microbial hydrogen production using photosynthetic and anaerobic bacteria in waste streams, with the added benefit of cleaning up some noxious pollution.

What we need are more people to think outside of their boxes. What I would really like to see is an education system that promotes critical and creative thinking skills based on a deeper knowledge of science. Then we can debate those who are stuck in the past with their vision of fossil fuels and nuclear energy, and are antisolar, as discussed in Don Loweburg's piece, "Zero Energy Homes." Let's not forget the enormous potential benefits of simple energy conservation. I'll be picking up your next issue—keep up the great work. Sincerely, Fred Magyar, Sunshine State • fred_magyar@yahoo.com

Hi Fred, I appreciate your comments. It's true that Dominic and I did not discuss the biological production of hydrogen. This is an emerging technological area that appears to be getting increased attention. My reasons for not bringing it up in the *debate were that I'm not well informed on the subject, having read just a handful of articles and having no hands-on experience with biohydrogen. We also were given a pretty tight word limit, which barely left Dominic and me room to cover the basics. Plus, I'm still in a wait-and-see position on biohydrogen—I'm not yet convinced it will or won't work technically.*

In addition to these issues, I have a pretty strong skepticism about biofuels in general, which also extends to biodiesel. The way I see it, we will already be hard-pressed in the twenty-first century and beyond to meet our arable land and fresh water needs for food production even without bringing biofuels into the picture. We'll be squeezing the biosphere way too hard if we try to substitute crops for our massive petroleum consumption. Now maybe something way outside the box, like ocean-based algae farms, is a viable way past that, but I'm still waiting to see. Richard Engel, Schatz Energy Research Center, Humboldt State University, Arcata, California • rae7001@humboldt.edu

No Substitute for Oil?

Dear *Home Power*, I watched with great interest as the CEO of Exxon Mobil Corp. dismissed all alternative forms of energy in a recent speech on C-SPAN, stating that basically there is no substitute for oil, and that we have to learn to get along with oil-producing nations, different as they may be from our culture. He dismissed solar energy ("the sun doesn't shine at night"), biofuels ("the entire crop production of Ohio and Illinois to make biofuel"), wind, and everything else. I wonder if he talks to British Petroleum (BP Solar parent company) executives who are marketing solar-electric panels and other renewable energy products? Craig Daskalakis • cjdask@juno.com

Hi Craig, I only have one suggestion for oil company spokespeople. Just remove the enormous subsidies on nonrenewables, and then *see how renewable energy fares in the marketplace. We just don't know what would happen with real pricing for all energy, and free choice for consumers. If oil company CEOs are happy to continue lapping up the subsidies, disguising the true costs of their products, they shouldn't talk about what is and isn't possible. Ian Woofenden • ian.woofenden@homepower.com*

Homeowners Associations

Hello *Home Power*, I have just heard a story about how some homeowners' associations are preventing solar equipment from being installed, and even having existing installations removed. All for the appearance and ambiance of their neighborhoods. Appearance to these people is more important than solar energy. They should be drawn and quartered, tarred and feathered, and ridden out of town on a rail. This type of attitude that the renewable energy community is up against is the same attitude that is preventing wind installations in the northeast United States. The Mojo Man

Hi Mojo Man, I hear lots of these horror stories about homeowners' associations, city planners, etc., being averse to RE installations. Yet these folks don't bat an eye about overhead utility lines and giant substations. To them, these are all just part of the "natural" landscape, I guess. Linda Pinkham • linda.pinkham@homepower.com

Maximum Power Point Tracking (MPPT)

Dear *Home Power*, Thank you for Tim Nolan's MPPT article in *HP102*, and thanks Tim, for your excellent work and for sharing in the public domain. The MPPT principle is well proven for optimizing PV output for both battery charging and solar water pumping. I would like readers to know that this function is already available in many commercial products that have appeared in the past five years, including most grid-tie inverters, charge controllers (including Blue Sky Energy, OutBack Power, BZ Products, and Solar Converters), and solar water pump products (including Etapump, Dankoff LCB, and Solar Converters LCB). When MPPT is included, it is stated in the product specifications. Tim does an excellent job explaining what it does (although control methods may vary). I have had an RV Power Products (now Blue Sky Energy) MPPT controller on my battery system since 1999 (described in *HP76*). On one cold winter day with my battery voltage relatively low, I measured 28 percent gain in charge current over non-MPPT charging. Some of our dealers report that replacing older charge controllers with MPPT models is the most cost-effective upgrade that they offer, especially for folks who run short in the winter (when the potential gain is maximum). More power to ya! Windy Dankoff, Dankoff Solar Products, Santa Fe, New Mexico • windy@dankoffsolar.com

Hello Windy, I fully agree. If you aren't running an MPPT on your PVs, you are wasting valuable PV energy! I just installed a 48-volt array (four Sharp 185-watt modules) and ran them through an OutBack MX60 MPPT charge controller and into our 24-volt battery. When outdoor temperatures are cool, I get the manufacturer's rated output from these PVs. When temperatures are downright cold, I see almost short-circuit current (higher than rated output). What a great deal! Richard Perez • richard.perez@homepower.com

Tax Credit

Dear Editors, Your otherwise excellent first two articles in *HP102* (pages 21 & 30) might mislead readers to believe that the 10 percent federal solar and geothermal energy tax credit is only available to businesses. Actually, any taxpayer can claim the credit. See the instructions to IRS Form 3468, Line 2.

Perhaps the confusion arises because you might have to file Form 3800, "General Business Credit" with your personal return. You might also tangle with Form 1045 and other esoterica. Since your neighborhood tax helper may not often deal with these forms, plan on courteous and efficient self-service!

Any individual who installed equipment in the past three years without claiming this tax credit should file an amended return for the years in question. If the credit exceeds your tax bill for the year the equipment was placed in service, it must be carried back to the previous year, and then carried forward for up to twenty years. Consult the IRS Web site for up-to-date forms and information, since Congress is presently working to change this section of the rules. I'd like to hear from anybody who recovers unexpected big bucks by legitimately claiming this credit. Joel Chinkes • solarbozo@escapees.com

Worth It?

Ian, Interesting review of the AWP 3.6 wind turbine in *HP102*, but I have a question. According to your review, this US$2,600 wind generator (+ tax + shipping + installation + etc.) produces only 189 KWH per month. I can buy that much electricity from my local electric company for US$28.35. I guess this type of energy can only be justified where there are no utility companies? Thank you. An architect from Pennsylvania

Greetings, Renewable electricity generally can't compete on a strictly financial basis with heavily subsidized utility electricity. But if you like clean air, water, soil, and lungs—and peace—then the "value" of RE increases significantly. And if you're 1/4- to 1/2-mile off-grid, the line extension costs can make RE even more attractive.

Utility electricity has both (huge) direct subsidies that skew the cost, and also "externalities"—costs incurred on others or the environment—that are not included in the sticker price. If renewables and nonrenewables competed on a level playing field, I suspect that we'd see wind turbines and solar-electric panels about as often as we now see utility poles supplying subsidized electricity.

That said, making your own electricity is not an endeavor to take lightly. You take on all the roles of a utility, from financing to maintenance to distribution. Most people using small-scale wind energy today are either off-grid, environmentally motivated, have a critical need for uninterrupted power, or are just in love with tinkering. It can be very satisfying on many levels.

Very few choices we make in life are purely financial. Most of us don't buy meals based only on price—we want quality food. We don't buy furniture only on price—we want comfortable furniture. When it comes to electricity, more and more people are making their choice based on the quality *of the energy source, not just the (subsidized...) price. Regards, Ian Woofenden • ian.woofenden@homepower.com*

CF Theft

I frequent a Holiday Inn in the Washington, DC, area that has implemented some good energy policies. One of those is washing the bed sheets only if you hang a tag on the door, or whenever the room is vacated. Another energy policy they implemented was using compact fluorescent (CF) lightbulbs in the guest rooms, as well as in the lobby and other common areas.

I was at the hotel two years ago, and CFs had been installed in the rooms. Just recently, I stayed at the hotel, and noticed only one fixture in my room had a CF lightbulb in it. I asked the clerk at the counter why they were switching back to the old-fashioned incandescent bulbs. She said that they had a considerable expense replacing the CFs after guests had removed them from the fixtures during their stay. She said that some guests would even go to the effort of buying incandescent bulbs to replace the hotel's CFs they steal. Now that people apparently have the knowledge of CFs and their advantages, this type of problem may become more common as energy conservation becomes more widespread. Steven Winner • steven.winner@verizon.net

Hi Steven, Thanks for writing. Yes, I have heard of this too. The other thing that we should see is that as more and more folks use CFs, the prices should come down, making them less of a theft target. Michael Welch • michael.welch@homepower.com

Hi Steven, I just can't figure out how a person concerned with energy conservation could rationalize something as immoral as theft. Stealing lightbulbs from a motel is pretty low. It recalls the days of cheap rental rooms when the poorest people would take the toilet paper and lightbulbs with them when they moved. But people who stay in a hotel in DC probably can afford their own lightbulbs.

People have been swiping towels and toilet paper from hotels and motels for years, and the innkeepers still replace them—thank goodness! You would think that they would continue to replace the CF lightbulbs as well, and just add the cost of theft onto the bills. Linda Pinkham • linda.pinkham@homepower.com

Response to "Responsible Wood Heating"

Dear *Home Power*, I recently read "Responsible Wood Heating" by John Gulland in *HP99*. In the article, he looks at carbon dioxide (CO_2) production and writes, "when trees mature and fall in the forest and decompose there, the same amount of CO_2 is emitted as would be released if they were burned." That is a true statement, but it does not necessarily mean that the quantity of CO_2 in the air is unaffected. Large quantities of carbon are stored in the soil and rotting organic matter. If this carbon storehouse is reduced by burning or accelerated decomposition, the stored carbon in the forest will decrease, and the CO_2 in the atmosphere will increase.

Where we live in northern California, downed redwood logs can store carbon on the ground for hundreds of years. As they decompose, part of the carbon will be metabolized and part will become incorporated into the structure of other living creatures. All of the carbon will not enter the atmosphere for many centuries. Those rotting logs are an important source of food for the base of the food chain in a forest ecosystem. Downed logs will initially supply energy and building blocks for an array of microorganisms. After being consumed by a variety of higher life-forms, those building blocks will become the energy sources and building blocks for an assortment of four- and possibly two-legged creatures. Even with so-called sustainable harvesting, the biomass accumulated per acre will be less than if no harvesting was carried out. A similar situation is encountered in agriculture where untouched soils contain considerably more organic matter than farmed land.

Burning a pound of carbon contained in a downed tree will not increase the amount of carbon in the atmosphere by a full pound. How much carbon will be added is a more complicated question, and I would be surprised if it has not been examined in detail. An additional complication with burning wood is that if wood is not burned cleanly, organic compounds can be emitted that cause more global warming than the CO_2 emissions. I guess there are no free lunches—for a cheap lunch, it's hard to beat conservation. Larry Schlussler, PhD • shipping@sunfrost.com

Hello Larry, You didn't really dispute any part of the article, but merely amplified one of the themes it explored, namely *the various impacts that heating with wood can have on the environment. You rightly point out that the carbon in wood can take a long time to cycle back to the atmosphere when a fallen tree decomposes, but that really depends on what type of forest is being discussed.*

Perhaps because of where you live, you left out one important aspect of the life of most forests—fire. While there are a few forests left in the Pacific Northwest that have lasted hundreds of years in an almost undisturbed condition, most forests never reach this pristine conclusion to their evolutionary path. Forest fires are natural and necessary events in the lives of most forested areas, even though humans view them as destructive disasters, and try to prevent and suppress them if possible. A fire sweeping through a forest, particularly one suffering from a drought, dramatically reduces the amount of stored carbon both above and below the soil surface. In such forests, the removal of a portion of annual biomass yield for firewood has only a small impact on the total stored carbon when averaged over several decades.

So, while your comment may be valid for the area in which you live, it is less relevant in areas of lower rainfall where forests are more frequently subjected to fire. As I pointed out in the article, "The key to understanding sustainable forestry is to view the forest not as a museum containing exhibits, but as a living community, which like all communities, is constantly evolving."

This is a complicated issue. A more detailed discussion can be found in a paper I coauthored with my colleague Dr. Ole Hendrickson, a forest ecologist. The article, "Residential Wood Heating: The Forest, the Atmosphere and the Public Consciousness" is posted on our Web site at www.woodheat.org/environment/forest.htm. Regards, John Gulland • john@gulland.ca

Understanding the Schematic

Hello. I have two questions about a diagram in *HP102*, page 49. First you have a butterfly breaker right below the wind generator. It looks like it's the kind where one side is normally open and the other is normally closed. When the switch flips the other way, it looks like you are shunting the wind generator output right back to the neutral side of the generator. Unless I'm misreading the diagram or missing something here, it seems like this would fry the generator.

I'm also wondering why the generator is feeding electricity directly to the batteries without a charge controller in between. There is a controller in front of the heater though. Does this controller just monitor system voltage and bleed off energy whenever a threshold is reached? I assume it would only work when the system is fully charged and the grid is not available. Sorry if these seem like dumb questions, but I'm a systems engineer who loves to look at diagrams, and this one seems a little confusing. Paul • paul@mail.rockeyventures.com

Hi Paul, It's a little hard to tell what's going on with the butterfly breaker in the schematic. It's actually two breakers, configured so that one has to be off when the other is on. It's simultaneously disconnecting the wind generator from the batteries and shorting the wind generator output, which brakes the turbine. This arrangement is necessary because it is dangerous to let the wind turbine run disconnected from the battery. But you don't want to do this shorting without watching the turbine and making sure it actually stops, since you could damage the generator if it continues to run while shorted.

It's very common to have charging sources (especially wind and hydro) go straight into the battery via the appropriate overcurrent protection, and then regulate battery voltage by diverting energy to a dump load directly from the battery. You're correct that in the system profiled in the article, the charge controllers only come into play when the grid goes down. In normal operation, the inverter is "selling the batteries down" to a preset voltage—sending the energy into the grid. Thanks for asking! Ian Woofenden • ian.woofenden@homepower.com

A Better Investment

A comment from out of the blue... It has been suggested that we should eliminate the purchase of any more world oil for the U.S. strategic reserve, that this would eliminate a major demand for the world's current oil production and reduce oil prices (read: gasoline). Great, I would like that.

What if the money that the government is spending on oil reserves could be put into a fund specifically reserved for a rebate program that would pay 50 percent of the cost of solar or wind energy generation systems for residential properties? It should include apartment complexes, condos, and multi- and single-family units. This rebate would encourage a lot of people to install systems like mine in Fresno, California.

Why did I put a system in? My electricity bill from June 2001 to June 2002 was US$4,446 for 23,464 KWH. I fixed this by installing a 10 KW solar-electric system (see pictures and early stats at www.baber.org). A US$40,000 rebate and a US$6,000 state income tax credit reduced my initial cost (US$80,000) to US$34,000. I installed a KVAR power factor correction unit and got about 6 percent reduction in wattage totals. I went to time-of-use billing.

The overall result has been that my June 2003 to June 2004 electricity bill was US$775 for 25,482 KWH (including solar electricity). I saved US$3,671 on electricity, got a new US$10,000 increase in my homeowner's income tax deduction, which saved about US$4,000 in my state and federal income taxes, and received a very good return on investment, at 22.5 percent.

Besides this benefit to the homeowner, my proposed government rebate plan would directly aid the economy by creating jobs for RE installers, creating sales for equipment manufacturers, generating more sales and income taxes, and decreasing demand for oil and gas further by reducing the demand for electricity.

Another major reason for doing this: the distributed electricity production would be much closer to the end users than the existing generation plants. This will do several good things.

- Reduce the needs for new and very expensive transmission lines with their "not in my backyard" and "a possible health hazard" problems.
- Additional electricity production capacity is rapidly obtainable without expensive analysis and studies.

- There are no direct long-term emissions and environmental damages.
- Distributed renewable energy is less susceptible to terrorists.
- The electrical grid will work better with many small sources than it does now with larger plants, although these will always be needed.
- The production from solar-electric modules will generally peak during the time periods when it is most needed, midday to late afternoon.

Yes, I know I'm preaching to the choir, but I did need to get it off my chest once again! Jim Baber • jim@baber.org

Easing into RE

I'm interested in easing into solar electricity without going into debt. My plan is to build a small system and grow it over time. My problem is that I don't know where to start, and I also don't want to buy any equipment that will become obsolete along the way, though I know it will probably be unavoidable eventually. I am going to be moving into an older house that my girlfriend just inherited, so I know that I should probably start by making everything more energy efficient. But again, I don't want any big up-front costs, and I'm just itching to get started, so the major appliances will have to be replaced over time as absolutely necessary. I know this is wasteful from an energy perspective, but the main concern now is initial costs.

My end goal is a hybrid battery/grid-tied system, mainly PV but possibly including wind-generated electricity, but that could be many years from now. The only inverter I'm aware of that can accommodate this system is a very expensive one from Beacon Power. Is there a practical, modular way to eventually do the same thing when I put all the pieces together? I'm thinking of going with some version of the Sunny Boy inverter for now because I like the idea of a series string, to which after having a professional install, I can just add panels as my finances allow. Another idea I have is to run a Sun Frost fridge and SunDanzer freezer, and perhaps a modest battery bank. Given the fact that they are so energy efficient, and I need a freezer and new fridge anyway (since I'll probably do some slight remodeling of the kitchen soon after moving in), would it be practical to go ahead and buy DC appliances, and run them with AC using some sort of converter for now? I know this will make some RE purists cringe, but I need to take baby steps here.

A variation of this idea is to install a few solar-electric panels and forego the inverter for now, making it a DC-only system with just a few basic (though large) loads. How do you go from a small, battery-based system and add a grid connection? On the other hand, if I do start out putting together a small grid-tied system, what options do I have for later adding battery backup? I have enjoyed reading articles in *Home Power* where people put together small, battery-based, office systems, and of course the grid-tied solar guerrillas, but how can I integrate both ideas in stages into an energy-independent home? I know this is short on specifics, but what overall strategies are there for the evolution of a system? Marshal Giggleman • gigglehertz@yahoo.com

Hello Marshal, Good for you! It's a challenge to avoid wasting both money and gear at the end of the line. First off, I'd recommend against the DC-only system. The appliances will be expensive (almost twice what a conventional 120 VAC, Energy Star appliance costs), and they will tie your system to a particular voltage. Running these DC appliances on a power supply from 120 VAC is possible, but inefficient.

The two major RE components that will need to be upgraded over time as your system grows will be the charge controller for the PVs and the inverter. So choose wisely here—this is a good place to spend some money if you have it. Some modern controllers have the advantage of being able to operate over a wide variety of PV input voltages, and this will allow you to upgrade your array without having to replace the controller. There are inverters that can operate with batteries and *tie to the grid. And they are stackable, so you can add more inverter capacity as needed. So start small. Buy a good inverter and charge controller that will last well into the future. Keep adding modules until you need to add another charge controller and inverter.*

And of course, do the efficiency work on the house first! Install those CF lightbulbs, reduce your phantom loads (check appliances in the kitchen and in the entertainment center, since both are probably full of them). If your fridge is more than four or five years old, replace it with a new Energy Star model (I personally like the new Maytags). Holler if you want to discuss this further or if you want more info. Richard Perez • richard.perez@homepower.com

Replacing Appliances

Dear *Home Power*, Thanks for quite a magazine. I hadn't seen it for about ten years and it's come a long way! In *HP101*, a couple of articles mentioned replacing your refrigerator with a more efficient new one. I wonder if you could address the energy, environmental, and production costs of refrigerators vs. operating costs. Also, if I ditch my ten-year-old refrigerator, what should I do with it? If I resell it, doesn't that just mean that someone else will use lots of electricity to keep it running? Sounds to me like a net increase in energy use, not a decrease. If reducing emissions and CO_2 is the goal, is there a good guide to assist consumers in deciding whether we are better off to use the old appliance or automobile until it is completely dead, vs. buying a new "efficient" one?

A good example of this is my car. I use a bicycle for most short trips, but drive about 15,000 miles each year in a 35 mpg Toyota wagon that has 208,000 miles on it. I think about getting a biodiesel-compatible vehicle, but doubt that I will until the body of my Toyota rusts out from the New England road salt. Is this the right choice? How can I find out? Best regards, Becka Roolf • becka@VTBikePed.org

Hi Becka, As far as cars go, yours gets pretty good mileage, so it is not an energy hog relative to most other cars. Plus, the embodied energy in a car is much greater than the embodied energy in a refrigerator, and there are many more nonrecyclable parts in a car than the fridge. So keeping your car may make the most sense. You could also go ahead and get that biodiesel *vehicle, and then sell your car to someone who is not interested in biodiesel, who may have an even older vehicle that gets worse gas mileage.*

The fridge is a different story. In California, where I live, it is against the law to throw fridges away. All major home appliances now get recycled here, and even the utilities have programs that take care of that for you when you take advantage of their offered rebates on Energy Star appliances. Fridges are mostly recyclable, because they are primarily steel, with some plastics that are recyclable. Even the refrigerant in them gets reused rather than released into the air to increase ozone layer depletion. The refrigerant issue does concern me a bit. Older fridges seem more likely to leak their refrigerants, which are quite harmful to the environment.

I have not done a cost-benefit analysis on keeping an old refrigerator vs. buying a new one and recycling the old. There are a lot of factors involved that can vary, like the embodied energy from extracting resources, and manufacturing and shipping the product—even trying to figure out the cost of pollutants that power plants produce. Such an analysis would be difficult to do, but I imagine the info is out there somewhere. My seat-of-the-pants guess is that if you can realize significant energy savings and *properly recycle your old fridge, you and the environment will be better off for having done so. Maybe our readers can point us to information that deals with these issues in a cost-benefit analysis. Thanks for writing. Michael Welch • michael.welch@homepower.com*

RE happenings

INTERNATIONAL

Solar On-Line (SóL); Internet courses on PV, green building, & international development. SóL, PO Box 217, Carbondale, CO 81623 • 720-489-3798 • info@solenergy.org • www.solenergy.org

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

BELIZE

Dec. 6–10, '04; Basic PV; Toledo District. Hands-on workshop with lectures, labs, & installs. Info: hareef99@yahoo.com • www.thefarm.org/etc/belizesolar2004.html

CANADA

Alberta Sustainable Home/Office; Calgary. Open last Sat. every month 1–4 PM, private tours available. Cold-climate, conservation, RE, efficiency, etc. 9211 Scurfield Dr. NW, Calgary, AB T3L 1V9 • 403-239-1882 • jdo@ecobuildings.net • www.ecobuildings.net

CHINA

Oct. 31–Nov. 4, '04; Wind Energy Conf. & RE Exhibition; Beijing. Info: World Wind Energy Assoc., Charles-de-Gaulle-Str. 5, 53113 Bonn, Germany • +49-228-369-40-80 • secretariat@wwindea.org • www.wwindea.org

COSTA RICA

Feb. 21–27, '05; Homebuilt Wind Generators workshop; Fundacion Durika, Costa Rica. Build wind generators from scratch. Info: see Washington State SEI listings.

Mar. 7–13, '05; RE for the Developing World: Hands On; Rancho Mastatal, Costa Rica. Solar electricity, hot water, & cooking; biogas & other RE technologies. Info: see Washington State SEI listings.

GERMANY

Oct. 21–24, '04; RENEXPO 2004; Augsburg. Hydropower, decentralization, biofuels, solar, biogas, energy-efficient construction. Info: Erneuerbare Energien, Kommunikations und Information Service GmbH, Unter den Linden 15 • 72762 Reutlingen, Germany • +49(0)71-21-30-16-0 • Fax: +49(0)71-21-30-16-100 • redaktion@energie-server.de • www.energy-server.com

Oct. 21–24, '04; WoodEnergy 2004; Augsburg. Energy from wood workshops, seminars, & special events. Info: www.ihe-woodenergy.com

Jan. 26–27, '05; Clean Energy Power 2005; Berlin. Consumer & trade fair for RE, alternative mobility, & energy efficiency. Info: www.energiemessen.de

Feb. 25–27, '05; Erneuerbare Energien 2005; Böblingen. Consumer & trade fair for RE & energy efficient building & reconstruction. Info: www.erneuerbareenergien.com

Mar. 21–23, '05; ENEX - New Energy 2005; Polen. RE trade & consumer fair. Info: www.enex-expo.com

SOUTH AFRICA

Apr. 18–22, '05; RE World Africa 2005; Midrand, Johannesburg. Conference, exhibition, & energy fair. Info: Christopher Raubenheimer, +27-11-463-2802 • chris.raubenheimer@terrapinn.co.za • www.powergenerationworld.com/2005/renew_ZA

UNITED KINGDOM

Apr. 18–21, '05; Int. Power Sources Symposium & Exhibition; Brighton Corn Exchange. Storage of RE. Info: Int. Power Sources Symposium • www.ipss.org.uk

U.S.A.

Oct. 2, '04; Green Buildings Open Houses; northeastern states. Homes & buildings open to the public. Learn how to incorporate RE & green building into a home or other building. Info: NESEA, 50 Miles St., Greenfield, MA 01301 • 413-774-6051 • nesea@nesea.org • www.nesea.org

Oct. 2, '04; National Tour of Solar Homes; Everywhere, U.S.A. Info: Local chapters of the American Solar Energy Society • www.ases.org/about_ases/chapters.htm

American Wind Energy Assoc.; Info about U.S. wind industry, membership, small turbine use, & more. www.awea.org

Info on state & federal incentives for RE. North Carolina Solar Center, Box 7401 NCSU, Raleigh, NC 27695 • 919-515-5666 • www.dsireusa.org

Ask an Energy Expert; online or phone questions to specialists. Energy Efficiency & RE Network (EREN) • 800-363-3732 • www.eere.energy.gov

Stand-Alone PV Systems Web site; Design practices, PV safety, technical briefs, battery & inverter testing. Sandia Labs • www.sandia.gov/pv

ARIZONA

Scottsdale, AZ. Living with the Sun; free energy lectures, 3rd Thurs. each month, 7 PM, City of Scottsdale Urban Design Studio. Dan Aiello • 602-952-8192; or AZ Solar Center • www.azsolarcenter.org

CALIFORNIA

Oct. 2–15, '04; Green Building for a Sustainable Future; Garberville, CA. Workshop covers ecological design, green building, RE, greywater, sustainable forestry, & indoor air quality. Info: Heartwood Institute, 877-936-9663 • hello@heartwoodinstitute.com • www.heartwoodinstitute.com

Oct. 16, '04; Green Remodeling Fair; Los Altos Hills, CA. Exhibits, tours, & presentations. Info: Hidden Villa, 26870 Moody Rd., Los Altos Hills, CA 94022 • 650-979-8653 • volunteers@hiddenvilla.org • www.hiddenvilla.org

Oct. 18–21, '04; Solar Power 2004; San Francisco. Conf. & expo for all forms of residential and commercial solar applications. Info: SEIA, 202-628-7745 • ebrown@seia.org • www.solarpower2004.com

Arcata, CA. Campus Center for Appropriate Technology, Humboldt State Univ. Workshops & presentations on renewable & sustainable living. CCAT, HSU, Arcata, CA 95521 • 707-826-3551 • ccat@humboldt.edu • www.humboldt.edu/~ccat

Hopland, CA. Ongoing workshops, including beginning to advanced PV, wind, hydro, alternative fuels, green building techniques, & more. Solar Living Institute, 13771 S. Highway 101, Hopland, CA 95449 • 707-744-2017 • sli@solarliving.org • www.solarliving.org

COLORADO

Carbondale, CO. SEI hands-on workshops & online distance courses on PV, solar pumping, wind power, microhydro, solar thermal, alternative fuels, green building, & women's courses. Solar Energy International, PO Box 715, Carbondale, CO 81623 • 970-963-8855 • sei@solarenergy.org • www.solarenergy.org

IOWA

Prairiewoods & Cedar Rapids, IA. Iowa RE Assoc. meets 2nd Sat. every month at 9 AM. Call for changes. IRENEW, PO Box 3405, Iowa City, IA 52244 • 563-432-6551 • irenew@irenew.org • www.irenew.org

KENTUCKY

Oct. 16–17, '04; Bluegrass Energy Expo; Lexington, KY; Energy efficiency & RE info; Mt. Vernon, KY. Appalachia: Science in the Public Interest. Projects & demos in solar electricity, solar hot water, gardening, sustainable forestry, more. ASPI, 50 Lair St., Mt. Vernon, KY 40456 • 606-256-0077 • solar@a-spi.org • www.a-spi.org

MICHIGAN

Oct. 11–13, '04; Advanced Energy & Fuel Cell Technologies; Livonia, MI. Conference & expo on manufacturing opportunities & challenges. Info: SME Resource Center • 800-733-4763 • www.sme.org/aet

Ferndale, MI. Urban Enviro Living Workshops. 2nd Wed. each month, 7 PM. Sustainability, energy efficiency & conservation, RE, & green building. Potluck. The Green House, 22757 Woodward Ste. 210, Ferndale, MI 48220 • 313-218-1628 • www.greenhouseonline.org

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

NORTH CAROLINA

Oct. 11–Nov. 29, '04 (Mon. nights); Advanced Biofuels & RE; Pittsboro, NC. Biofuels, wind energy, solar, geothermal, & energy conservation. Info: Rachel Burton • wrenchwench@blast.com, or Central Carolina Community College • 919-542-6495 ext. 222

Saxapahaw, NC. How to Get Your Solar-Powered Home; Call for dates. Solar Village Institute • PO Box 14, Saxapahaw, NC 27340 • 336-376-9530 • info@solarvillage.com • www.solarvillage.com

OHIO

Oct. 9–10, '04; Athens Area Sustainability Festival; Athens, OH. Recycling, solar, wind, watershed restoration, organic farming, alternative transportation, local arts, music, theatre, jugglers, food, education, etc. Info: AASF, PO Box 58, Amesville, OH 45711 • 740-448-2696 • media@susfest.org • www.susfest.org

Nov. 9–10, '04; Ohio Wind Power Conference; Cleveland, OH. Educational seminar on wind development for Ohio & Lake Erie. Info: Green Energy Ohio, 866-GREEN-OH • geo@greenenergyohio.org • www.greenenergyohio.org

OREGON

Cottage Grove, OR. Adv. Studies in Appropriate Tech.; 10 weeks, 14 interns per quarter. Aprovecho Research Center, 80574 Haxelton Rd., Cottage Grove, OR 97424 • 541-942-8198 • apro@efn.org • www.aprovecho.net

PENNSYLVANIA

Philadelphia, PA. Penn. Solar Energy Assoc. meeting info: PO Box 42400, Philadelphia, PA 19101 • 610-667-0412 • rose-bryant@erols.com

TEXAS

El Paso, TX. El Paso Solar Energy Assoc.; meets 1st Thurs. each month. EPSEA, PO Box 26384, El Paso, TX 79926 • 915-772-7657 • epsea@txses.org • www.epsea.org

Houston, TX. Houston RE Group: e-mail for meeting times: HREG • hreg04@txses.org • www.txses.org/hreg

WASHINGTON, DC

Dec. 6–7, '04, Renewable Energy in America–Phase II; Wash., DC. ACORE policy conference for developing & deploying RE. Info: American Council On Renewable Energy • www.AmericanRenewables.org

WASHINGTON STATE

Oct. 16, '04; Intro to RE; Guemes Island, WA. Solar, wind, & microhydro for homeowners. Info: Solar Energy International, PO Box 715, Carbondale, CO 81623 • 970-963-8855 • sei@solarenergy.org • www.solarenergy.org • Local coordinator: Ian Woofenden • 360-293-7448 • ian.woofenden@homepower.com

Oct. 18–23, '04; Wind Power Workshop; Guemes Island, WA. Design, system sizing, site analysis, safety issues, hardware specs, & a hands-on installation. Info: see above.

Oct. 25–30, '04; PV Design & Install Workshop; Guemes Island, WA. System design, components, site analysis, system sizing, & a hands-on installation. Info: see above.

WISCONSIN

MREA '04 workshops; Oct. 9, PV Site Auditor Certification Test; Oct. 16–17, Basic PV–PV Site Auditor; Oct. 16, Veg. Oil & Biodiesel; Oct. 16, Solar Water & Space Heating; Nov. 6, Masonry Heaters Intro; Nov. 16–19, Wind Site Assessor Training; & more. Info: MREA, 7558 Deer Rd., Custer, WI 54423 • 715-592-6595 • info@the-mrea.org • www.the-mrea.org

Send your renewable energy event info to happs@homepower.com

Expansion

Richard Perez

I've often said that one of the biggest advantages of a solar-electric system is that it is expandable. When you need more energy, you can simply add more photovoltaic (PV) modules to get that energy.

Our systems on Agate Flat haven't had any new modules added to them since September 1998. We'd been happily cruising along, with more than enough energy most of the time. On the plus side, we'd instituted energy saving measures during this period, such as replacing all our computer CRT monitors with flat-panel LCD displays. This saved at least 2 KWH per day.

On the minus side, we'd accumulated a bunch of new appliances, most notable being the home theater setup with a 31-inch (79 cm) CRT display. This ate up most of the energy we'd saved by replacing the computers' displays. The point here is that few systems are static. They all tend to expand and contract in their energy usage.

The new fridge—an Energy Star, 27-cubic-foot Maytag—with the freezer on the left.

New Fridge

For several years, my wife Karen had been wanting a new refrigerator/freezer. While our ten-year-old Sun Frost RF19 is still trucking along, she felt the need for more food storage space, especially in the freezer. We've been going to town less, and one limiting factor on the time between town trips has been food storage. Add to this that we routinely get snowed in during the winter (six weeks last winter). So we went refrigerator shopping.

One of the criteria for Karen's new fridge was that it have all the conveniences found in a modern fridge—shelves that are easily adjustable, temperature-controlled bins to store veggies and meat, rolling or slide-out bins for the freezer, automatic defrost, and of course, a big freezer. My concern was that this new fridge be as energy efficient as possible. I could see that we'd need to expand our PV production to meet this new energy demand, and I didn't want to buy any more modules than necessary.

After doing some research on the Web, we finally decided on a new fridge—a Maytag model MZD2766. It is a side-by-side door model with a capacity of 27.32 cubic feet (0.77 m^3)—17.01 in the fridge and 10.31 in the freezer. It has all the features that Karen wants, and since it is an Energy Star model, it is relatively low in energy consumption. The Energy Star sticker pasted on the model said that it used 660 KWH per year, or about 1.8 KWH per day.

We placed the new fridge in our backroom pantry, which is uninsulated and not heated during the winter. Six months of the year, the temperature is below 60°F (16°C), and in the winter, below 40°F (4°C). The fridge was so big that we had to replace the outside door of the pantry just to get the beast into the building.

One advantage of running this new fridge in the unheated pantry is that it uses less energy—though the documentation warns that operation of the unit may become erratic if temperatures drop below 50°F (10°C). We've been running it for almost a full year now, and I measure its average energy consumption in the range of 1.5 KWH per day.

Karen is happy! She has lots of fridge and freezer space and no more manual defrosting. Shelves and bins can easily be repositioned to handle oddly sized food packages.

Since I love ice cubes in my drinks, I am happy not to have to jam two small ice trays into the Sun Frost's overfilled freezer compartment. The new Maytag spits ice cubes and cold water right out of the freezer's door. Alhough through-door features can be energy hogs, I figure that it's an "energy wash" since we don't open the freezer door several times a day to get at ice cubes.

The new charge controller—an OutBack MX60.

The new PV array—four Sharp, 185-watt modules running at 48 VDC.

More Energy

I knew that I had to come up with the energy to run this new major appliance. So next it was my turn to do the research and planning for expanding our PV system to accommodate it. Our battery bank and inverters were more than capable of handling the additional load, which was less than 200 watts peak. I just needed the energy.

Since all of our charge controllers were already fully loaded, I decided to establish an entirely new array and run it into a new controller. I settled on four Sharp, 185-watt, 24-volt PV modules on a Direct Power and Water roof/ground PV rack. I planned to wire them for 48-volt operation and run this energy into an OutBack MX60 MPPT charge controller for down-conversion to 24 VDC for our battery bank.

I figured that this new array would make more than 3 DC KWH per day—and about 75 percent of this would be consumed by the fridge. I was also planning ahead for the next system expansion, since in a 24 VDC output configuration, the controller and wiring infrastructure can handle more than double the number of modules we purchased.

My brother Michael installed this new PV array. He has just retired after 23 years with the San Antonio, Texas, municipal utility—the second largest muni in the United States—and is looking to become a renewable energy installer as a second career. He was already an accomplished electrician, and he took the time to do it right. The work turned out beautifully.

This new PV array has exceeded my expectations. It makes in excess of 3 DC KWH per day, partly due to the OutBack MX60's accurate maximum power point tracking. When the temperature is cool, less than 68°F (20°C), the array produces slightly more than its rated output.

So all is well. Karen has the fridge she wants, and we came up with more than enough solar energy to run it. And the newly established path for solar energy into our system can be further increased to handle future needs. What needs? Well, Karen has this electric convection oven and is waiting to give it a try. But that's another story…

Access

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

questions & answers

Concentrator Modules

In the early days of photovoltaics (PVs), there was a lot of work on concentrators—lenses, reflectors, etc. Why is there so little work on these devices today? It seems to me that a simple reflector could produce a concentration of 2x to 4x. Together with a tracker, you should be able to significantly reduce a PV system's costs. The cost of the reflector would be negligible. So it seems that you could perhaps double a system's efficiency. Since I have not seen anybody doing this, what am I missing? Have there been any articles in *Home Power* about concentrators for photovoltaic systems? Chris Wasshuber • wasshuber@lybrary.com

Hello Chris, I ran two different concentrator arrays here at my home on Agate Flat. The best lasted two years before failing. The problem is heat. When you concentrate sunlight, you also concentrate solar heat, which accelerates cell degradation.

Economics also can be problematic with concentrating arrays. Considering the cost of special heat-resistant PV cells, a super-precise tracker, and the necessary heat-sinking to keep the cells cool, more concentration is more economical. The economics break even at about 100 suns of concentration—at this level, the increased performance pays for the additional hardware. The last array I ran concentrated at 300 suns. Its PV cells were the size of a nickel.

We ran a few articles on the concentrating arrays made by Midway Labs in Chicago. They worked well, but didn't last very long—two years at most. Midway Labs went out of business when their main scientist, Dr. Paul Collard, died. It's a real pity that they did not solve the long-term heat problems before then.

Low levels of concentration such as 2x and 4x are simply not cost effective, since the array must still be tracked and the heat removed from the cells. No PV manufacturers will warranty their cells or modules if they are used with concentrators. Richard Perez • richard.perez@homepower.com

First Steps

Hi, I just moved into a house and my first month's electricity bill was way more than what I thought it should be. Is there something that a homeowner can do to cut electricity costs? Thank you. Stephen Smith • bearpol@aol.com

Hello Stephen, First off, here are some simple things to do. Replace incandescent lightbulbs with compact fluorescent bulbs and turn them off when not in use. If your fridge/freezer is more than four years old, replace it with a new Energy Star model. Put plug strips on phantom loads (anything with a clock, such as a VCR, a microwave, or all the electronic stuff that sits in an entertainment center). Install a clothesline and use it when possible instead of a dryer.

Now the more difficult stuff. Examine the home's heating/cooling system—perhaps it is wasting energy. Install an intelligent thermostat that maintains the temperature in a reasonable range. Examine the building for air leaks and plug them. Are the windows double-pane? If not, replace them. In short, give the home an energy audit and find out where the energy is going. Some utilities offer this as a free service. For more information on determining the energy requirements of specific appliances, take a look at the load analysis article by Scott Russell on page 70 of HP102. *Richard Perez • richard.perez@homepower.com*

Septic System Methane

Greetings! I've recently moved to a new house (I constructed it) that has a septic system. The thought has occurred to me that my septic system more than likely produces methane gas. As a result, I've been wondering if someone has developed some sort of a septic system methane digester—something that collects the gas and then compresses it so it can be stored and used. Thanks for any suggestions. Guy Palmer, Lagunitas, California • g_palmer@speakeasy.net

Hello Guy, Folks frequently ask if the methane gas produced by a septic system can be harnessed. The short answer is no. The reason is that the design of a septic system does not foster the conditions that anaerobic organisms require in order to produce a significant amount of gas.

A septic tank is similar to a stagnant pond in your backyard. It will produce a tiny amount of methane gas, but not enough to be of practical use. Anaerobic organisms require three conditions to produce gas effectively:

1. A constant temperature between 95 and 100°F (35 and 38°C). Gas is produced at lower temperatures, but only in very small amounts over an extended period of time.

2. The exclusion of oxygen. A septic tank is not *designed to keep out oxygen. Granted, some oxygen is excluded by virtue of the water in which the organic matter is transported, but a septic tank is not a sealed system.*

3. A gentle mixing action. The bacteria that produce methane either have to be transported to their nourishment or their nourishment has to be taken to them. Gentle motion accomplishes this.

The information needed to grasp the key elements for harnessing anaerobic fermentation effectively can be found at my Web site, www.methane-gas.com. Al Rutan • al_rutan@yahoo.com

Lighting a Ski Trail

HP people, I thought I'd drop you a line since a group I'm working with wants to use solar electricity for a specialized application. We are trying to light a cross-country ski trail for night skiing outside of Boise, Idaho. The trail will be about 1 mile (5 km) long. It will be snow-covered, so the light levels can be fairly low, but a number of poles will be needed to light the length of the trail. System design will be important since it will be replicated on 50 to 100 poles. There probably won't be a need for more than five hours of light per night, and DC is preferred. Have you heard of any projects like this? Where would you recommend I go for more help? Thanks, Mike Purcell • grashpr@cableone.net

Hello Mike, Sounds like a great project for DC photovoltaic lighting systems! It may be possible to use LEDs to light the *way. They are super energy-efficient, can supply low light levels, and are very long lasting. Perhaps some of our readers have experience with projects of this type—I haven't heard of any. But any high quality renewable energy (RE) supplier should be able to help you. Check out our Installers Directory in the back of the magazine, and the RE Directory on the Web site. Richard Perez • richard.perez@homepower.com*

Equalizing

Dear *Home Power*, I'm writing about a problem I think a lot of us have. I have two 6-volt batteries (220 amp-hours) and obviously they need an equalization charge. I gleaned from your pages that for my system, this will consist of approximately five hours of charging at 11 amps, and the volts might reach 16.5. But where do I get a charger that can be set at 11 amps and stay there? John Pielaszczyk • john.p@earthlink.net

Hello John, The exact charge rate is not critical as long as it's 11 amps or less for your battery capacity. A 10-amp charger will be adequate for your system. If you charge at a lower rate, just charge longer. If you are using PV, use the equalize function built into your charge controller. Richard Perez • richard.perez@homepower.com

120 VDC

This is really a two-part question. Is an inverter more efficient at converting 120 VDC to 120 VAC? If it is, would it be possible to wire a bank of ten, 12 VDC batteries in series (120 VDC) to an inverter, but have the batteries be charged in parallel? Love your magazine—a magazine that I actually do read. M. H. • johnnyc12@yahoo.com

Hello M. H., Yes, conversion from 120 VDC to 120 VAC is theoretically more efficient than doing this job at lower voltages. And at least one inverter manufacturer makes 120 VDC models that operate on a battery as you describe. In real life, 120 VDC nominal battery-based, renewable energy systems are uncommon, for several reasons.

Article 690.71(B) of the National Electrical Code (NEC) *discourages the use of storage batteries operating at above 50 VDC nominal. Higher voltage battery banks pose an increased shock hazard. It's possible to charge a high-voltage battery bank from a lower-voltage source using parallel wiring as you suggest above. But it would require the use of electrically isolated PV arrays, array wiring, charge controllers, and overcurrent protection devices. Doing this is simply not cost effective, and would lead to less than ideal battery charging/discharging, ultimately decreasing a battery bank's operational life. Finally, the conversion efficiency gain from increasing the DC input voltage of battery-based inverters would likely only be a percent or two at best. Combine this with the hurdles mentioned above, and you see why most battery-based inverter and charge controller manufacturers are sticking with 48 VDC nominal as the high design voltage today. Best, Joe Schwartz and Richard Perez • joe.schwartz@homepower.com • richard.perez@homepower.com*

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- Top-Ten Green Building Products from the Experts
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- Anatomy of a Simple Solar-Electric System

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