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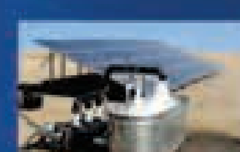

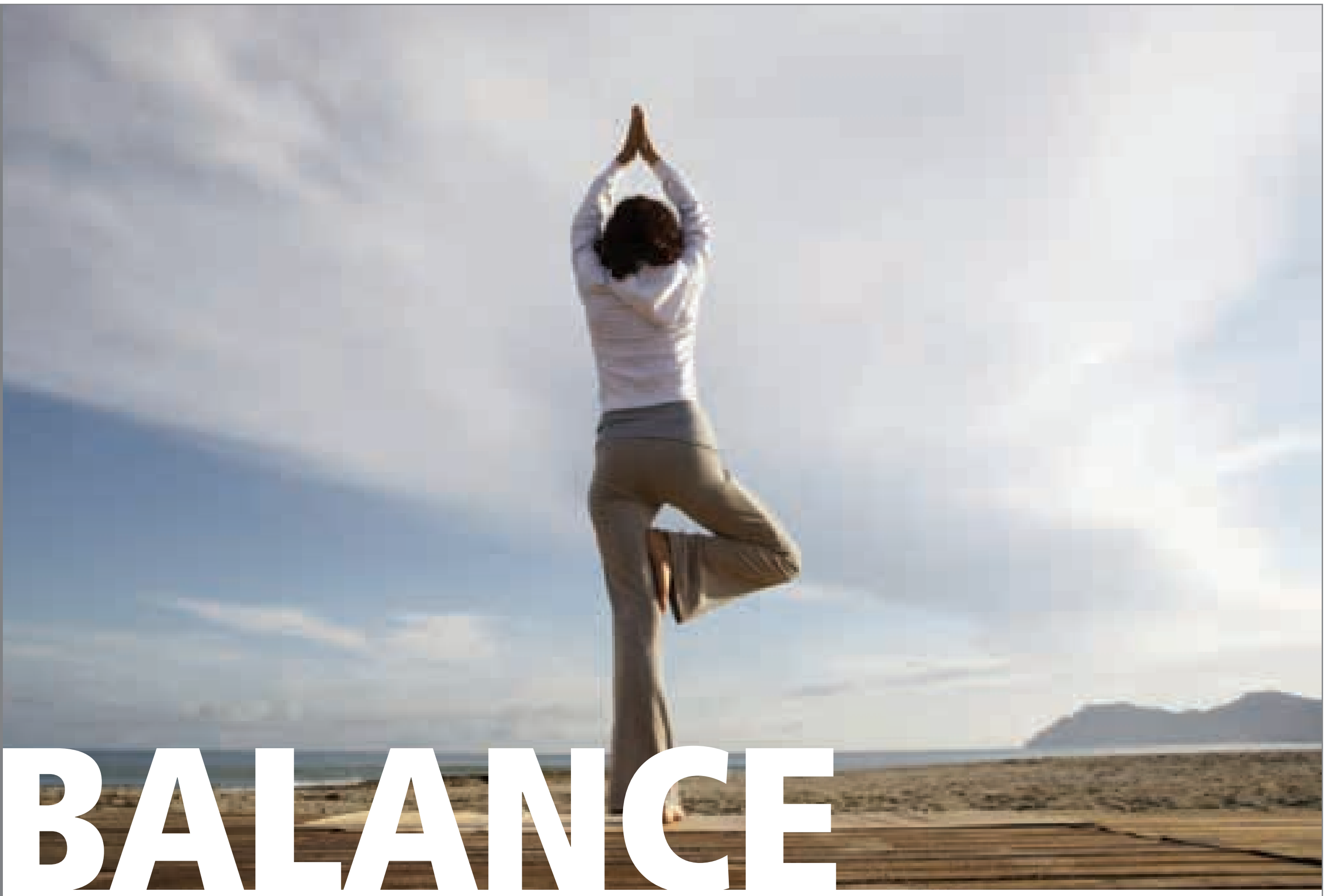

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Towerful

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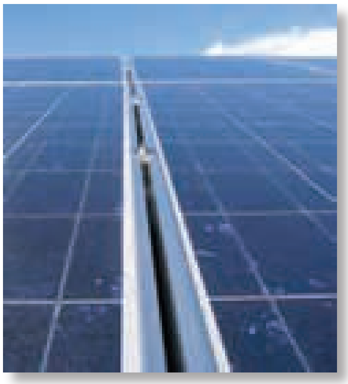
February & March 2007

On the Cover

Ginger D'Olivo and Tom Frantz take stock of a creek's microhydro potential.

Photo by Shawn Schreiner



Regulars

from us *to you*

Offshore wind turbines between Malmö and Copenhagen. Photo: einbo

YES, In My Backyard

Last fall I traveled back to my childhood stomping grounds in New England, and spent a weekend sailing with my sister's family in Nantucket Sound. The docks were filled with locals debating the proposed Cape Wind Project, which would place 130 turbines in the Sound. Opponents were quick to voice their opinions that the project would ruin the Sound's view, and stifle the local tourism-based economy. And while it's a little hard for me to admit it, while I was at the helm and taking in the beautiful coastal landscape, there was a moment when I thought, "I can see why people wouldn't want wind turbines here."

Months have passed, and I still ponder the thoughts I had on the water. I live off the grid with solar electricity, contribute to a magazine that has been promoting renewable energy for two decades, and firmly believe that renewables will be the major component in creating a sustainable global energy supply. Plus, I just plain love to watch big wind gennies spin. Back East, I had experienced a classic "not in my backyard" moment, even though coastal New England hasn't been my backyard for close to twenty years.

The fact is, we all use electricity. And the resources required for its generation must come from somewhere, whether it's strip mines covering hundreds of square miles in Appalachia, coal-fired plants in the Midwest pumping out emissions that fall as acid rain in upstate New York, a nuclear plant on the coast of New Hampshire, or wind turbines in Nantucket Sound. Our nation's geographic dispersal of per-capita wealth and influence determines which communities will bear the brunt of our energy choices, and this probably will not change anytime soon. What *can* change are the energy sources that each of us chooses to support, and the awareness of how our decisions affect others.

Early this morning, as I sat outside with a cup of coffee, I noticed the eastern sun glinting off the solar-electric arrays in my meadow. It felt good to be responsible for making my own pollution-free electricity, and yes, to be doing it in my own backyard.

—Joe Schwartz, for the *Home Power* crew

Think About It...

"Give Americans the facts and they'll do the right thing."

—Harry S. Truman

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Managing Editor	**Claire Anderson**
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Ask the EXPERTS!

Wind System Choices

I'm planning to have a wind-electric system installed at my rural property. I have utility service at the site, and I'm on the fence about going with a battery-based, grid-tie system, or going with a batteryless system. The grid goes down a couple of times a year, and the longest outage lasts an hour or two. Any recommendations for including batteries or not?

Dean McAllister • Dubuque, Iowa

Courtesy www.solarwindworks.com

Modern inverters and wind generators, like this Proven turbine, make batteryless grid-intertie wind-electric systems a reality.

Technically, financially, and environmentally, it's easy to conclude that you should purchase a batteryless wind-electric system. It will be lower cost, simpler to install, easier to maintain, and more efficient than a battery-based system. To me, it's a huge waste to buy, maintain, and charge a battery bank day in and day out, so that you can have a bit of electricity backup for the few hours out of a year when the utility is out.

But this conclusion may not take into account your needs and desires. You don't mention why you want a wind-electric system. If it's because you want uninterruptible electricity for critical loads, a batteryless system will not fill that need, since it's designed to shut down when the utility shuts down. But you should know the cost of your backup system—in dollars, system efficiency, and environmental impact.

SMA America's Windy Boy batteryless inverter.

For example, with Bergey Windpower's Excel line, the manufacturer estimates that the battery-based version produces about 15 percent less energy overall than the batteryless version. This, of course, depends on the size of the battery bank, as well as other factors. But I suspect that 15 percent loss is close to the best-case scenario with small wind-electric systems, and urge you and others to be realistic about the losses incurred when adding batteries to a system.

OutBack's battery-based inverter.

Ian Woofenden • *Home Power*

Rescuing Damaged Batteries

OK, I'm really mad at myself. I have a set of two new golf-cart batteries that had been sitting for a while. They weren't being used. I was waiting to finish some system upgrades before I installed them. I had them on a trickle charger from time to time just to keep them going, but I wasn't monitoring them very often. The water level dropped enough to barely expose the plates in one cell. Is there any way to save these batteries? So far, all I've done is put in enough distilled water to cover the plates again.

Tod Whitehurst • Blacksburg, Virginia

You've already learned the first lesson of working with battery-based renewable energy systems—don't purchase your batteries until you're ready to install them! For optimal longevity, deep-cycle batteries should receive a full charge at least once a week, and be cycled (discharged to 50 percent and then recharged) every month or two. Flooded lead-acid batteries require an equalization charge four to six times a year. These three requirements are difficult to fulfill if the batteries are not installed in a working system.

(continued on page 14)


Now appearing in backyards everywhere.
Small wind has never been so easy. Announcing the Skystream 3.7™ residential power appliance. It's the first compact, utility-connected, all-inclusive wind generator designed to provide inexpensive, quiet, clean electricity to reduce or eliminate your home's monthly energy bill. Learn if Skystream can work for you at www.skystreamenergy.com.
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Battery electrolyte levels should be checked regularly—every one to three months, depending on how high the system's charge regulation voltage is set and how large the charging source (PV, wind generator, microhydro turbine, engine generator) is, compared to the battery bank's capacity. Once you live with the system for a year or so, you'll have a good sense for how often the batteries need to have distilled water added.

Exposed battery plates should definitely be avoided. Once the plates are exposed to air, oxidation occurs and the surface area of the plates that were above the battery water level will be damaged, resulting in a loss of capacity for that cell. The fact that your batteries were using water when they were in storage and being periodically trickle-charged is actually a good sign. It means they were being fully charged, at least periodically.

Since you've already purchased the batteries, install them in your system and see how they perform. If you're lucky, they may operate well, with only a minor loss of capacity. Once the batteries are installed, gradually increase the charge regulation voltage over the course of several charging cycles. Start at 14.2 VDC and increase to 14.8 VDC. Keep the regulation voltage at 14.8 volts for a few weeks, before reducing it to the setpoints recommended by the battery manufacturer. The high charge voltage will cause battery gassing, and help to physically mix the battery electrolyte and distilled water, which probably have stratified over time due to lack of regular charging. Next, within the time frame that you're ramping up the regulation voltage, cycle the batteries—draw them down to 50 percent state of charge and recharge them several times. Finally, after you've run the batteries through the cycling routine, perform equalization charges monthly for the first few months.

Well-maintained batteries can provide years of service.

Last but not least, it's always a good idea to install a battery monitor (amp-hour meter) in all but the smallest stand-alone battery systems. The monitor will allow you to effectively track the state of charge of your batteries, and will also provide historical data if troubleshooting is required. Good luck!

Joe Schwartz • *Home Power*

Certification for Tax Credit

I'm looking at installing a solar water heating system. I have noticed that some vendors are saying you have to purchase an SRCC certified system to qualify for the federal tax credit. Is this true? If true, it makes no sense if someone wishes to pick and choose system components to best suit their situation. Is it your understanding that just the collector needs to be certified or the whole system (SRCC protocol OG-100 or OG-300)?

Bob Lobsiger • Gretna, Nebraska

Courtesy www.solarthermal.com

If you want to take advantage of the federal tax credit for your solar hot water system, make sure your collector has SRCC certification.

At the very least, the *collector* will need to have SRCC certification for the system to be eligible for the federal tax credit. According to SEIA's *Guide to Federal Tax Incentives for Solar Energy*:

Credits can only be claimed on solar hot water heaters that have been certified for performance by the nonprofit SRCC or by a "comparable entity" endorsed by the state government in the state where the water heater will be used.

It's unclear whether the tax credit stipulations requiring certification apply only to the collectors or to the whole system. Since the IRS has never clarified this, an OG-100 would seem to meet the language of what constitutes "certified" property. Or you could choose from among the many OG-300 certified systems, which all use collectors certified to the OG-100 standard. Installing an OG-300 system would eliminate any concern about compliance with the federal tax credit regulations should the IRS decide to rule on this topic at some future point in time.

Chuck Marken • *Home Power*

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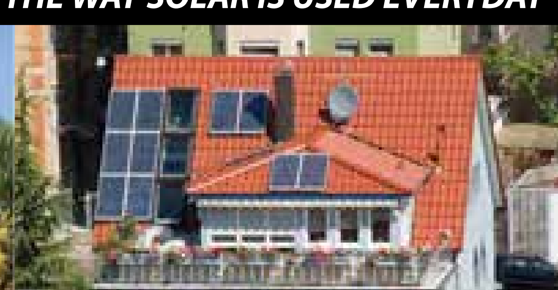


BUS STOPS | **CONSTRUCTION** | **HOME LIGHTING**

Efficient Motion Sensors

I have been trying to link motion sensors to LED lights to try to minimize energy use in rooms in my house that are traversed frequently, but seldom have occupants for any length of time. These same rooms seem to have the lights left on regularly. How much electricity do the motion sensors use? Do they all require a high power threshold to switch on? One of the sensors that I use requires a load of 40 watts to work. Clearly, I do not need 40 watts' worth of LED lights to navigate the basement or find things in the pantry. Is a motion sensor commercially available that doesn't use much energy itself, and that I can use with small loads such as LED lights?

Craig Doser • via e-mail

RAB Electric's 12-volt motion sensor.

It's certainly possible to do the job with minimal energy use—you simply need to shop for the appropriate equipment. RAB Electric makes a motion sensor that operates from a 12-volt battery and can switch up to 8 amps DC. It draws only 7 milliamps in idle, and 40 milliamps when powering a load. It will turn lights on at approach, and hold them on for an adjustable time, from 5 seconds to 12 minutes after motion stops. Sensitivity distance is adjustable, up to about 50 feet. For loads larger than 8 amps DC, or to control 120 V loads (without an inverter being on 24/7), use an external relay. The motion sensor then simply controls the coil of the relay; the power source and load are connected to the common and normally open contacts of the relay, respectively. If you do not need to have the light on a lot and have a way of running a wire from your basement to an outside wall with solar exposure, you might consider using a solar-powered, motion-activated security light. The entire lighting system costs only a few dollars more than the RAB motion detector.

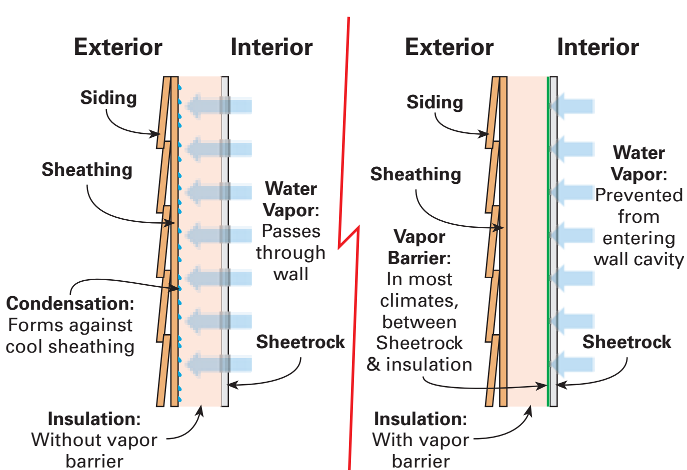
John O'Hara • Backwoods Solar

Vapor Barriers

I'm planning to build a house and I'm confused about vapor barriers. Where exactly should they be installed for ceiling/roof, walls, and my crawl space?

Jon Miltstead • Poughkeepsie, New York

Vapor barriers impede the flow of water vapor as it travels from "more to less" as well as "from warm to cold." Common vapor barriers used with insulation include 4-mil or 6-mil polyethylene plastic, and you can also purchase batt or blanket insulation with an attached vapor barrier, usually made of coated kraft paper or foil-backed paper.



It's most important to prevent warm, moist air from entering your building envelope. Moisture problems mostly occur when warm, moist air is allowed to condense on a cold surface. One way to avoid these problems is to build walls and roofs that use "solid" nonconvective construction, like structural insulated panels (SIPs). Another strategy is to "outsulate" the building envelope (with rigid insulation under the siding).

Because different climates call for different strategies, it's important to know the vapor profiles of the entire wall assembly, including the materials incorporated into the building envelope. In general, vapor barriers are most effective in extreme climates, where the differences between indoor and outdoor temperature and humidity are great.

An excellent online resource is www.buildingscience.com. You'll find house design recommendations by climate regions, and extensive resources that further explain the issues surrounding if and how vapor barriers should be installed in your particular design and climate. Do your homework first!

Rachel Connor • Solar Energy International

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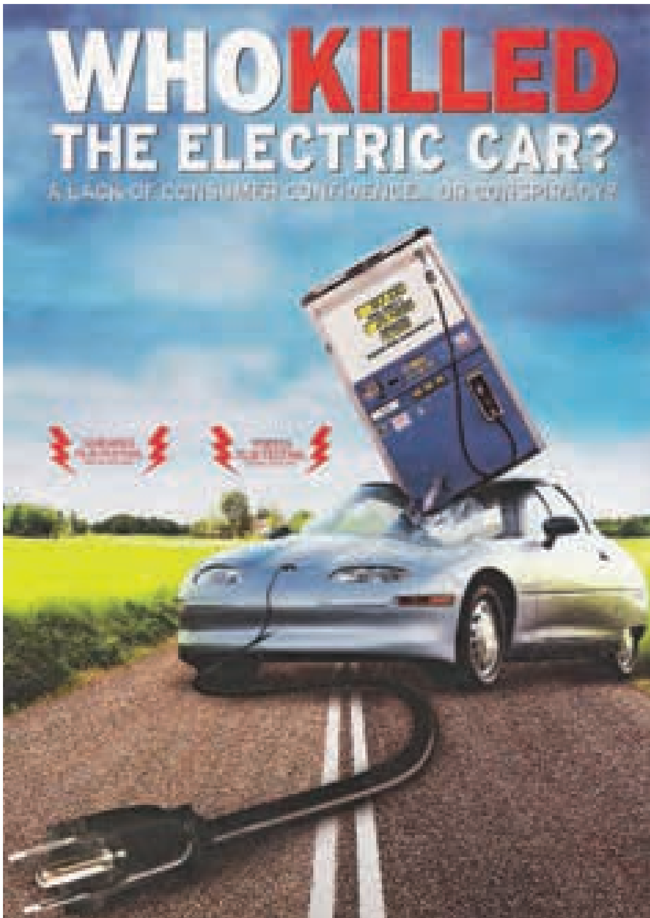

Courtesy of www.sonyclassics.com/whokilledtheelectriccar

Bring Back Electric Vehicles

Yesterday I saw the film *Who Killed the Electric Car?* at the local movie palace. The brutal crushing (literally!) of the EV1 project by the General Motors Corporation was shown in a somewhat heavy-handed style reminiscent of filmmaker and activist Michael Moore, but was very moving. The woman who watched it with me (one of my off-grid customers) wept at several points during the screening. Bring back the CARB (California Air Resources Board) clean air requirements! Hurrah for zero emission vehicles! I want a Xebra PK!

Nick Houser, Off Grid Services • Powell River, British Columbia

I second the motion! This is a very clear and balanced film on the issue of electric vehicles, and their history and potential in our society. The film is now available on DVD. I recently purchased a copy, and we'll be having a public showing in our community later this month. I encourage other *Home Power* readers to do the same.

Ian Woofenden • *Home Power*

PV in the Netherlands

I recently installed a grid-intertied solar-electric system. I have made a simple Web site about this installation at www.jharingman.demon.nl. Unfortunately, I am one of few people in the Netherlands who install solar-electric modules these days, due to the total lack of incentives. Our government thinks that building nuclear power plants, and shipping wood chips from Canada and burning them here is a more efficient allocation of money.

I have a different opinion. I think individuals should be encouraged to conserve energy, and if possible, produce their own in a renewable way. Measures to reduce our home's electrical consumption led to an annual usage of only 1,000 KWH for our two-person household (as opposed to the 3,500 KWH usage for the average Dutch household). This enables a relatively small system (555 Wp) to cover about half our annual consumption. I enjoy your magazine greatly—keep up the good work! Sunny regards,

Jeroen Haringman • Netherlands

Recycling

Mike Dalton's letter about lending *Home Power* magazines and not getting them back reminded me of a related problem I had. I lent out three issues to a friend, being careful to stress that I really wanted them returned. I even put a "Please Return to..." sticker on the front, along with my phone number.

Months later, another friend was at the local dump doing a little picking up as well as dropping off. He found all three magazines and returned them to me—after reading them of course. There's more than one way to spread the word!

Jim Palmer • Courtenay, British Columbia

RE Missionary

It's hard to believe it has been more than ten years since I became a huge fan of your magazine. I lived and worked on a missionary station in remote southwestern Ethiopia from 1993 until 2001. The senior missionary, Fred Van Gorkom, had a collection of your magazines from *HP1*, and I read through all of them.

Thanks to your dedication, service, and educational articles, not only did I live long enough to hand my translation project over to my Ethiopian co-workers, I was also able to leave them with a reliable renewable energy system to run their computers and printers. (Not to mention a solar pump on the well, and a good rainwater catchment system.)

Since returning to the United States, and living on the grid, I thought my days of renewable energy sources were just going to be an interesting footnote on my résumé. Well...I have a friend who is in a monastery (www.monasteryofstjohn.org), and they have recently acquired 42 acres near Lassen Volcanic National Park, in California. They have great plans for using renewable energy for their lighting and heating, if possible. But they need some guidance in terms of design and materials.

When the abbot, Father Jonah, asked me how much I knew about solar electricity and water heating, I immediately felt immensely under-qualified and thought, "Gee, wouldn't it be great if Richard and Karen Perez and all those folks at *Home Power* could be here?"

John Chan • Nanuet, NY

Thanks for the kind words, and we hope your friends at the monastery will look for qualified local help to set up their solar energy systems. Maybe you'll write about these projects for *Home Power* when they are done.

Ian Woofenden • *Home Power*

Debating Renewable Options

Over the last several issues, you have featured articles discussing and debating technologies such as hydrogen and biofuels as replacements for our current fossil-fuel-derived energy sources. Although I have enjoyed reading these widely varied opinions on these subjects, one theme seems to be running through all of the discussions—no single replacement technology can fill the rather enormous void that will be left when we run out of fossil fuels.

Therefore, would it not be a more sensible approach to get all of these brilliant minds working toward a sustainable *set* of technologies that will be able to replace fossil fuels? It seems to me that we are sitting around debating what direction to go when we should be going in all the various directions and looking to match the positive attributes of each sustainable technology with the particular fossil fuel it will be able to help replace. Although it would be absolutely great to solve all our energy problems with a single technology, I just don't see that happening. Use solar electricity or heating where it makes the most sense. Use microhydro where it makes sense. Use biofuels where they make sense.

"No single replacement technology can fill the rather enormous void that will be left when we run out of fossil fuels."

Finally, significantly improve our methods and processes for storing energy. I firmly believe that a very robust set of energy storage technologies are key to replacing fossil fuels. We must collect our energy when there is an abundance and be able to store it for when there is a deficit.

I believe that these and other yet-to-be-discovered sustainable technologies should be researched, developed, and

"With the availability of renewable energy technologies, just how 'necessary' is it to build yet another coal-fired power plant and develop more strip mines?"

deployed—and then let the markets decide the fate of each. If we, as a world, lose our "one-time use" mentality and begin to think about how to maximize the use of *every* resource, we will begin to make real progress. I also believe we need to change our definition of what a "resource" is. As a recipient of the Boy Scouts of America's Wood Badge, an adult-leader training award, the very first two lessons we learned were: 1. Fully use all available resources. 2. *Everything* and *everyone* is a resource.

Let's see more articles exploring ways to make these sustainable technologies work to reduce or replace the fossil fuels, and let's quit debating on which approach is right. If we apply the technologies correctly, we will build a sustainable cycle. If we don't, the entire process will fail. We can keep the technologies that work and shelve the ones that don't, while keeping in mind that all technologies are not right for all situations. Thank you,

Greg Guldenschuh • Grayson, Georgia

Propose Solutions

I can't find a lot to argue with in Michael Welch's *Power Politics* column about energy and environmental justice in *HP115*. What he writes about is the reality of what is happening in the United States today. My concern is that he gives us no alternative. I have always been taught that if you want to complain about something you feel is wrong, come up with an alternative.

Here's the reality: If you try to put any type of energy generation facility near a community that is well off, you will spend decades in court paying expensive

lawyers, and eventually either give up or get shot down. The only place these service businesses can get anything done is in places where either the people are too poor to fight it, or where there is a small population. Everyone immediately starts with "not in my backyard" (NIMBY), and if the community has the financial resources, they will eventually win.

What alternatives do you propose? If you make it so that these necessary industries cannot be built anywhere, what then? The businesses have to have somewhere to build the plants, dumps, factories, etc., to supply the necessary services. Where do you propose they do this in a cost-effective manner, in a reasonable amount of time? The environmental justice movement you write about seems like an extension of NIMBY to "not in *anyone's* backyard," which is a very unrealistic stance to take. How about answering some of these questions in one of your future articles? Sincerely,

Kevin Kleinhomer • Newark, Delaware

I wrote about environmental justice (EJ) because many folks have not even considered the concept. The EJ movement is relatively new and just beginning to have some effect, as more and more people are finding out about the inequities that exist. If the movement gets enough of a voice, maybe polluting industries will no longer find it easy or inexpensive to burden *any* community—rich or poor—and be forced to seek less-polluting alternatives instead.

Poor communities should not be the dumping grounds of the privileged and powerful. I also believe that if our society is to prove successful in the long run, the poor will need to have voices just as loud as the wealthy. As for how to accomplish this, I am not sure. For example, there has been a lot of antiracism work done for a long, long time, yet our society still has to deal with racist attitudes. We don't just give up on fixing problems like these.

It will help if people start by recognizing that environmental justice problems exist. Then, just like with other addictions and poor habits, we can deal with them, which means understanding the problems and mitigating them when decisions need to be made.

It is far too easy to dismiss social and environmental problems by labeling them NIMBYism. There are many things that should not be in *anybody's* backyard. With the availability of renewable energy technologies, just how "necessary" is it to build yet another coal-fired power plant and develop more strip mines—especially when faced with global warming and diminishing supplies of clean water? We have pollution-free solutions to energy production—we just need to use them.

Michael Welch • *Home Power*

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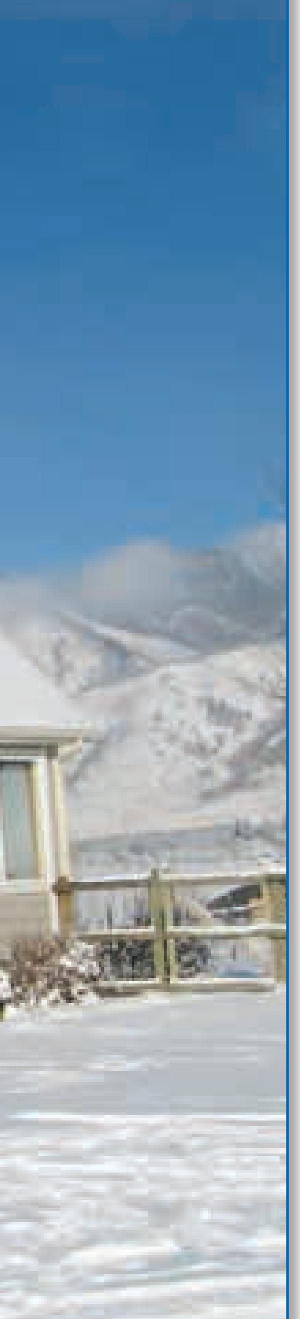
Passive Solar Retrofit

Custom-built glazed doors can turn your garage into a sun-warmed winter workshop.

...in a Weekend

by Gary Reysa

Having a shop or studio in the garage can be a great use of space, but garages aren't always pleasant places to work. They can be frigid in the winter, sweltering in the summer, and cavelike at any time of the year. This weekend project will make your garage a more comfortable work space, while reducing your energy consumption from lighting and space heating.



The biggest boon is that you can do this weekend retrofit yourself for about $400. Depending on your climate and energy costs, you can recoup that expense with utility bill savings over the first winter or two. At about $4 per square foot, these simple solar collectors can do as good a job of solar heating as commercial collectors costing $30 per square foot—and they give you the added bonuses of natural lighting and a view to the great outdoors!

Project Overview

This inexpensive and easy-to-build project converts a garage that has a south-facing overhead door into a solar-heated and lighted workshop, studio, playroom, sun space, or greenhouse, using readily available materials and hardware. If you're handy with a few power tools, you're good to go, with one caveat—if your garage door doesn't face south, this project won't work for you. (If you're still interested in heating the garage with solar energy, take a look my other article, "Build a Solar Heater for $350" in *HP106*, which details how to construct a solar hot air collection system.)

The solar "collectors" are a set of custom-built glazed doors mounted to the existing garage door frame, just outside of the garage door itself. Each set consists of two doors hinged at their vertical edges to open outward. The new doors are about 80 percent glazing to admit as much sunlight as possible.

The large expanse of glazing admits low-angled winter sunshine directly into the garage, warming the concrete floor and other surfaces. The thermal mass of the floor and shop's contents absorbs the sun's heat energy and then slowly distributes it into the space. On partly cloudy or thinly overcast days, solar thermal energy will still provide quite a bit of heat, but on heavily overcast days, you may need to use a supplementary heater. An optional screen of greenhouse shade cloth, suspended from a horizontal wire just inside the existing garage door, reduces daytime glare, while still admitting ample light and maintaining a screened view to the outdoors.

Project Pros & Cons

Pros:

- Makes the garage/shop a comfortable, well-lit place to work
- Reduces need for daytime electrical lighting
- Saves money and reduces greenhouse gas emissions by not using fossil fuels for heating and lighting
- Reduces the need for auxiliary heating
- Inexpensive
- Requires only basic tools and carpentry skills
- Is attractive (even better-looking than the original garage door)

Cons:

- You have to remember to raise the garage door in the morning and shut it at night
- By itself, provides less security than the garage door (substituting twin-wall polycarbonate glazing could help, because it's more impact-resistant than acrylic)
- On cloudy days, some form of backup heat may be necessary to keep the shop space comfortable
- Over time, the acrylic panels may become scratched, marring the glazing's appearance
- Outward-opening doors might be an inconvenience, especially if there is a lot of snow and ice on the driveway or it is necessary to park close to the building

Glazed doors provide passive heating and natural lighting for the garage–workshop.

Two of the four "solar" doors installed on the right side of the center column (not yet finished). The original garage door can still close, providing some nighttime insulation.

The column is made from three 2 by 4s nailed together. The top and bottom of the column are attached to metal plates that are lag-screwed to the concrete floor and the upper door frame. To restore the full-width opening of the garage, the column can be removed by taking out the lag screws. To mask the ganged 2 by 4s and match the existing door frame, you can add trim pieces to the outside of the column.

Door Frames. The column divides the open garage door frame into two spaces, which can be further divided by door panels, depending on the width of the openings. In this case, two doors were designed to fit each of the approximately 8- by 8-foot openings on either side of the column. In each opening, one door is hinged to the existing garage door frame, and the other door is hinged to the new column.

The door frames' minimal construction allows for maximum glazing area. If you plan to open and close the doors a lot, consider somewhat beefier construction. My doors are made with 5- by 1 1/4-inch pine boards milled from rough-sawn lumber, locally purchased. They can also be constructed using 2 by 6s.

Be sure to reinforce the corners of the panel frames. I used glue and biscuit joinery to make the corner joints, but you can also use pocket screws, plywood gussets, or metal plates. If you anticipate opening and closing the doors frequently, good corner reinforcement is imperative. Before gluing the corner joints, make sure that the door frames are square by checking that the diagonal corner-to-corner distances are equal. Use a high-quality, water-resistant carpenter's wood glue (also known as "yellow glue") or, for even better weather protection, polyurethane glue.

Glazing. The glazing panels are 3/16-inch-thick acrylic. Each door panel required most of a 4- by 8-foot sheet of acrylic. The glazing sits in a rabbeted groove that is cut around the inside of each framed section. I made the rabbets by simply routing around the inside of each door frame. To allow room for thermal expansion, cut the acrylic panels to leave a 1/16-inch clearance all the way around. Secure the glazing to the door frame by running a light bead of silicone caulk in the rabbeted groove, setting the glazing in the frame, and then nailing a small piece of 1/2- by 1/2-inch wood molding to the frame.

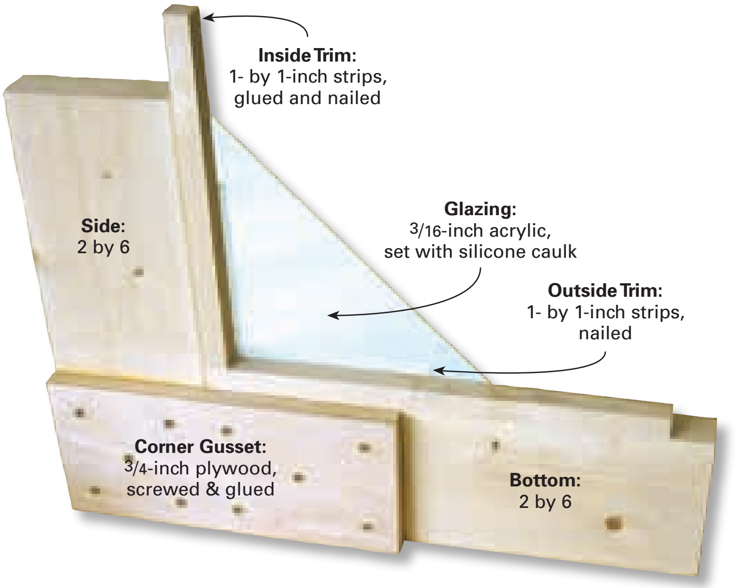
If you don't have access to a router and biscuit joiner, you can construct the door frames as shown at left, using 2 by 6s for the framing, and plywood gussets glued and screwed to the door frames at the corners. Two 1- by 1-inch frames, attached to the 2 by 6s and spaced apart, hold the glazing in position. This technique results in a strong and attractive door frame.

Project Details

This is how I designed my doors, but you'll need to customize the construction details to suit your garage door opening's specific dimensions.

Center column. A removable column in the middle of the existing double-wide garage door opening supports the two center doors, which are hinged on the center column.

Alternative Frame Construction Details



As an alternative to using acrylic glazing, you can use twin-wall polycarbonate panels. The twin-wall material is extremely tough and more impact-resistant than acrylic. Although the polycarbonate panels will obscure the view, they'll still allow up to 85 percent light transmission. Another option is to use acrylic panels on the upper frames and twin-wall on the lower frames to preserve some view, while providing some privacy.

Mounting. After the doors are completed, prop them into the openings, and trim as needed to make them fit properly. Mount the doors at least 1/4 inch above the floor so they will open without scraping on the concrete. To allow for thermal expansion, I left 1/4-inch gaps all the way around and between the doors—the weather stripping you will install later does a good job of sealing these gaps. Check carefully that there are no clearance problems with the existing garage door or frame.

Outside view of the removable center column, trimmed to match the existing frame.

Inside view of the bottom of a door pair, without trim strip installed. Toggles hold summer reflector panels in place.

Inside view of the top of a door pair with stop block. A trim strip and weather stripping reduce air infiltration.

Keeping Cool in the Summer

Lots of thermal gain is great for keeping your workshop warm in the winter, but what about preventing overheating in the summer? Without an adequate roof overhang on the building's south side, the temperature within the work space can become uncomfortably hot. Here are some ways to control summertime temperatures:

- Keep the overhead garage door closed. This is effective, but you'll lose the daylighting and view.
- Open the garage door and the glazed doors to allow more ventilation.
- Build an overhang above the glazed doors that blocks the high summer sun, but still allows the winter sun to enter (see www.builditsolar.com/References/SunChartRS.htm#Overhangs).
- During the summer, install reflective, 1/8-inch-thick, white hardboard panels just behind the glazing in the lower sections of the doors, using "toggle" strips to secure them. These panels will reflect most of the sun, and the upper door sections will still allow daylight in and views out. Most lumberyards carry inexpensive, 1/8-inch hardboard with a glossy white finish that works well. Attach flat wood strips horizontally across the back of the frame to keep the panels from warping.

To prevent your shop from overheating in the summer, install 1/8-inch, white hardboard panels on the inside of the lower door panels.

Once you are satisfied with the fit, use three door hinges to attach each door to the existing garage door frame and new post. As a general rule, use one hinge for every 30 inches of door or fraction thereof. I used ordinary door hinges, which have worked fine, but heavier hinges could be used if the doors get a lot of use.

Weather Stripping. Once the new doors are in place, they should be weather stripped to help curb air infiltration. I used vinyl "garage door" weather stripping around the top and sides of the doors. To prevent drafts from entering below the doors, I attached a 1 1/2- by 1/2-inch wood strip to the garage floor using concrete fasteners. The doors butt against this strip when closed. The strip reduces air infiltration, and is still easy to drive over. To seal the vertical joint between the doors, I attached a 1 1/2- by 1/2-inch wood strip to one door so that it overlaps the other door when closed. Don't forget to search for other areas where air could enter, and seal them up.

The doors are latched from the inside by simple door bolts attached to the upper and lower portions of the doors—one set of latches per pair of doors. The bolt seats into holes drilled into the concrete floor and into the garage door frame. I use the west-most two doors so infrequently that I just screwed them to stop blocks mounted on the floor and door frame—this is simple, and it only takes a couple of minutes to remove the screws if a door needs to be opened.

Finishing Touches. A 1/16-inch steel cable stretched across the garage's width and anchored to the side walls supports the shade cloth. The support cable is about 7 1/2 feet above the floor, and runs just under the opened overhead garage door. A turnbuckle at one end allows the cable to be stretched tight. The shade cloth I used is 6 feet tall; I cut three 83-inch-wide panels to overlap a bit and fit across the 18-foot door width. Shower-curtain hangers suspend the cloth from the cable, allowing each panel to be drawn to the side when not in use. Shade cloth comes in a wide selection of colors and densities. Even a dense cloth, rated to block about 85 percent of ultraviolet light, still allows light to enter the shop while permitting a very diffuse view out.

Solar Retrofit Costs

Needed Items	Cost
4 Acrylic sheets, 4 x 8 ft., 3/16 in. thick	$280
Glue, screws, caulk, hinges, latches, paint, weather stripping, etc.	70
14 Studs, 2 x 6, 8 ft. long	50
Total, Needed Items	$400

Optional Items	
Greenhouse shade cloth, 120 sq. ft.; plus 18 ft. of steel cable	$60
2 Hardboard panels, white, 4 x 8 ft.	16
Total, Optional Items	$76
Grand Total	$476

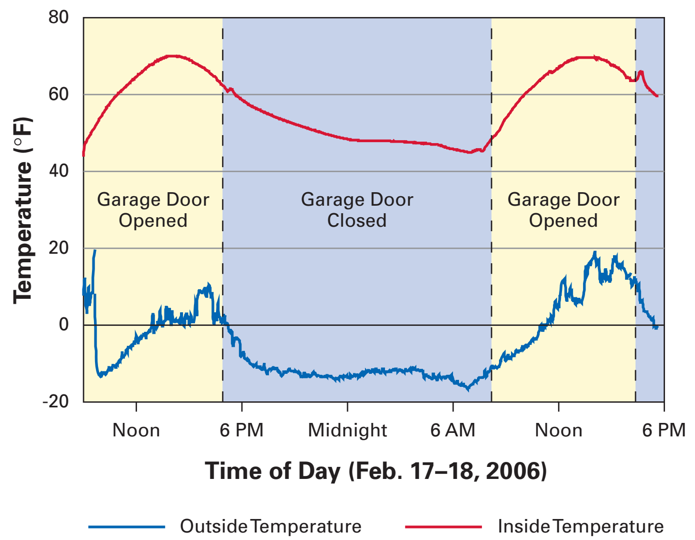
Operation

On sunny days, I open the overhead garage door, leaving the glazed doors shut. The thermal mass in the garage floor and the shop's contents absorb solar energy and redistribute it to heat the space evenly. The large glazed doors also provide excellent daylighting, eliminating the need for supplementary electrical lighting during the day, and provide a good view of the outside world—creating the feeling of working outside, without the bracing winter breeze or blazing summer sun.

I usually draw the shade cloth screen off to the side so that sun can shine directly into the shop, but if the sunlight produces too much glare, the shade cloth curtain can be used to reduce it. (Another use for the shade cloth, if you're the disorganized type, is to keep people from seeing your messy shop!)

On partly cloudy or thinly overcast days, the collector still works fairly well, but on really cloudy days, keep the overhead garage door closed to slow heat loss. At night I close the garage door to provide additional insulation and reduce heat loss through the glazed door panels.

Solar Workshop Heating Performance



Performance

Occasionally, I hear comments that passive solar thermal heating can't possibly work when it's really cold out—wrong! Since I added the glazed doors, the temperatures in my workshop are usually in the high 60s or low 70s—without additional heating. I monitored the temperatures inside the shop during a period of cold, clear weather. The ambient temperature dropped to 20°F below zero, but the daytime shop temperature—just relying on the solar collector for heating—still reached 70°F (see graph). So far, the shop has never been too cold to work in.

Water barrels set inside the solar doors act as thermal mass, helping minimize temperature swings from day to night. (Here, temperature sensors monitor heat gain.)

The downside of using glazed doors or windows for collectors is that the heat loss at night can be high. Without some form of insulation to reduce nighttime heat loss, the glazed door can lose much of the day's heat gain. This is where using the existing garage door can dramatically reduce heat losses at night. Garage doors are typically well sealed to prevent drafts, and insulated to between R-6 and R-9. When you add this to the R-1 (or above) of the new glazed doors, you get a *whole-wall* R-value similar to a typical, fiberglass-insulated, 2 by 4 wall. Closing the garage door after a cold, but sunny, day increases the workshop's net heat gain by a factor of 2.5. The garage door also adds a second barrier to help prevent air infiltration.

If you find that the shop space tends to be a bit warm in the afternoons, and a little chilly in the mornings, try adding some thermal mass to even out the temperature swings. One strategy is to place several dark-colored water barrels just inside the garage door. Position the barrels so that the sun shines directly on them. They will absorb heat during the day and temper afternoon temperatures inside. Once the space starts to cool, the barrels will slowly release their stored heat, making the space warmer and more comfortable at night and the next morning. Based on my experience, you will need about four 55-gallon water barrels to make a significant difference.

With or without water barrels, the combination of the new outer glazed doors, the existing overhead garage door, and the sliding screen is a simple but very effective way to harvest some free solar heat and to control the temperature in the shop. Invest a weekend creating your own passive solar workshop, and you'll spend many an afternoon thereafter basking in the warmth of your reward.

Access

Gary Reysa • gary@builditsolar.com • www.builditsolar.com

Small-Scale System

for an On-Grid Island Getaway

by Ian Woofenden

Rod and Barbara Brown live busy lives in California's San Francisco Bay Area, and travel the world on business. When they want to relax, they head north to Guemes Island in northwest Washington, to a beach cabin they've owned for the last five years. They love the island for its natural beauty, and recently decided to make their cabin's electricity with natural energy—sunshine.

A small, rooftop-mounted solar-electric array provides all of the Brown family's annual electricity needs for their vacation cabin.

Rod was looking to slow the pace of his life and devote more time to his family. "I have spent many years working many hours," says Rod, "and I sometimes feel that my family paid a price for that.

"An island getaway—with a focus on nature, the sea, the air, and a slower pace—seemed the best place to begin," he says. "I wanted my children to know about boats, the cycles of the sea and tides, and food from the sea. These are things they cannot learn from school, television, and video games."

Renewable Decision

Rod and his family were introduced to Guemes Island through a friend with long-term ties to the island. In 2001, they found and purchased their modest place, a 1950s-era, 1,000-square-foot cabin on the island's stunning West Beach.

The Browns have been fixing up their cabin for the last few years. They have added a two-bay garage/shop to house their boat, sports equipment, washer and dryer, and some bunks for friends and family who visit on occasion. The home's electrical loads are modest and seasonal, and with Rod's long-term interest in the environmental and technological aspects of renewable energy, installing a solar-electric (photovoltaic; PV) system seemed like a great fit.

"I want to help further the technology, and the best way to do that is to buy the equipment and support those generally smaller firms that are leading the way," says Rod. "I felt that my own purchase and use of a system would help me to learn and understand more, and also help the entire cause in some minute way. Although I am pleased to get some tax credits and some relief from our own energy bills, that was not the point. I wanted to know more, and to start on a path of renewable energy progress. This was a brilliant, easy, and fun first step."

A rack mounted to the metal roof supports the photovoltaic modules.

A batteryless grid-tie system is relatively simple—all components, except for the solar-electric array, are pictured here.

Small Design, Satisfying Rewards

Rod and Barbara's island home is small, and their lifestyle on the island is not extravagant. They use electricity for lighting and water heating, and to power basic appliances and their laptop computers. They have no TV or video game consoles at the cabin, preferring to spend their time enjoying the beach and sea.

But the largest reason their annual electrical usage is so low is that they only use their beach home four to five weeks during the year. Their visits also coincide with a season when the house needs no heating, no cooling, and little lighting. When they head back to California, they close up the cabin, shut off all electricity to the house, shut off the water, and drain the water lines. A radiant heating system in the garage floor is set to maintain temperatures just above freezing, and all electrical devices in the shop that have phantom loads are unplugged. Meanwhile, even while the Browns are away, the grid-tied PV system keeps producing electricity, meeting the minimal loads, and sending excess electricity to the grid, which is credited to the Browns' electric bill.

From my standpoint as an RE consultant, designing the Brown's system was easy and exciting. Guemes Island experiences occasional utility outages, but these normally occur in the winter, when the Browns are living at their California home. A batteryless, grid-tied system was determined to be the best approach, compared to an off-grid system or one with battery backup.

With off-grid systems, a complete load analysis is vital to make sure that the PV array and battery are sized appropriately. With battery backup systems, installers need to make sure end users have realistic expectations about how much backup energy they need, for what loads, for how long—and at what price. Both off-grid and on-grid battery-based backup systems require periodic maintenance, and eventual replacement of the batteries. The increased cost, maintenance, and somewhat lower efficiency of these systems mean that people should take a hard look at their needs. In

Excess length is trimmed off the array rack's rails for a neat, streamlined installation.

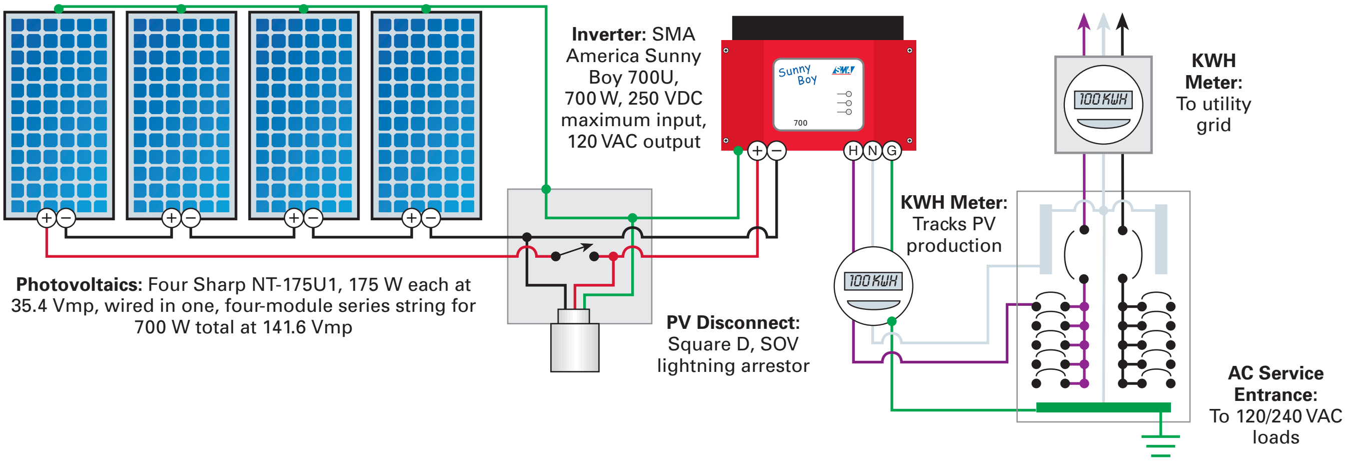
Brown System Costs

Item	Cost
4 Sharp NT-175U1 PV modules, 175 W	$4,132
Labor	1,940
Sunny Boy 700U inverter with LCD display	1,573
Misc. electrical	362
UniRac PV mounts	203
Square D disconnect, 30 A	148
Miscellaneous hardware	80
Delta LA602DC DC lightning arrestor	38
Delta LA302R AC lightning arrestor	34
Multi-Contact module cables/connectors	30
Total	$8,540
Less federal tax credit	-$2,000
Less utility rebate	-403
Grand Total	$6,137

contrast, sizing the Browns' system was straightforward—by analyzing their utility bills, it was easy to calculate their average daily usage. The figure was a pleasant surprise—a year-round average of only 2 kilowatt-hours (KWH) per day.

The potential of showcasing this small system to other seasonal islanders was particularly exciting to me. Most people buy vacation homes on Guemes Island because they love the area's natural beauty. Using clean, renewable energy fits within this value system, and helps offset a household's environmental impacts due to energy use. Plus, about half of the homes on the island are only occupied during the summer months, which means seasonal needs for electricity come at a time of abundant sunshine—a perfect pairing for a solar-electric system, especially when the utility's annualized net metering program is considered. This, coupled with a relatively small up-front investment, makes installing similarly sized systems a very viable option for other vacation-home owners.

Brown On-Grid Photovoltaic System



On Grid, No Maintenance

Rod and Barbara's system was installed as part of a Solar Energy International (SEI) workshop, with the help of a local solar contractor, Kelly Keilwitz of Whidbey Sun & Wind. The installation was completed and commissioned in one day, after two days of classroom instruction by electrician Carol Weis of SEI.

With only six major components—PV modules, racks, wiring, inverter, disconnects, and metering—system installation was straightforward. The direct current (DC) output of the PV array is routed to an inverter, which produces grid-synchronous alternating current (AC) electricity. This feeds the house loads as needed, or is sent back to the utility grid.

The 2 KWH per day average consumption allowed using the smallest available batteryless inverter, SMA America's Sunny Boy 700U, which has a 700-watt rating. An array of four, 175-watt Sharp solar-electric modules feed the inverter. This combination may produce somewhat more than the 2 KWH per day needed to meet average loads, but that's OK—the goal here is more renewable energy. The Browns will likely have a slight energy surplus when the utility zeroes their net metering account on January 1 of each year. But that fits with Rod and Barbara's environmental goals too—they want to reduce their impact on the environment while enjoying their lifestyle.

PV Payoff

Although western Washington has a reputation for being cloudy and rainy, the sun shows its face all summer and frequently during other times of the year, with an average of 4 peak sun-hours (1,000 watts per square meter equivalent) per day in the islands. This is roughly the same amount of average peak sun-hours that New York City, Indianapolis, or Boston receives. The Browns' grid-tied PV system helps them put this seasonal advantage to good use through an annualized net metering agreement with the utility.

Net metering laws require utilities to pay renewable electricity producers at the same rate they are billed for electricity, up to the level of the their usage (net). This utility rate structure, now in 40 states (plus Washington, D.C.), allows consumers to use the utility grid as a sort of "battery," banking excess energy credits when their homes don't use all of the solar electricity being produced, and drawing from that credit when they do.

Most net metering agreements stipulate a "zeroing" time, when the energy balance is settled. Any energy surplus produced by the consumer's RE system is either forfeited or, in some cases, paid for (generally at a lower rate). This

High Quality, Low-Power Batteryless Inverters

Low-power, batteryless inverter options for small, grid-tied solar-electric systems are limited. Trace's somewhat-popular, 90-watt MicroSine batteryless PV inverter went out of production several years ago, and Exeltech's module-based inverter is still under development. At the time of writing, SMA America's 700-watt SB700U inverter is the lowest power batteryless PV inverter on the U.S. market. And while some end users may be waiting for even lower power inverters that can be directly coupled with PV modules, the SB700U offers high performance, reliability, and design flexibility, making it a great choice for small grid-tied PV systems.

The SB700U's main selling point, other than its low-power design focus, is three field-selectable PV voltage ranges. This allows you or your installer to design a small, batteryless PV system with as few as three 24 VDC nominal modules and, depending on the voltage and wattage rating of the modules you're using, add up to about five 24 VDC modules. To determine the exact PV string configuration for your particular SB700U system, use the string-sizing calculator at www.sma-america.com.

While modularity is a great aspect of the SB700U inverter—and of PV systems in general—before you get started, it's always a good idea to determine your ultimate goal for PV array size. In residential systems, multiple, low-power inverters will typically have a higher cost per watt when compared to a single, larger unit. For example, the SB700U has an MSRP of about $1,600 ($2.29 per watt), while a 2,500-watt batteryless inverter will have an MSRP of about $2,300 ($0.92 per watt). In this example, if you used multiple low-power inverters, you'd end up paying roughly 2.5 times as much per rated watt of inverter capacity if you were to eventually install 2,500 watts of PVs. However, if you're planning to keep the size of your PV array within the wattage specifications of the low-power inverter, it will be cost effective, even though the cost per watt is higher.

Sunny Boy 700U Voltage Specs

Configuration (VDC)	Rated AC Amps	Maximum AC Amps	Maximum AC Watts
75–150	3.8	4.3	460
100–200	5.0	5.7	600
125–250	5.8	6.6	700

zeroing time is crucial to the usefulness of the net metering policy, and to how systems are designed. With monthly net metering agreements, if a household's RE system generates more energy in a month than the household uses, no credit may be given for that surplus. In places that are sunny year-round, this may not be a drawback. But overall, annualized net metering is much more useful, since a surplus in one season builds up a credit for another.

In addition to the advantages of net metering, the Browns are eligible for a $2,000 federal tax credit and a $403 up-front rebate from the local utility, Puget Sound Energy. They can also apply for a 15-cent-per-KWH incentive from the state of Washington, and a 5-cent-per-KWH "green tags" incentive from a regional organization promoting renewable energy.

Small Steps

"I believe it is very important for our country and the world to be using renewable sources of energy," says Rod's wife Barbara, "for the sake of the planet and for national security. Many Americans discuss this matter, but do nothing to begin to solve the problem. We decided to take the first steps toward creating our own household energy with the sun."

"We must all take steps, even small ones, to help further the effort toward environmentally sound electricity production," says Rod. "For me, purchasing the solar-electric system is my family's first step." The next steps for Rod and Barbara are a rainwater catchment system for their island home, and solar energy systems for their home in the San Francisco Bay area.

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

Kelly Keilwitz, Whidbey Sun & Wind • 360-678-7131 • www.whidbeysunwind.com • Project contractor

Solar Energy International • 970-963-8855 • www.solarenergy.org • Workshop project coordinator

PV System Components:

Sharp Electronics, Solar Systems Division • 800-SOLAR06 • www.sharp-usa.com/solar • PVs

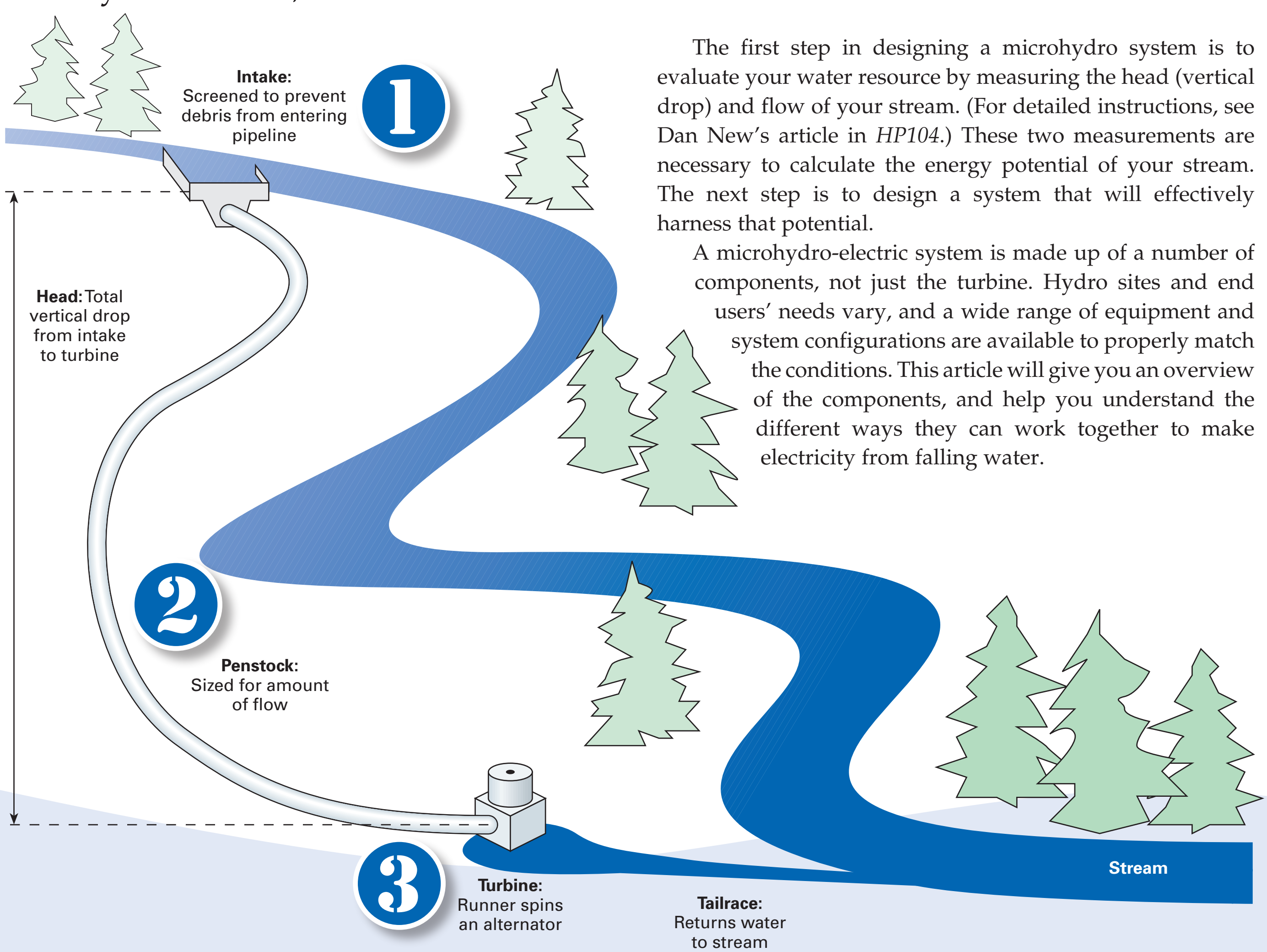
SMA America Inc. • 530-273-4895 • www.sma-america.com • Inverter

UniRac Inc. • 505-242-6411 • www.unirac.com • Module rack

Microhydro-Electric Systems SIMPLIFIED

by Paul Cunningham & Ian Woofenden

If you have a suitable site, harnessing the energy in a stream or creek can be the most cost-effective way to make renewable electricity. Compared to the sun and wind's variability, a stream's flow is relatively consistent, making microhydro-electric system output the most predictable of all the renewable energy (RE) electrical systems. Hydro resources are also the most site specific, since your property must have a usable water source. If you are one of the lucky few with a stream running down your hillside, it's the resource to assess first.



The first step in designing a microhydro system is to evaluate your water resource by measuring the head (vertical drop) and flow of your stream. (For detailed instructions, see Dan New's article in *HP104*.) These two measurements are necessary to calculate the energy potential of your stream. The next step is to design a system that will effectively harness that potential.

A microhydro-electric system is made up of a number of components, not just the turbine. Hydro sites and end users' needs vary, and a wide range of equipment and system configurations are available to properly match the conditions. This article will give you an overview of the components, and help you understand the different ways they can work together to make electricity from falling water.

1 Intake *AKA: Screen, diversion, impoundment*

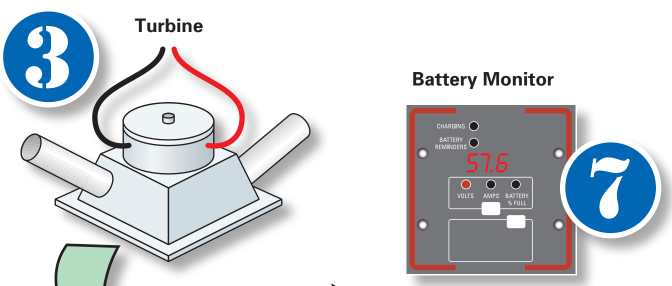
Intakes can be as simple as a screened box submerged in the watercourse, or they can involve a complete damming of the stream. The goal is to divert debris- and air-free water into a pipeline. Effectively getting the water into the system's pipeline is a critical issue that often does not get enough attention. Poorly designed intakes often become the focus of maintenance and repair efforts for hydro-electric systems.

A large pool of water at the intake will not increase the output of the turbine, nor will it likely provide useful storage, but it will allow the water to calm so debris can sink or float. An intake that is above the bottom of the pool, but below the surface, will avoid the grit on the stream bottom and most of the floating debris on top. Another way to remove debris is to direct the water over a sloped screen. The turbine's water falls through, and debris passes with the overflow water.

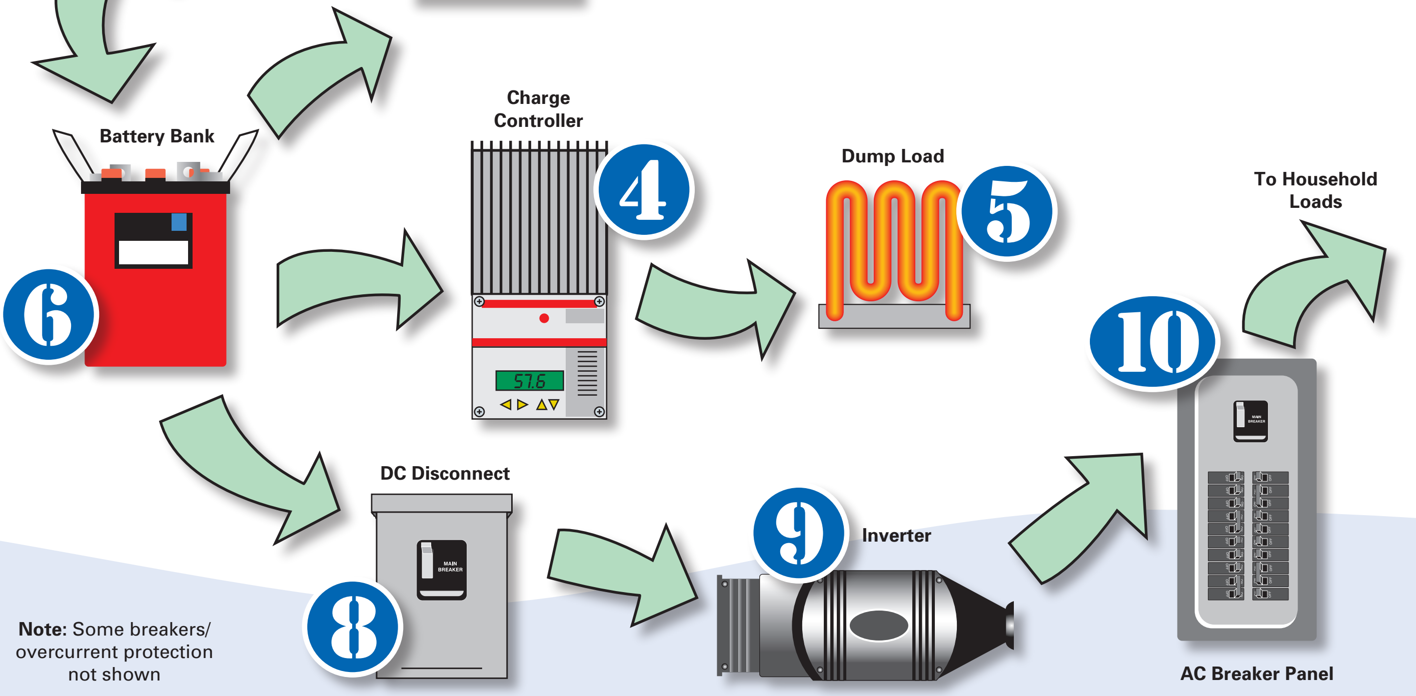
2 Pipeline *AKA: Penstock*

Most hydro turbines require at least a short run of pipe to bring the water to the machine, and some turbines require piping to move water away from it. The length can vary widely depending on the distance between the source and the turbine. The pipeline's diameter may range from 1 inch to 1 foot or more, and must be large enough to handle the design flow. Losses due to friction need to be minimized to maximize the energy available for conversion into electricity. Plastic in the form of polyethylene or PVC is the usual choice for home-scale systems. Burying the pipeline is desirable to prevent freezing in extremely cold climates, to keep the pipe from shifting, and to protect it from damage (cows, bears, etc.) and ultraviolet (UV) light degradation.

OFF-GRID BATTERY-BASED HYDRO-ELECTRIC SYSTEM

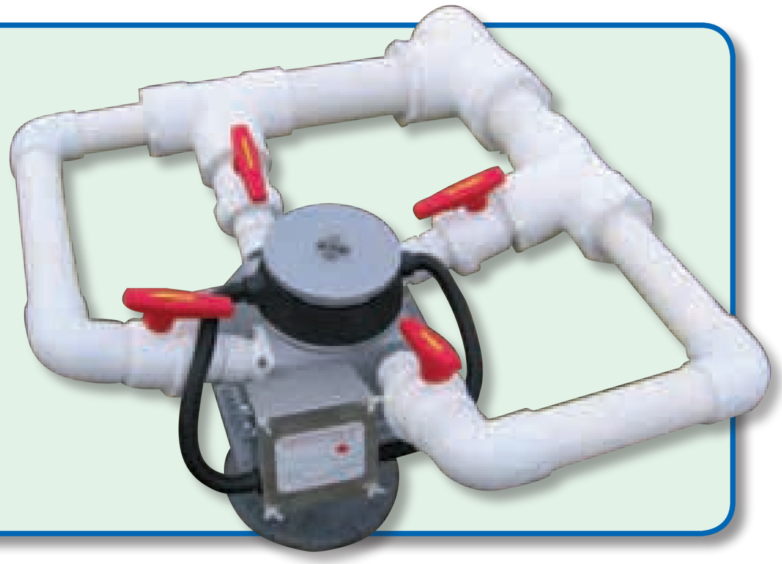


Most small off-grid hydro systems are battery-based. Battery systems have great flexibility and can be combined with other energy sources, such as wind generators and solar-electric arrays, if your stream is seasonal. Because stream flow is usually consistent, battery charging is as well, and it's often possible to use a relatively small battery bank. Instantaneous demand (watts) will be limited not by the water potential or turbine, but by the size of the inverter.



Note: Some breakers/ overcurrent protection not shown

3 Turbine *AKA: Waterwheel*



The turbine converts the energy in the water into electricity. Many types of turbines are available, so it is important to match the machine to the site's conditions of head and flow.

In *impulse* turbines, the water is routed through nozzles that direct the water at some type of runner or wheel (Pelton and Turgo are two common types). *Reaction* turbines are propeller machines and centrifugal pumps used as turbines, where the runner is submerged within a closed housing. With either turbine type, the energy of the falling water is converted into rotary motion in the runner's shaft. This shaft is coupled directly or belted to either a permanent magnet alternator, or a "synchronous" or induction AC generator.

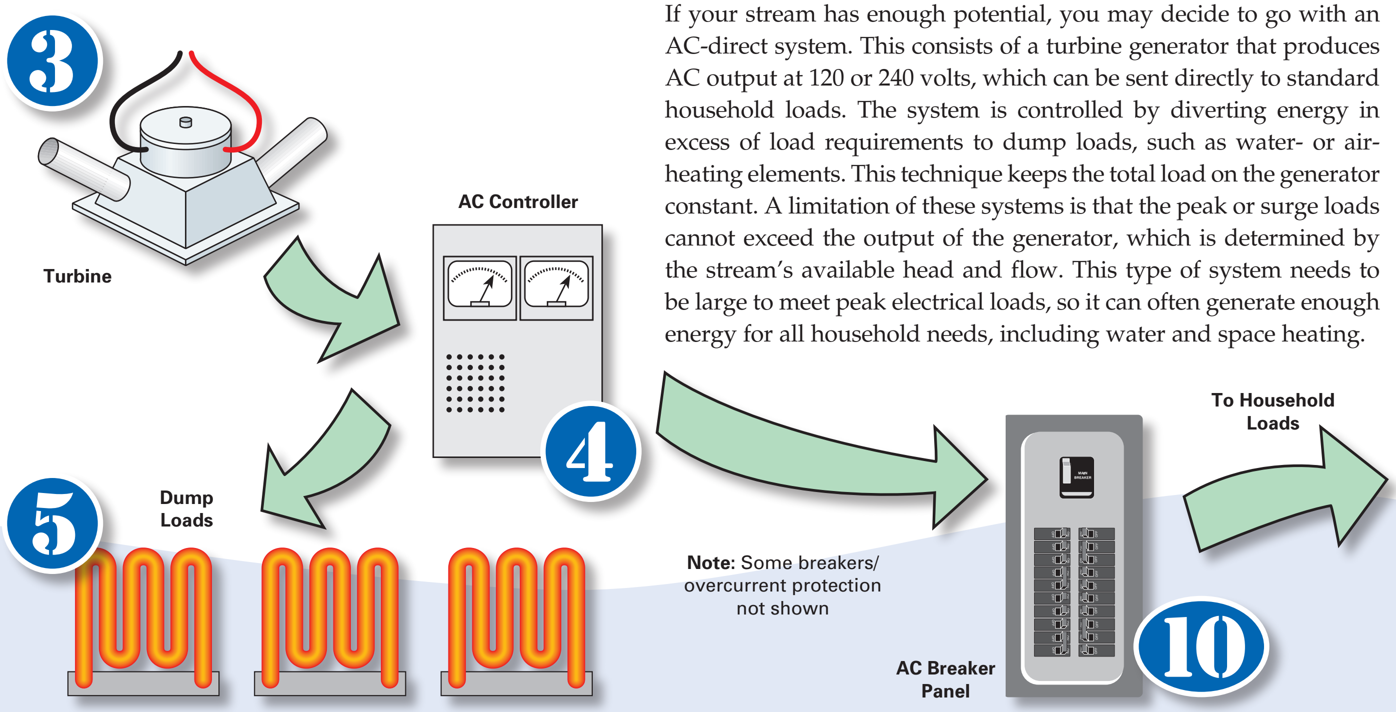
4 Controls *AKA: Charge controller, controller, regulator*

The function of a charge controller in a hydro system is equivalent to turning on a load to absorb excess energy. Battery-based microhydro systems require charge controllers to prevent overcharging the batteries. Controllers generally send excess energy to a secondary (dump) load, such as an air or water heater. Unlike a solar-electric controller, a microhydro system controller does not disconnect the turbine from the batteries. This could create voltages that are higher than some components can withstand, or cause the turbine to overspeed, which could result in dangerous and damaging overvoltages.

Off-grid, batteryless AC-direct microhydro systems need controls too. A load–control governor monitors the voltage or frequency of the system, and keeps the generator correctly loaded, turning dump-load capacity on and off as the load pattern changes, or mechanically deflects water away from the runner. Grid-tied batteryless AC and DC systems also need controls to protect the system if the utility grid fails.

OFF-GRID BATTERYLESS HYDRO-ELECTRIC SYSTEM

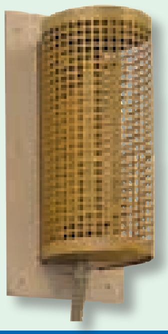
If your stream has enough potential, you may decide to go with an AC-direct system. This consists of a turbine generator that produces AC output at 120 or 240 volts, which can be sent directly to standard household loads. The system is controlled by diverting energy in excess of load requirements to dump loads, such as water- or air-heating elements. This technique keeps the total load on the generator constant. A limitation of these systems is that the peak or surge loads cannot exceed the output of the generator, which is determined by the stream's available head and flow. This type of system needs to be large to meet peak electrical loads, so it can often generate enough energy for all household needs, including water and space heating.



5 Dump Load

AKA: Diversion load, shunt load

A dump load is an electrical resistance heater that must be sized to handle the full generating capacity of the microhydro turbine. Dump loads can be air or water heaters, and are activated by the charge controller whenever the batteries or the grid cannot accept the energy being produced, to prevent damage to the system. Excess energy is "shunted" to the dump load when necessary.



6 Battery Bank

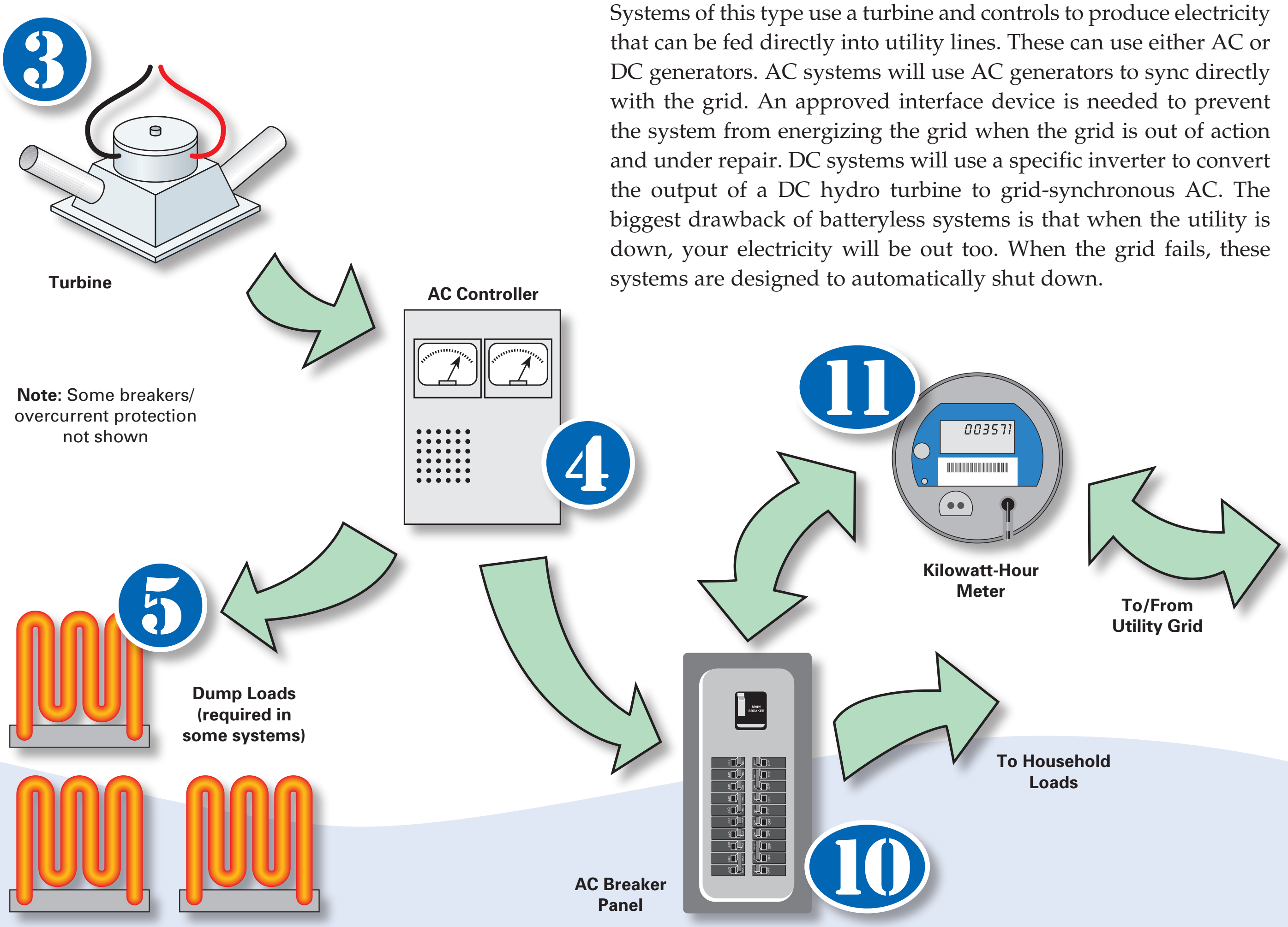
AKA: Storage battery

By using reversible chemical reactions, a battery bank provides a way to store surplus energy when more is being produced than consumed. When demand increases beyond what is generated, the batteries can be called on to release energy to keep your household loads operating.

A microhydro system is typically the most gentle of the RE systems on the batteries, since they do not often remain in a discharged state. The bank can also be smaller than for a wind or PV system. One or two days of storage is usually sufficient. Deep-cycle lead-acid batteries are typically used in these systems. They are cost effective and do not usually account for a large percentage of the system cost.

GRID-TIED BATTERYLESS HYDRO-ELECTRIC SYSTEM

Systems of this type use a turbine and controls to produce electricity that can be fed directly into utility lines. These can use either AC or DC generators. AC systems will use AC generators to sync directly with the grid. An approved interface device is needed to prevent the system from energizing the grid when the grid is out of action and under repair. DC systems will use a specific inverter to convert the output of a DC hydro turbine to grid-synchronous AC. The biggest drawback of batteryless systems is that when the utility is down, your electricity will be out too. When the grid fails, these systems are designed to automatically shut down.



7 Metering *AKA: Battery monitor, watt-hour meter, amp-hour meter*

System meters measure and display several different aspects of your microhydro-electric system's performance and status—tracking how full your battery bank is, how much electricity your turbine is producing or has produced, and how much electricity is being used. Operating your system without metering is like running your car without any gauges—although possible to do, it's always better to know how well the car is operating and how much fuel is in the tank.

8 Main DC Disconnect *AKA: Battery–inverter disconnect*

In battery-based systems, a disconnect between the batteries and inverter is required. This disconnect is typically a large, DC-rated breaker mounted in a sheet metal enclosure. It allows the inverter to be disconnected from the batteries for service, and protects the inverter-to-battery wiring against electrical faults.

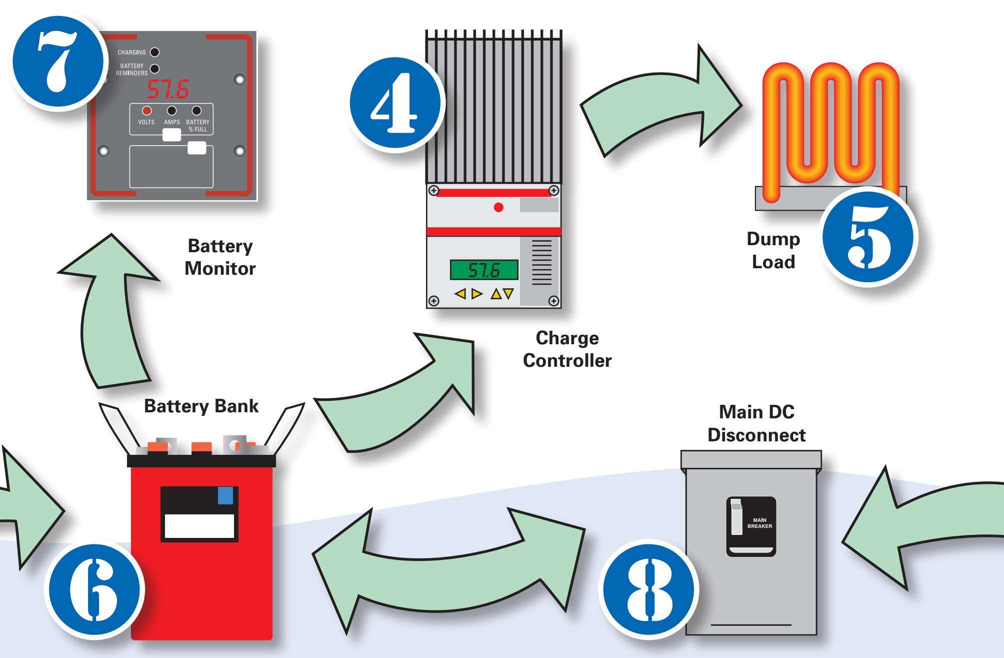
9 Inverter *AKA: DC-to-AC converter*

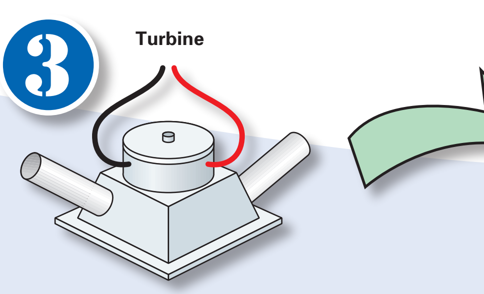
Inverters transform the DC electricity stored in your battery bank into AC electricity for powering household appliances. Grid-tied inverters synchronize the system's output with the utility's AC electricity, allowing the system to feed hydro-electricity to the utility grid. Battery-based inverters for off-grid or grid-tied systems often include a battery charger, which is capable of charging a battery bank from either the grid or a backup generator if your creek isn't flowing or your system is down for maintenance.

In rare cases, an inverter and battery bank are used with larger, off-grid AC-direct systems to increase power availability. The inverter uses the AC to charge the batteries, and synchronizes with the hydro-electric AC supply to supplement it when demand is greater than the output of the hydro generator.

Grid-Tied Battery-Based Hydro-Electric System

Using batteries with your grid-tied system allows it to operate when the utility grid doesn't. This type of system is the same as an off-grid system, except that the inverter needs to be designed and approved for grid-tied operation, so it can feed excess electricity into the utility lines. The dump load is only activated in the event of a grid failure, to protect the batteries from overcharging.





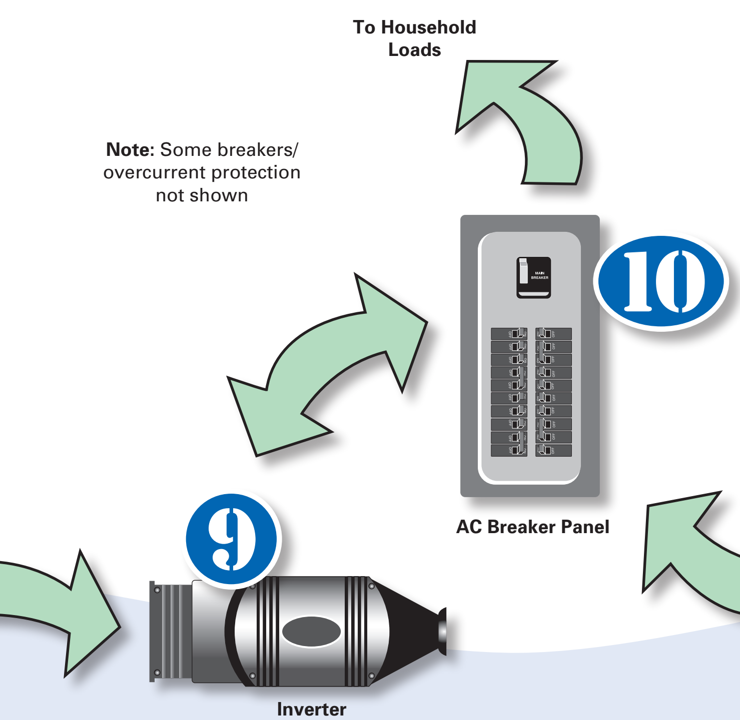
10 AC Breaker Panel *AKA: Mains panel, breaker box, service entrance*

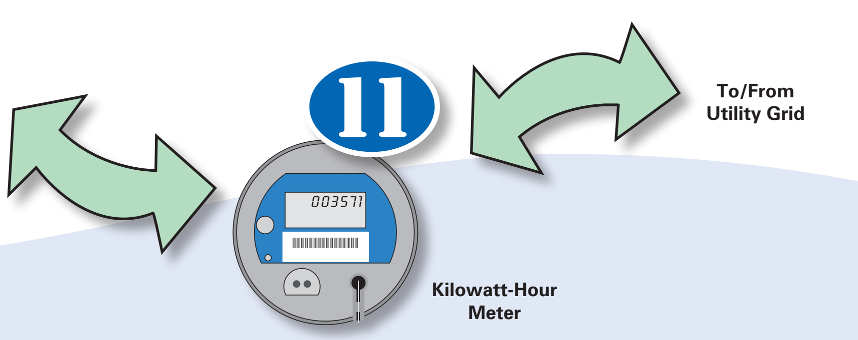
The AC breaker panel, or mains panel, is the point at which all of a home's electrical wiring meets with the provider of the electricity, whether that's the grid or a microhydro-electric system. This wall-mounted panel or box is usually installed in a utility room, basement, garage, or on the exterior of a building. It contains a number of labeled circuit breakers that route electricity to the various rooms throughout a house. These breakers allow electricity to be disconnected for servicing, and also protect the building's wiring against electrical fires.

Just like the electrical circuits in your home or office, a grid-tied inverter's electrical output needs to be routed through an AC circuit breaker. This breaker is usually mounted inside the building's mains panel. It enables the inverter to be disconnected from either the grid or from electrical loads if servicing is necessary. The breaker also safeguards the circuit's electrical wiring.

11 Kilowatt-Hour Meter *AKA: KWH meter, utility meter*

Most homes with grid-tied microhydro-electric systems will have AC electricity both coming from and going to the utility grid. A multichannel KWH meter keeps track of how much grid electricity you're using and how much your RE system is producing. The utility company often provides intertie-capable meters at no cost.





Realize Your Potential

Hydro-electric systems have great potential, but several things can make using this technology difficult. Diverting the water in a stream or creek is likely subject to regulation by local authorities and may require seeking approval. You also may need to contend with droughts or floods. All hydro turbines have moving parts that require maintenance and periodic replacement. The most common maintenance chore is keeping debris out of the intake.

Despite the various challenges, most of the problems can be easily overcome. If installed correctly and properly maintained, a microhydro system can provide many years of service. The predictable and often ample output is the envy of those restricted to using only wind or solar electricity. As an owner of a microhydro system, you'll go to bed at night with the knowledge that while you are sleeping, your system is charging and will be ready for another day of energy use when you rise.

Access

Paul Cunningham, Energy Systems & Design, PO Box 4557, Sussex, NB, E4E 5L7, Canada • 506-433-3151 • Fax: 506-433-6151 • hydropow@nbnet.nb.ca • www.microhydropower.com

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

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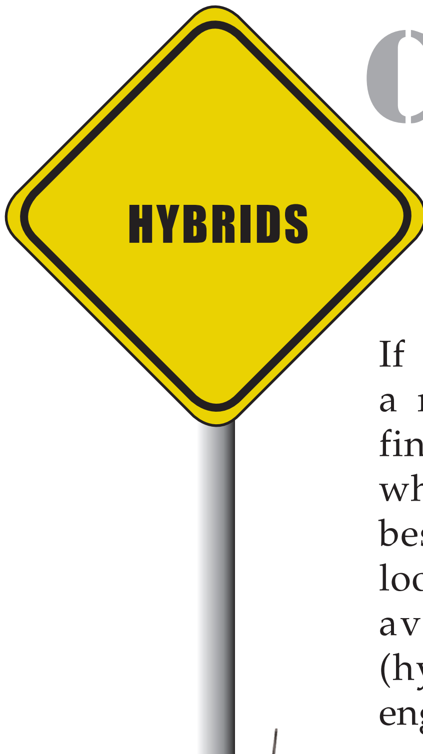

by Ray Holan

If you are in the market for a more fuel-efficient car, but find yourself spinning your wheels over figuring out the best choice, here's a closer look at the two major options available—gasoline-electric (hybrid) autos and diesel-engine vehicles.

Hybrid Honda Accord

Diesel Volkswagen Jetta

Hybrids have been touted as the champs for lower fuel costs and fewer environmental impacts. But the higher prices of hybrids can be a deal-breaker for those in the market for more fuel-efficient wheels. Are diesel engine vehicles a viable alternative? Here's Aesop's fable of the tortoise and the hare—twenty-first-century style.

Diesel Volkswagen Beetle

Purchase Price & Payback Time

Whether you buy a hybrid or a diesel, you'll pay a premium over a gasoline-engine vehicle, which you expect to recoup in the form of fuel savings. Compared to their nonhybrid counterparts, hybrids generally have an even greater difference in their purchase prices than diesels. Why? Hybrids have two power plants: one gasoline and one electric. You can't get two power plants for the price of one, and the hybrid's sophisticated storage battery and electronic controls come at a price.

But with federal tax credits (from $600 to more than $3,000), hybrids could kick into overdrive to sprint ahead of the diesel in this event. So hybrids win, right? Not according to the photo finish. First, tax credits vary considerably from model to model and are slated to be reduced as hybrid sales figures hit predetermined levels. The Purchase Price & Payback table below shows how long you'll wait for your reward for certain models based on November 2006 fuel prices. The purchase premium is the difference between the hybrid or diesel's price and the price of a stock gasoline version of the same model. Of course, this difference (and the payback time) depends on how many miles per year are driven, and the price of gasoline and diesel fuel. But in most cases, for faster payback, the advantage goes to diesels.

Fuel Economy

Both diesels and hybrids outperform their gas-engine counterparts, although real-world hybrid fuel mileage reported by individual drivers is often lower than the U.S. Environmental Protection Agency's (EPA) estimates. (In the cases of driver-reported fuel economies of Mercedes E320 Cdi and Volkwagen Jetta TDI models, diesels tend to *outperform* their EPA ratings.)

Case in point: The Honda 2005 Civic Hybrid's EPA rating is 48 miles per gallon, but when *Consumer Reports* tested it in real-world driving conditions, it got 36 mpg. And *Autoweek* reported in its November 2005 issue that their long-term testing of the 2005 Prius realized 41.2 mpg over a 16,000-mile span of mostly

Purchase Price & Payback

Hybrid[1]	Purchase Premium	Stock Model MPG (Combined)[3]	Stock Fuel Costs[2]	Hybrid Model MPG (Combined)[3]	Hybrid Fuel Costs[2]	Years to Recoup Investment
Honda Civic (4 cyl., auto)	$3,090	34	$1,049	50	$714	9.22
Ford Escape (FWD)	3,630	26	1,372	33	1,079	12.39
Honda Accord (6 cyl., auto)	3,690	24	1,487	28	1,274	17.30

Diesel[1]	Purchase Premium	Stock Model MPG (Combined)[3]	Gasoline Fuel Costs[2]	Diesel Model MPG (Combined)[3]	Diesel Fuel Costs[2]	Years to Recoup Investment
Mercedes E350/E320 Cdi	$1,000	22	$2,145	30	$1,616	0.94
Volkswagen Jetta TDI	2,015	28	1,686	38	1,276	4.90
Jeep Liberty Ltd. CRD 4x4	1,360	19	1,877	23	1,830	28.93

[1]2006 models (comparisons based on similar trim packages, where applicable)
[2]Based on 16,000 miles driven per year; gasoline prices at $2.23 per gallon; diesel fuel prices at $2.63 per gallon (Nov. 2006 avg. prices)
[3]U.S. EPA ratings
Purchase premium calculated by using MSRP from manufacturers' Web sites
Adapted from www.fueleconomy.gov

highway driving—far below the EPA's combined (city/highway) estimate of 55 mpg, and well below its highway rating of 51 mpg. The EPA is changing their test protocol for 2007, and new ratings are expected to better reflect real-world mileage for future models. (You can find driver-reported fuel economy at www.fueleconomy.gov/feg/findacar.htm.)

Another quirk of hybrid fuel economy is that their city mileage frequently surpasses their highway mileage. For example, a 2006 Toyota Highlander SUV hybrid is EPA-rated at 33 mpg in the city and only 28 mpg on the highway. Why? A full hybrid uses its electric motor more often in stop-and-go city driving, with the gasoline engine off completely (or only lightly loaded), especially at or below 25 mph. Conversely, at highway speeds, the electric motor and its batteries are idle, and their extra weight can actually penalize fuel mileage. If you're a prospective hybrid buyer and you don't do much stop-and-go city driving, your return probably won't be as good as another hybrid driver who travels more stop-and-go urban miles. On the other hand, if you drive exclusively in the city, it may be difficult to rack up enough miles required to recuperate the premium you paid for the hybrid.

Even with the hybrids' lower-than-reported fuel economy, generally, they are still competitive compared to similarly sized diesel vehicles. Take the 2006 Toyota Prius, for example, which has a driver-reported combined fuel economy average of 47.2 mpg, and the 2006 VW Jetta TDI, which has an average reported combined mpg of 41.9.

Fuel Economy Best Bets Hybrid & Diesel Models

Best Fuel Economy[1]	EPA City	EPA Hwy.	EPA Combined	Avg. MPG[3]
Honda Insight Hybrid (manual)	60	66	63	70.5
Toyota Prius Hybrid	60	51	55	47.2
Honda Civic Hybrid	49	51	50	46.4
VW Golf TDI Diesel	37	44	40	46.2
Toyota Camry Hybrid[2]	40	38	39	37.1
VW Jetta TDI Diesel	35	42	38	41.9
VW Beetle TDI Diesel	35	42	38	36.7
Mid-Range Fuel Economy[1]				
Ford Escape Hybrid FWD	36	31	33	31.9
Mercury Mariner Hybrid, 4WD[2]	33	29	31	27.2
Mercedes E320 Cdi Diesel	27	37	30	33.1
Lexus RX 400h Hybrid	33	28	30	23.8
Toyota Highlander Hybrid[2]	33	28	30	25.0
Honda Accord Hybrid	25	34	28	35.8

[1]2006 model, unless otherwise noted
[2]2007 model
[3]Owner-reported as "Your MPG," from www.fueleconomy.gov

Fuel Costs

Diesel used to be cheaper than gasoline. But these days, in most areas of the country, it costs even more than premium gasoline. And biodiesel is even pricier. So the gasoline-electric hybrid wins the fuel-cost event hands down, right?

Not so fast: Using straight or waste vegetable oil (SVO or WVO), which can often be obtained at no cost from restaurants, can blow the doors off any hybrid when the mpg ratings of the vehicles are similar. Of course, while the fuel can be sourced at no charge, you'll pay another price if you don't like getting dirty—grease-gathering can be messy, and you'll need a place to store and filter the veggie oil. You'll also need to pony up some greenbacks to install a vegetable-oil conversion kit, which typically includes an auxiliary fuel tank, additional hoses, fuel-heating apparatus, and an under-the-hood veggie-oil fuel filter. Kit prices usually start at about $800 (uninstalled).

The amount you'll shell out for fuel each year depends on how much driving you'll do—and where (in the city or on the highways). We'll call this event a draw.

Maintenance & Repair Costs

Hybrids are still rookies in this arena. The Japanese hybrids from Toyota and Honda have maintenance costs similar to the rest of their models. In short, lower than the industry average. Domestic hybrids like the Ford Escape Hybrid are still new to the game, so we'll have to leave them out of this scoring.

Hybrids are more complex than diesels, which can mean higher repair costs when something breaks. The replacement cost of a hybrid's battery pack can be a whopper: $3,000 plus some pocket change. To allay consumer fears, most hybrids have longer warranty periods than the industry average. Toyota, for example, warrants their hybrid electrical components for 8 years or 100,000 miles. While warranties are a welcome relief, a long warranty period means that you are at the mercy of your local dealership—most independent shops are not yet equipped or trained to work on these modern marvels.

Diesel Jeep Liberty

Consumer Reports says that hybrids seem to be holding up well, with the first-generation Prius among the most reliable in their survey. *CR* also reported "outstanding reliability" for the 2003 Civic Hybrid. Although they say it's too early to predict the Ford Escape Hybrid's reliability, they say the 2005 Lexus RX 400h SUV hybrid "stands a good chance of being reliable, based on Lexus' track record."

Diesel technology is relatively proven, says *CR*. And although diesels, as a class of vehicles, once had higher costs than gasoline models (requiring more frequent oil changes), the advent of synthetic motor oil and technical refinements of the diesel engine has eliminated that disadvantage. Still, VW's Jetta TDI and new Mercedes diesels like the E-Class can have high maintenance costs because of nondiesel items, like power window regulators. Domestic light-duty diesels like the Ford Powerstroke, Chevy Duramax, and Dodge Cummins are quality products, but still are beat by Toyota and Honda in global marketing information firm J.D. Power and Associates' surveys.

With their greater fuel economy, both hybrids and diesels emit less CO_2 pollution than their gas-engine-only counterparts.

Depreciation & Insurance

Depreciation is a roller-coaster ride that's difficult to predict, especially in the case of hybrids, since few have hit the used car market. Diesels tend to hold their value longer, according to the Kelly Blue Book, especially with today's volatile fuel prices. In a March 2006 CNNMoney.com article, James Bell, publisher of the automotive guide *IntelliChoice*, says that "hybrid systems will likely remain rare enough to command a premium among used car buyers."

Insurance premiums are where hybrids' high tech could become their Achilles' heel. Imagine what a front-end collision does to all the electronics under a hybrid's hood. Semiconductor spaghetti. Unfortunately, you won't find replacements at your local salvage-yard. In an Insurance.com article, John Eager, director with the Property Casualty Insurers Association of America, said that they are "expecting to see a diminished frequency of claims as high technology vehicles including hybrids continue to improve over time." He also says that he "anticipates an increase in the severity of physical damage claims. When a hybrid car gets into an accident, or any car with high technology for that matter, you're going to have a greater chance of a total loss. The repair of hybrids is something that our organization and others in the industry are looking at."

Advantage? Neither. Before you buy, check out online pricing guides like Kelly Blue Book, and get a quote from your insurance agent.

Emissions Reduction

According to the EPA, driving a car is the single most polluting thing that most of us do. Autos emit millions of tons of pollutants into the air each year. Cars emit several pollutants classified as toxics, and contribute to acid rain and global warning. The bottom line? If you really want green wheels, get a bicycle. If you still need motorized transportation, keep reading.

With their greater fuel economy, compared to their stock counterparts, both hybrids and diesels emit less carbon dioxide

(CO_2) pollution (a major contributor to global warming). CO_2 emissions are the same no matter what liquid fuel an engine burns—about 19 pounds of CO_2 emitted for every gallon of fuel burned. Using biofuels like ethanol and biodiesel, which are produced renewably from plant crops, has the potential to make some auto emissions "carbon-neutral."

Overall, hybrids are cleaner than their petrodiesel-powered counterparts, and produce about 80 percent fewer emissions than their gasoline cousins. Even better, for low-speed, low-acceleration driving, full-hybrid models will switch to their all-electric mode, shutting their gas engines down completely and running only on electricity stored in their batteries. The result? No tailpipe emissions for at least part of the vehicle's driving time, a feat that no diesel or standard gasoline-engine vehicle can pull off.

U.S. standards for diesel engines target nitrogen oxide (NO_x) emissions, the ringleader in smog formation. Diesel manufacturers plan to blow past the NO_x issue soon by streamlining engine combustion (using piezo injectors,) and by sopping up extra NO_x using exhaust devices like cerium-oxide or urea-SCR catalysts. The recent U.S. switch to ultralow-sulfur petrodiesel production will also help cut diesel engine NO_x emissions. Some states, like New York and California, prohibit the sale of new diesel autos because of concerns about diesel tailpipe emissions.

New federal standards introduced this year will require diesel-fueled vehicles to meet the same emissions standards as gasoline models. On average, these new criteria call for a 77 percent reduction of NO_x emissions and an 88 percent drop in particulate emissions for diesels to be on par with standard gas-engine cars.

At least 50% of all petroleum used in the United States is from foreign sources. Vehicles we drive gobble up more than half of that imported oil.

Because of the tightened emission standards, several diesel automakers are opting to bow out of the U.S. market, and will not import their new diesel models for 2007. But DaimlerChrysler is planning to release their Jeep Grand Cherokee 3.0-liter, common-rail-turbodiesel in the first quarter of 2007. Volkwagen (VW) will still offer their V10 TDI Touareg SUV, but will not be sending new diesel Jettas, Golfs, or Beetles to the United States. VW plans to re-engineer engines in 2008 models to meet the stricter U.S. emissions standards. (For a list of new diesel models currently offered or coming soon to the U.S. market, visit the Diesel Technology Forum Web site at www.dieselforum.org/where-is-diesel/cars-trucks-suvs.)

Various studies have compared the emissions of biodiesel, SVO/WVO, and petrodiesel. The EPA reports that, compared to petrodiesel, biodiesel reduces emissions of hydrocarbons, carbon monoxide, and particulate matter. Test results published in a May 2006 *Consumer Reports* article reported that biodiesel and SVO also produced fewer particulate emissions, but greater hydrocarbon emissions than petrodiesel. In terms of NO_x, biodiesel had the highest emissions, and SVO had the lowest emissions. Most studies agree that burning biofuels does produce fewer health hazards compared to petrodiesel.

Renewability/Sustainability of Fuel

Thus far, hybrids sold in the United States have been gasoline-electric hybrids. Since the primary power plant is an internal combustion engine, these hybrids are still heavily dependent upon petroleum. Diesels are dependent upon petroleum as well, but to a lesser extent if the fuel is biodiesel or SVO.

One of the inherent drawbacks of petroleum as a transportation fuel is that it is not renewable. While the amount of untapped world oil reserves may be debated, one fact is undeniable: There's only so much oil underground. Biofuels like biodiesel and SVO are renewable. More crops can be grown to replace the "fuel" that has been harvested from oil-bearing crops like canola, soybeans, and peanuts. To sweeten the deal, these sources could be classified as "carbon neutral." The carbon dioxide released into the atmosphere when their oil is burned as fuel equals the amount captured while the plant was growing. Petroleum fuels cannot make this claim.

But what about ethanol, a renewable biofuel for gasoline engines? Ethanol is renewable, and a cleaner-burning fuel than gasoline, but it has a lower energy content than gasoline, so you'll have to burn more fuel to travel the same distance. No hybrid on the U.S. market is designed to use ethanol or even the much publicized, but still difficult to find, ethanol blend. Although Ford is testing an E85 (85 percent ethanol; 15 percent gasoline blend) Escape Hybrid, at this point, ethanol is moot.

More than 50 percent of the petroleum used in the United States is imported. And, according to the American Council for an Energy Efficient Economy, the vehicles we drive gobble up a little more than half of that imported oil. Growing demand from countries like China means stiffer competition for oil and higher costs in the future, so it makes good business sense to develop alternative domestic sources of transportation fuel and the vehicles to use them. A diesel vehicle or a diesel-electric hybrid could use a domestically produced fuel like SVO. (Although no diesel-electric cars have hit the market yet, both General Motors Corp. and Mercedes-Benz have concept cars on the road.) Since the U.S. market currently has no gasoline-electric hybrids capable of running on E85, the final event goes to diesels.

Choosing a Car

When the dust and the exhaust smoke settles, is there a clear winner? As you've probably figured out, there's no pat answer to finding sustainable, economical, and environmentally friendlier transportation solutions. Ultimately, you'll need to weigh your needs against the available options to find the wheels that are right for you.

If you need a greener get-around-town car, and want something new, a hybrid may be your best bet. They are price-competitive with most new diesels, although their limited production numbers may mean putting your name on a waiting list. Here's the hybrid hype and dirt on diesels, though—newer standard gasoline models introduced this year, like Toyota's Corolla and Yaris, and Honda's Fit, are edging up on them in terms of fuel economy—all while doing less damage to your bank account, with prices of almost half that of hybrids and diesels. The Corolla and Yaris get a respectable 40 mpg on the highway, and the Honda Fit gets 38 mpg.

If you need four-wheel drive, the new hybrid SUVs beat the wheels off their gasoline-only counterparts, and even trump the mileage of comparable diesel models (the Jeep Grand Cherokee diesel and VW Touareg). Hybrid options for light-duty trucks are limited to Chevrolet's Silverado, which gains you an extra 1 to 2 mpg—a 5 to 10 percent improvement, and still helpful—compared to its nonhybrid version. As for new light-duty diesel trucks—forget it. (In the pre-owned market, you may be lucky to stumble on some older-model diesel Toyotas and Volkwagens). No heavy-duty hybrid trucks are now available, and diesels still remain the workhorses. Diesel trucks only get moderately better mileage than their gasoline-guzzling cousins (and some get the same, so do your research first). But if you install an SVO-kit, they can run on free fuel—if you can find it and don't mind getting your hands dirty.

Access

Ray Holan • ray@burningriverfuels.com

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Window Shopping

by Keith Boulac

Find the Right Match for Your Home

Today's window technology offers improved window-frame materials, thicker (and more) panes of glazing, and specialty coatings and films, which all add up to energy—and dollars and cents—saved, and improved comfort in your home. In well-designed passive-solar homes, selecting the right windows and placing them appropriately can even eliminate heating and cooling bills. Here's what you need to know before you start shopping.

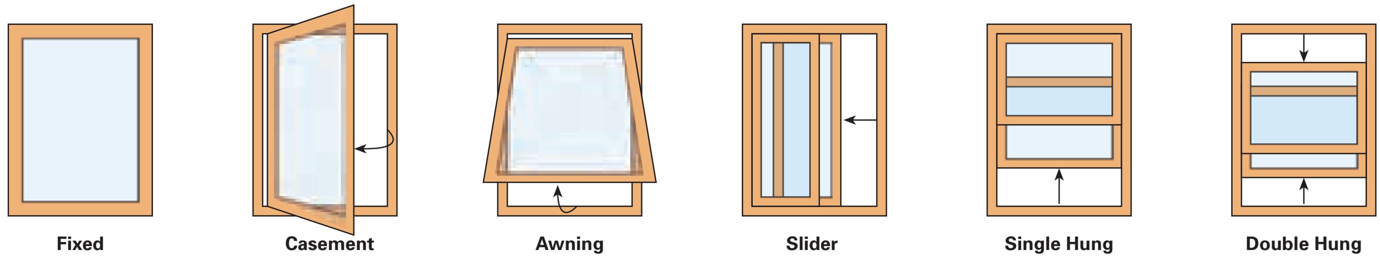
Good Glazing

Until the middle of the twentieth century, homes had single-pane window glass, and used heavy drapes and shades to block heat and cold. Later, storm windows attached to the outside were used to provide more insulation, as well as draft protection.

The first insulated glass units (IGUs)—two panes of glass separated by an air space and hermetically sealed—were produced in the 1930s. Trapping a layer of dead air between the panes helped reduce heat transfer through the glass, offering a major improvement in window performance. Compared to single-paned windows, double-paned units reduce heat flow—measured as the U-factor—by half.

In the late 1970s, triple-pane IGUs provided even more substantial gains over dual-glazed units by decreasing heat flow by an additional 35 percent. Today, though, they still are considerably more expensive, and because of their extra weight, may complicate framing approaches. Triple glazing requires a wide sash to hold the glass and is generally better suited for extremely cold climates—in certain areas of the United States, and most of Canada and northern Europe.

Window Types



Choose an Efficient Frame

Besides complementing a home's style, your particular choice of window frame will influence your home's overall energy performance.

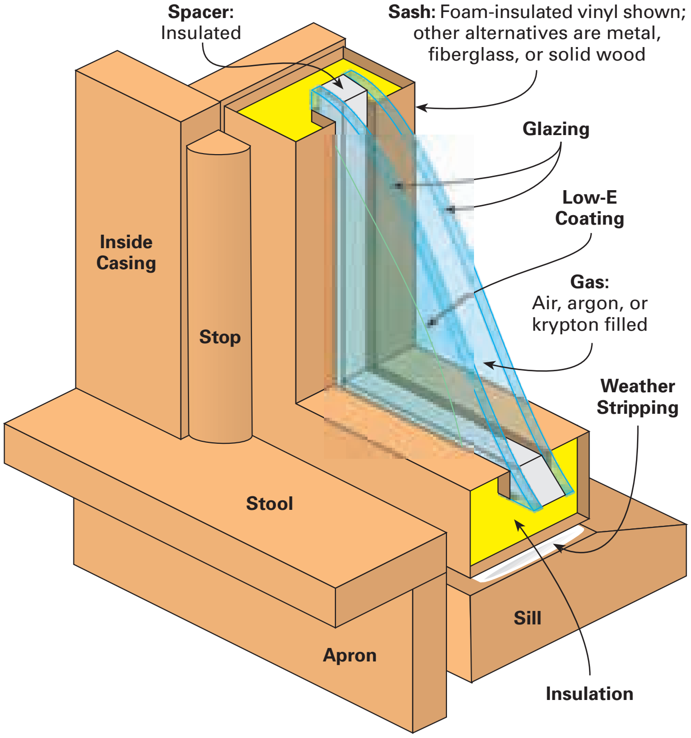
Wood frames continue to be one of the most popular choices for their durability, natural beauty, and relatively good resistance to heat flow. Made from a renewable resource, they are also one of the "greenest" frame choices you can make, although few window manufacturers have agreed to only use wood from certified, sustainably managed forests. Some companies now use engineered wood, from finger-jointed pieces to high-tech laminated veneers, for some of the components. The biggest downsides to wooden frames are their expense and maintenance requirements. Poorly maintained wood windows will deteriorate over time, leading to increased air leakage and, eventually, failure.

Vinyl frames account for almost half of all windows sold for residences. They are generally among the least expensive choices, are low maintenance, and easy to find (most home improvement stores stock a wide selection). For energy performance, hollow, extruded vinyl windows are on par with wood. But where their manufacture is concerned, vinyl windows are among the least green. Polyvinyl chloride (PVC) production is an energy-intensive, polluting process—so much so that some groups continue to call for the complete phaseout of PVC and other chlorine-based chemicals. Vinyl frames can contract and expand more than other frame materials, which can cause cracks and loosen seals, and can also be prone to discoloration over time.

Courtesy www.pella.com

Choices in window technology and placement can make or break your home's thermal performance.

Parts of an Efficient Window



Composite frames use two or more materials, such as vinyl-clad wood, to achieve durability and high performance. They generally have insulating values between that of the materials of which they are composed. Andersen Windows reduces its reliance on PVC with its Renewal line. Its proprietary Fibrex frame is made from wood fibers and PVC scrap from the manufacturing plant. Stronger than PVC alone, the material also offers more resistance to thermal expansion.

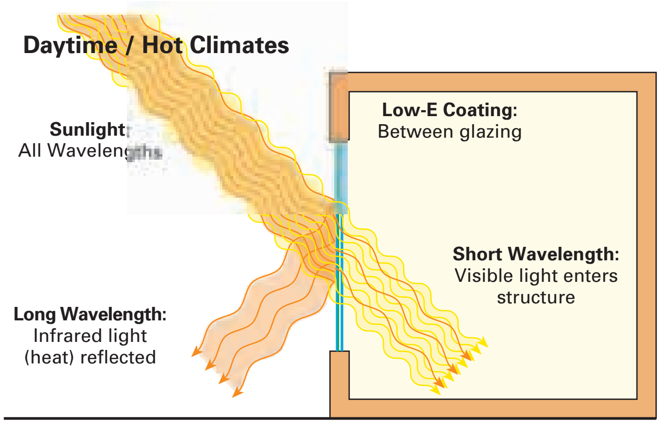
Strong, weather-resistant, and stable, fiberglass frames offer a thermal expansion coefficient similar to glass, which makes it an ideal partner. Fiberglass windows are priced a bit higher than vinyl ones, but usually 10 to 20 percent below the price of wood windows. Fiberglass has high embodied energy and its manufacture, like PVC's, may contribute more heavily to localized air pollution.

Lightweight, strong, and almost maintenance-free, aluminum-frame windows with properly designed thermal breaks are best suited for moderate climates. Avoid using metal-framed windows without thermal breaks—strips of plastic between the inside and outside of the frame and sash. Steel and aluminum conduct heat well, and this thermal bridging compromises a window's energy efficiency.

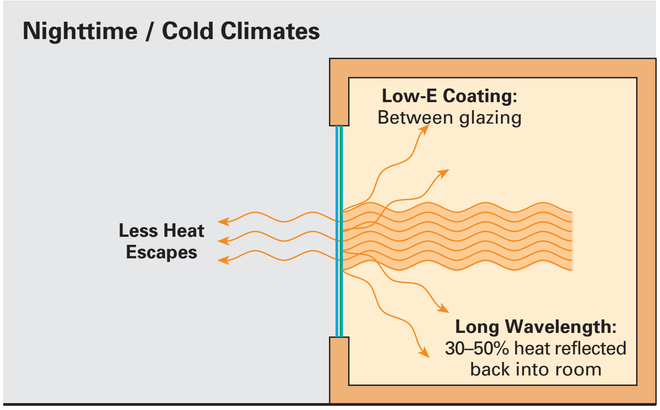
Space-Age Coatings & Gases

The use of metallic coatings has further improved a window's sun-blocking and heat-retention capabilities. "Low-E"

Effects of Low-E Coatings on Radiant Heat Transfer



To reduce heat gain through the window, low-E coatings should be applied to the inside of the outermost window pane, where they can effectively reflect a portion of the sun's heat.



To reduce heat loss from a home's interior, low-E coatings should be applied to the inside surface of the pane closest to the home's interior, to reflect heat back into living spaces.

(emissivity) coatings, applied to one or more of the panes of glass, work by reducing infrared (heat) radiation transfer and lower the U-value of the window. They can reduce energy transmittance by 30 to 65 percent compared to noncoated glass.

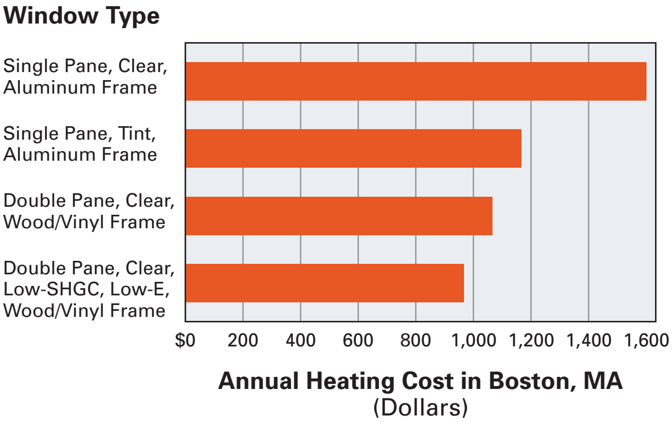
Different coatings allow for high, moderate, or low solar gain. In general, to prevent solar gain (in hot climates, and on east- and west-facing windows, and unshaded south-facing windows), make sure the low-E coating is applied to the *outermost* pane of glass (see illustration above). If you want to admit solar heat gain *and* prevent that heat from escaping the house, the low-E coating should be applied to the *innermost* pane of glass.

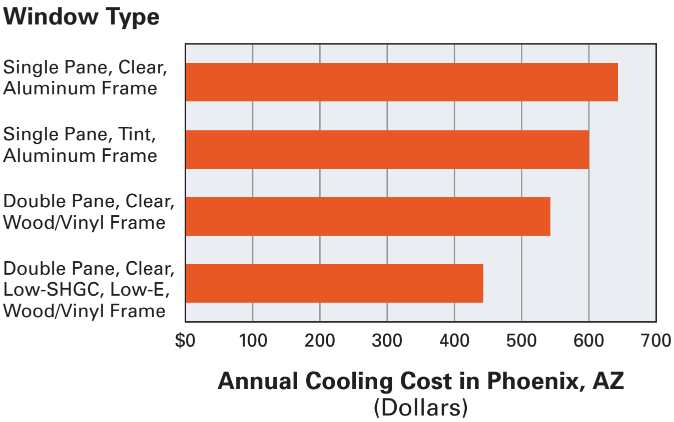
Low-E coatings can also reduce a window's visible light transmittance. If this is a concern, be sure to specify spectrally selective coatings, which are designed to reflect particular wavelengths of light, but remain transparent to others. Spectrally selective coatings can filter between 40 and 70 percent of the heat normally transmitted through insulated window glass, while allowing nearly 90 percent of the visible light to pass through. These coatings have proven especially effective in hot climates. According to the U.S. Department of Energy, computer simulations show that using spectrally selective coatings can reduce electric space cooling requirements of new homes in hot climates by almost half.

Gas-filled windows improve a window's thermal performance by providing increased resistance to heat flow. Instead of air being trapped between the panes, an inert gas with a lower conductivity than air, such as argon or krypton, fills the space. Krypton and even xenon gas are used in the highest performance windows made today.

During the past 25 years, steady advancements have also been made in the technology of suspended coated film (SCF) insulating glass. The Insulating Glass Certification Council now recognizes SCF units as "triple" with the incorporation of two air (argon- or krypton-filled) "interspaces." Positioned

Typical Heating & Cooling Costs for Homes Using Various Window Technologies





Data courtesy www.efficientwindows.org

midway between inner and outer glass panes, these films can provide various levels of heat and light transmission. SCF units incorporating "Heat Mirror" technology report insulating R-values as high as 15.5—with no increased weight relative to double glazing. These windows complement cold-climate, superinsulation construction strategies. Several SCF manufacturers offer high-performance "QuadPane" units, with two suspended films and three gas interspaces.

Super (Passive) Solar Windows

If you're building a new home, or remodeling, and want to maximize your home's energy efficiency, passive solar design can reduce heating, cooling, and lighting needs considerably. For these designs, selecting the right windows is critical. Although design strategies vary by region and home site, the basic techniques for choosing the right windows are the same: Orient and size windows to control solar heat gain. In most climates in the United States, you'll want to have the greatest heat gain during the winter and the smallest gain in the summer.

Cold Climate Strategies. In cold climates dominated by heating loads, locate most of your windows along the southern face of your home to admit solar heat during the winter, when the sun is low in the sky. For the summer, when the sun's angle is higher, provide ample overhangs to shade these windows and prevent overheating. In general, south-facing windows should have a solar heat gain coefficient (SHGC) of 0.6 or greater, a U-factor of 0.35 or less to reduce heat transfer, and high visible light transmittance for good light transfer.

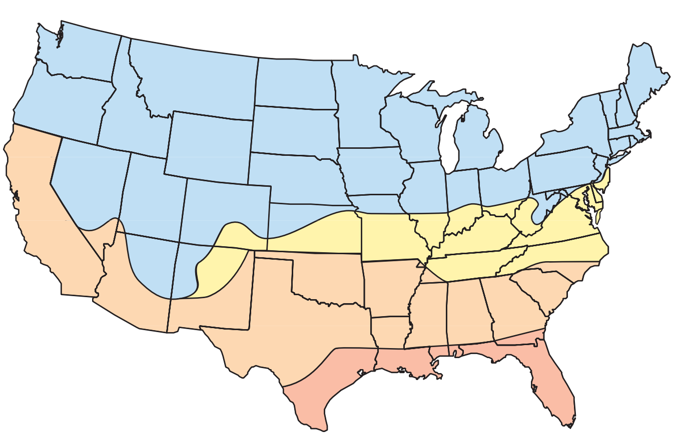
Reduce the number of windows on the north, east, and west walls of the house, while still allowing for ample daylighting opportunities. In most cases, west-facing windows should have a low SHGC and be shaded to prevent excess summertime heat gain. North-facing windows will admit very little, if any, solar gain, and should be sized only to provide natural lighting.

Window Selection for Hot Climates. In regions where cooling loads predominate (the South, for instance), install north-facing windows and well-shaded south-facing windows. Choose windows with low SHGCs to further reduce your home's reliance on mechanical cooling. Tinted, reflective, low-E, and spectrally selective coatings also will help lower a window's SHGC. Be aware, though, that these coatings can also lower a window's visible light transmittance.

Courtesy www.pella.com

Modern replacement windows install easily into old casings, making energy efficiency upgrades less complicated and less expensive.

Energy Star Rating Criteria by Region



Region	U-factor	SHGC
Northern	≤ 0.35	–
North Central	≤ 0.40	≤ 0.55
South Central	≤ 0.40	≤ 0.40
Southern	≤ 0.65	≤ 0.40
All	≤ 0.35	≤ 0.40

Data courtesy www.energystar.gov

In some regions, custom ratios of U-factor and SHGC are acceptable; see www.energystar.gov for details.

Window Shopping Checklist

Once you've determined where your windows will go, and how many and what size you need, you're ready to hit your home improvement store. This quick list gives some general guidelines.

Frames. Fiberglass frames offer the best energy performance, but vinyl, composite, and wood frames also are close competitors. If you're building "green," consider energy performance, embodied energy, and the pollution generated by the frame material's manufacture, and choose the window frame that offers the highest performance at the lowest environmental cost.

Look to the Label

When you're shopping for windows, use the National Fenestration Rating Council (NFRC) label affixed to the window as your guide. The NFRC, a nonprofit organization, administers a uniform, independent rating program to allow building professionals and homeowners to compare products directly, regardless of glazing and frame type.

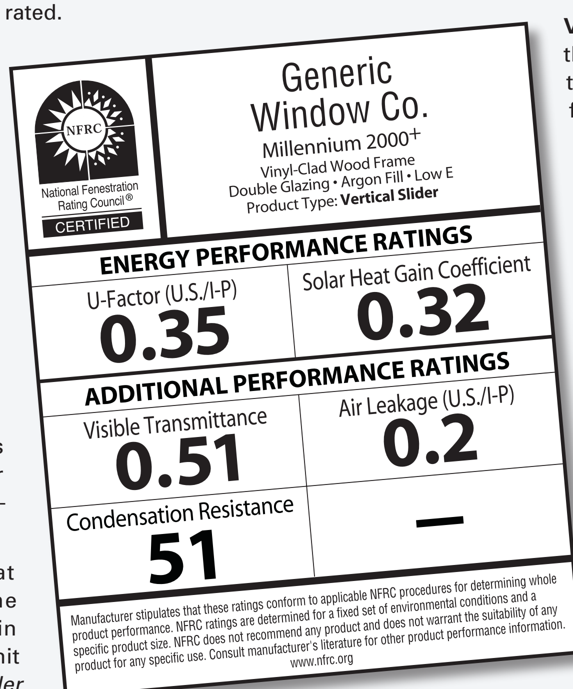
NFRC Insignia. The official "stamp of approval" that this window has been independently rated.

Certification & Inspection Agency. These organizations are licensed by the NFRC to review simulation and testing lab reports, issue certification, and conduct annual plant inspections of window manufacturing facilities.

Product Description. Lists model number, window type, coating specifications, type of gas fill, and the width of the air space between panes.

Rating Type. These columns specify ratings for either residential or commercial applications.

U-Factor. Measures heat transmission through the unit due to a difference in temperature for the entire unit (frame and glazing). The *smaller* the U-factor, the less heat is transmitted through the window, and the better the window's insulating value. U-factors typically fall between 0.2 and 1.20.



Solar Heat Gain Coefficient. Measures how well a unit blocks heat. SHGC is expressed as a number between 0 and 1; the lower the number, the less heat transmitted through the unit.

For passive solar design, maximizing SHGC for certain windows can optimize home heating with the sun. In regions where cooling loads predominate, consider shopping for windows with low SHGCs.

Visible Light Transmittance. Indicates the fraction of visible light that passes through a window. VLT can range from 0 to 1. For maximal daylighting, look for high VLT numbers.

Air Leakage. Measures the rate of air infiltration through the particular window unit, as cubic feet per minute per square foot of window area. The lower the air leakage (AL), the less air will pass through cracks in the window assembly.

Condensation Resistance. Measures the window's ability to resist condensation forming on the interior surface. The higher the rating, the better resistance. Rated on a scale from 0 to 100.

If this is too much number-crunching for you, look to the Energy Star label to point you in the right direction. Energy Star windows are rated, certified, and labeled for both U-factor and SHGC by the NFRC at levels specified by Energy Star qualification criteria. You can find a savings breakout by region on the Energy Star Web site (www.energystar.gov/windows).

Multipane Windows/Multiple Glazings. Although having many panes improves a window unit's efficiency, investing in triple-pane windows is generally not necessary in most climates in the United States. Paired with low-E coatings, improved framing materials, warm edge spacers, and gas fills, double-pane windows fit the bill for most applications.

Gas Fill. Gas-filled windows generally provide better insulation (lower U-factors).

Weather stripping. Look for durable plastic weather stripping in Energy Star-rated windows.

Glass Coatings. Select the right low-E coating for your climate:

- Cool summers, with very cold winters: Choose windows with high solar gain, low-E coatings. Look for SHGCs between 0.56 and 0.75.
- Moderately hot summers, with cold or mild winters: Aim for SHGCs between 0.41 and 0.55.
- Very hot summers, with cold or mild winters: Windows best suited for this climate type generally should have SHGCs between 0.20 and 0.40. Coatings will also help reduce fading of furniture and window treatments by blocking ultraviolet radiation.

Warm Edge Spacers. Steel, foam, fiberglass, and vinyl have replaced the aluminum that was once used to separate a window's glazing layers. These "warm edge" spacers help reduce thermal bridging (heat transfer), lower the U-factor, and prevent condensation.

Incentives to Save

The 2005 Federal Energy Bill offers a tax credit of up to $200 for purchasing and installing efficient windows. Internal Revenue Service guidelines qualify all Energy Star windows and skylights for the tax credit, but only if they are installed in the regions they are certified for (see the map).

Don't forget to save the sticker—you'll need it for documentation, should the IRS come knocking. And act fast—these credits expire on January 1, 2008. Some states and utilities also offer financial incentives for installing energy efficient windows. Search the Database of State Incentives for Renewables & Efficiency at www.dsireusa.org for individual state listings.

The small federal tax credit can seem like a drop in the bucket compared to the total cost of new or replacement windows. But you can take real comfort in the fact that over their lifetime, your new, efficient windows will recoup their initial cost, increase your home's efficiency, reduce heating and cooling bills, and make your home more comfortable.

Access

Keith Boulac • kboulac@alpeninc.com

Other Resources:

Efficient Windows Collaborative • www.efficientwindows.org • Tool for selecting windows based on locale and specifications

Energy Star • www.energystar.gov • Find Energy Star-rated windows and purchasing tips

Information on federal tax credits for windows • www.energystar.gov/index.cfm?c=windows_doors.pr_taxcredits

National Fenestration Rating Council Inc. • 301-589-1776 • www.nfrc.org • RESFEN, a software program to fine-tune home design and window selection. $15


POWER LEVELS FROM 1KW TO 60KW
OUTPUT VOLTAGES OF 100,120,230
INPUT VOLTAGES OF 12 TO 108
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MODULAR
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TRUE SINE WAVE MX SERIES POWER INVERTERS
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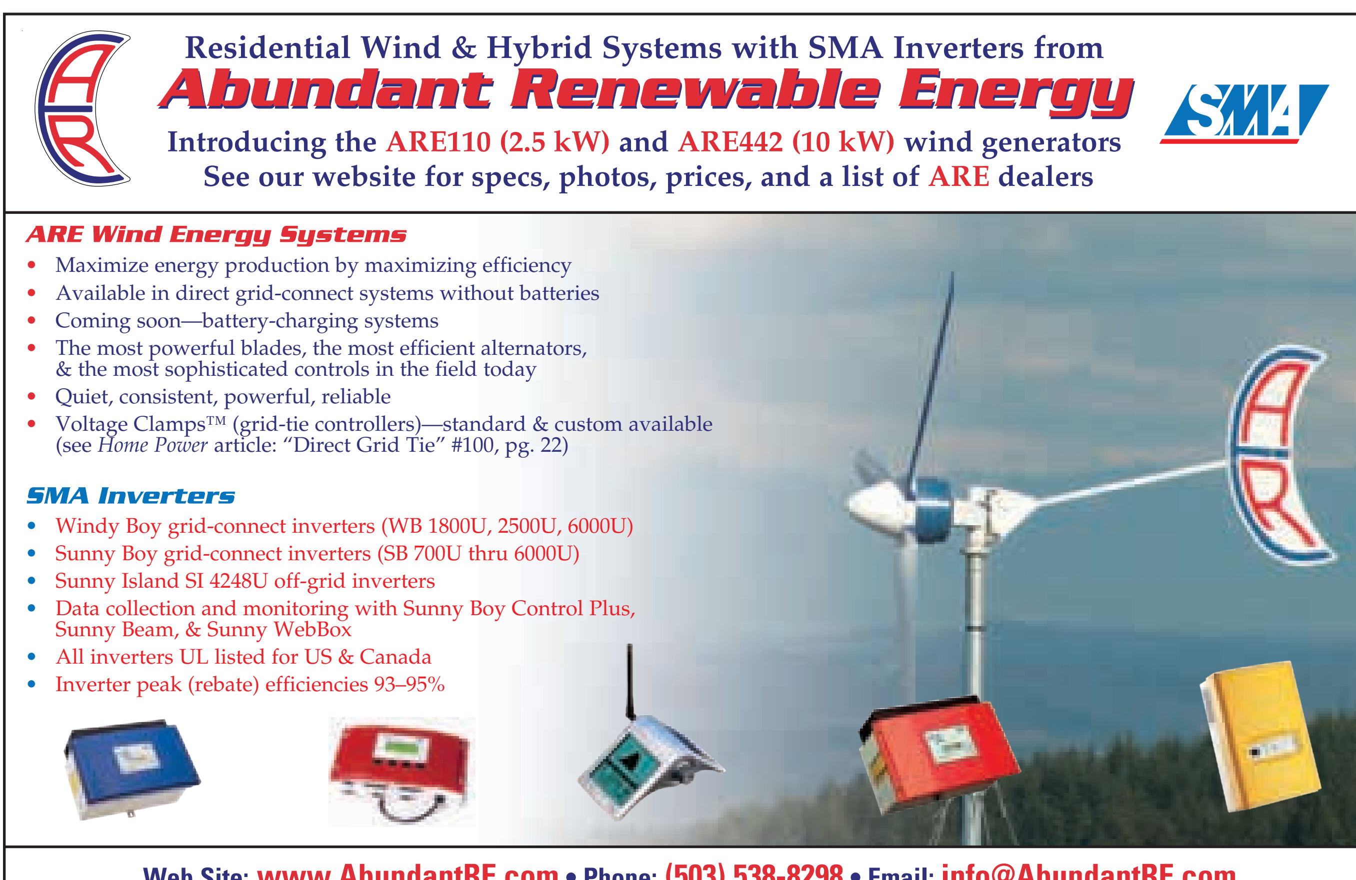
Residential Wind & Hybrid Systems with SMA Inverters from
Abundant Renewable Energy
Introducing the ARE110 (2.5 kW) and ARE442 (10 kW) wind generators
See our website for specs, photos, prices, and a list of ARE dealers
SMA
ARE Wind Energy Systems
• Maximize energy production by maximizing efficiency
• Available in direct grid-connect systems without batteries
• Coming soon—battery-charging systems
• The most powerful blades, the most efficient alternators, & the most sophisticated controls in the field today
• Quiet, consistent, powerful, reliable
• Voltage Clamps™ (grid-tie controllers)—standard & custom available (see Home Power article: "Direct Grid Tie" #100, pg. 22)
SMA Inverters
• Windy Boy grid-connect inverters (WB 1800U, 2500U, 6000U)
• Sunny Boy grid-connect inverters (SB 700U thru 6000U)
• Sunny Island SI 4248U off-grid inverters
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Finding the Phantoms

Eliminate Standby Energy Loss

by Joe Schwartz

When you climb into bed at night, ready to shut down for the day, are your home's electrical appliances doing the same? Some of your appliances do useful work while you sleep—refrigerators and centralized heating systems cycle on and off to keep your food cool and your house warm. Other appliances, like TVs, computers, and modems, are likely also using energy while you sleep, but not performing any useful service. These useless energy draws are referred to as phantom loads, and unless you keep them in check, they will haunt your home's energy use all night, every night.

The energy wasted by phantom loads is commonly referred to as standby loss. And while a given appliance's standby loss may be small in terms of *power* (watts; W), these phantom loads are consuming electricity 24 hours a day, seven days a week. As a result, the cumulative *energy* (watt-hours; WH) they waste is substantial.

Some quick math can help put phantom loads in perspective in terms of overall energy use. The average U.S. household has about 40 to 60 W of continuous phantom loads running, day in and day out. On average, this amounts to approximately 1,200 WH per day (50 W x 24 hrs./day = 1,200 WH/day) or 1.2 kilowatt-hours (KWH) per day. The same average U.S. home uses about 900 KWH of electricity per month, and 36 KWH per month, or about 4 percent of total electricity use, is due to standby losses. Multiply this figure by 122 million U.S. housing units, and enough energy is wasted by standby losses in the United States to run all of the homes on the continent of Australia, and then some. These figures are the stuff that energy nightmares are made of.

Identifying Phantoms

Many, if not most, electronic devices can be phantom loads—TVs; microwave ovens; VCR, CD and DVD players; computers; etc. Products that have external power supplies (wall cubes) are often accompanied by constant standby consumption. The table surveys some phantom loads present in a typical U.S. household. Keep in mind that a home's standby energy consumption can vary widely depending on the number of appliances and how they are designed.

Phantom loads fall into two general categories—appliances that consume energy even when they're turned "off," and appliances that, compared to when they're fully operational, use a lesser amount of energy to keep displays, remote controls, and power supplies ready for the product's primary use. Let's look at the energy use of a DVD player as an example.

One current model DVD player draws 11 W while showing your favorite flick. With no movie playing, and just the LCD display lit, it consumes a little bit less—9 W. But even when you turn off the DVD player, it still draws 3 W. If you look at the DVD player's energy use modes (playing, on, and off) over the course of a day, some interesting energy use figures come to light.

Let's assume that you're a full-on video-head and watch a two-hour movie every night. If you break down the DVD player's 24-hour energy use by the time spent in each mode, it consumes 22 WH (11 W x 2 hrs.) while the movie's spinning. If you shut the player off after you're done watching, the DVD player will still consume another 66 WH (3 W x 22 hrs.) before you plunk down to watch another movie the next night. If you zonk out during the movie and forget to turn the DVD player off, it will consume 198 WH (9 W x 22 hours) over the same time frame. So over a 24-hour period, the DVD player uses *three times* as much energy when it's *off* as when it's playing, and *nine times* the energy if you forget to turn it off altogether.

The Making of a Phantom

Nearly all of the electronic appliances around your home rely on power supplies to convert the 120 volts AC provided at your electrical outlet to lower-voltage DC to power the appliance's electronics. The familiar wall cubes you plug in to power your cordless phone or to charge your cell phone battery are both examples of external power supplies.

Unfortunately, the inexpensive electronics we've become accustomed to have notoriously inefficient power supplies. High transformer core losses in the power supplies themselves will waste electricity as long as they're plugged in. And many built-in power supplies are switched on the output, rather than on the input side of the transformer, so some electricity at 120 volts is continuously being consumed. This means that the transformer is never actually turned off, even though the appliance itself may be.

Not all appliances have external power supplies, but the lack of a visible wall cube doesn't mean you're off the hook. Many electronic devices such as computers and TVs have built-in internal power supplies. So just like your cordless phone, your TV is likely using electricity unless it's unplugged from the wall outlet. Plus, most TVs and many other appliances have remote control receivers that are powered all the time, ready for you to hit their power buttons to turn the appliances on.

Household Survey of Standby Losses

Appliance	Standby Power (Watts)	Energy Use (Watt-Hrs./Day)
DirecTV receiver	10	240
Mac G4 desktop computer tower	7	168
Cambridge Soundworks speakers & subwoofer	7	168
Motorola cable modem	5	120
General Electric VCR	5	120
Sony TV, 9 in.	4	96
AirPort Extreme wireless router	3	72
Samsung DVD player	3	72
Panasonic fax	3	72
Black & Decker electric lawn mower charger (float)	2	48
DeWalt cordless tool battery charger	2	48
AirPort Express wireless router	1	24
Apple LCD computer display, 20 in.	1	24
Sonicare electric toothbrush	1	24
Sharp microwave/toaster	1	24
Uniden cordless phone base station	1	24
Uniden cordless phone satellite charger	1	24
Hewlett-Packard laser printer	1	24
Totals	58	1,392

Kilowatt-Hour Meters

Standby Losses & Renewable Electricity Systems

Minimizing standby losses is an important aspect of optimizing a home renewable electricity system. Every watt-hour you save is a watt-hour your RE system doesn't need to produce, and money you save in up-front system costs.

The majority of solar-electric (photovoltaic; PV) systems installed are grid-tied, and rely on batteryless inverters to convert the DC electricity generated by your PV array to AC electricity used in your home or sent to the grid. Most batteryless inverters are designed with low standby loss in mind, and will shut down overnight, drawing only a fraction of a watt after the sun goes down. In grid-tied systems with battery backup, standby losses can be more significant compared to batteryless systems, since battery charging and management is required. Correct programming will minimize inverter energy consumption overnight.

Modern inverters are designed to minimize standby energy use.

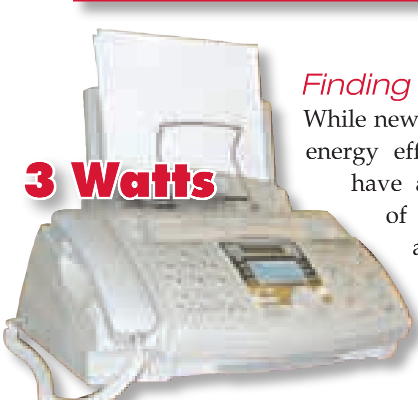
Keeping standby losses to a minimum is extremely important in off-grid RE systems. Any electricity demand beyond what the RE system can generate is typically provided by an engine generator, which is noisy, polluting, and expensive to run and maintain. One design approach for large off-grid PV systems (3 KW array and greater) is to simply add additional modules to offset standby energy use by appliances and inverters in idle mode. This approach is most convenient, but requires a larger cash outlay up front. For small off-grid systems (1 KW array or less), unchecked standby losses can quickly become one of the largest loads on the system.

Home-scale, battery-based inverters typically have two modes that affect standby energy usage—idle, and a standby mode commonly referred to as "sleep" or "search" mode. Modern, battery-based inverters can draw as much as 22 W per inverter without loads (at idle). Multiply this by 24 hours in the day and your inverter can quickly become a significant load on the system, consuming more than 500 WH per day. The same inverter, programmed to go to into an energy saving sleep mode if AC loads are not present, will draw about 4 W, or 96 WH per day, consuming only about 18 percent of the energy of idle mode.

Eliminating all phantom loads will allow your inverter to go into sleep mode, saving energy when you're not actively using AC electricity. Then, if an AC load is turned on, it takes a moment for the inverter to "wake up," ramp up to full voltage, and power the AC appliance. This momentary inconvenience is well worth it for many small system owners focused on maximal system performance and minimum generator run time.

Comparing PV output and initial costs to energy consumption helps drive home the benefits of minimizing standby energy use. Let's assume that you have installed an array with 100-watt PV modules at a location with 5 daily peak sun-hours, and appliance and inverter standby losses amount to 1,200 WH per day. For a batteryless, on-grid system, an overall annual system efficiency of about 80 percent is realistic in many locations. To offset the daily standby energy use only, the output of three 100 W modules would be required (1,200 WH/day ÷ 5 sun-hrs./day = 240 W; 240 W ÷ 0.8 (efficiency factor) = 300 W; 300 W ÷ 100 W/PV module = 3 PV modules). Off-grid systems have a conversion efficiency of about 70 percent, so four 100 W modules would be required to offset the standby energy use in that case.

You can expect to pay about $600 for a 100 W module in today's market. That means your standby energy use would cost you $1,800 in up-front PV module costs in the batteryless grid-tied system described above, and $2,400 in the off-grid system example. Add this to the cost and nuisance factors related to generator use when a few days of cloudy weather appear, and additional installation and balance of system equipment costs, and minimizing standby energy use can amount to big savings.



Finding the Phantoms

While new appliances are getting more energy efficient, most of our homes have all manner—and all ages—of appliances. You may have a new high-definition TV, but an old cordless phone. As a result, the standby losses of appliances can vary radically between one home and another. To complicate things, standby loss figures are rarely presented on an appliance's labeling. In the end, actual hands-on measurement is the only way to accurately quantify standby losses. Luckily, inexpensive, handheld digital power meters are available to help you determine your appliances' standby energy use (see Access). Other than a piece of paper, a pencil, and a calculator, a power meter is all you need to ferret out phantoms around your home.

In general, identify appliances with external power supplies, remote controls, continuous digital displays, or

rechargeable batteries. Chances are that these products will have standby losses. Plug the power meter into the electrical outlet, and the appliance being measured into the meter. Set the display to watts and jot down the power draw when the appliance is turned off, powered up, and operational. Multiplying the wattage you measure by 24 hours (or the amount of time the appliance is not in use each day) will give you a daily energy loss (WH) figure for the appliance. An hour or so spent roaming around your house with paper and meter in hand will probably be all the time it takes to determine how many phantom loads are present, and how much energy they're using each day. Once you've identified the worst offenders, the next step is to truly shut them down.

Defeating Phantoms

You'll likely need to live with some phantom loads, such as cordless phones that need to be ready to go at any time. Answering machines, on the other hand, can easily be replaced by voice mail provided by your phone company. Once you've identified unnecessary phantom loads around your house, the next step is to figure out how to conveniently shut them down when they're not in use or required.

One option is to unplug any appliance that has a standby loss, but this can be inconvenient. Instead, using plug strips can be a simple and effective strategy to defeat phantom loads. They cost about $5 each, and are available at hardware and appliance stores everywhere. Plug strips can be used to group appliances that you regularly use in conjunction with one another—your modem, computer, and monitor can be on one strip, while hardware you use less frequently, like your printer, scanner, and external hard drive, can be on another. If you're rewiring circuits in your home, or building from scratch, well-planned electrical circuits can include switched receptacles that will shut down phantom loads at the flip of a switch.

Serious About Standby Losses

The subsidized, low cost of grid electricity in the United States has led many of us into bad habits when it comes to energy use, and it has also served as a disincentive for appliance manufacturers to design highly efficient products with low standby losses. As electricity costs continue to escalate, and as federal programs like Energy Star continue to reward manufacturers with efficient designs, we can expect the trend of improved appliance energy efficiency to continue.

Some of the super energy-efficient homes featured in *Home Power* can run all their household loads using the same amount of electricity that a typical American household *wastes* on phantom loads. So see how low you can go—get your hands on a power meter, and spend an hour or two surveying your home for phantom loads. You'll be rewarded by shaving a bit off your next electrical bill, and you'll sleep better at night knowing that your efforts are helping to reduce our overall energy use, and the pollution associated with fossil fuel and nuclear electricity generation. And when you do install an RE system to power your home, there will be significant savings in up-front equipment costs (see sidebar). Remember, energy saved is energy that doesn't need to be generated in the first place.

Access

Joe Schwartz, *Home Power*, PO Box 520, Ashland, OR 97520 • joe.schwartz@homepower.com • www.homepower.com

Energy Star • www.energystar.gov • Information on energy efficient, low standby power appliances

Watt-Hour Meters:

Brand Electronics • 888-433-6600 • www.brandelectronics.com • Brand meter

Electronic Educational Devices • 877-928-8701• www.doubleed.com • Watts Up? meter

P3 International Corp. • 888-895-6282 • www.p3international.com • Kill A Watt meter

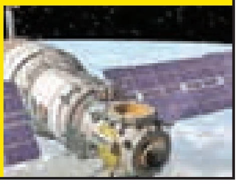
Electronic Advances

In recent years, manufacturers have become more aware of the need to minimize standby losses in appliances they design and manufacture. Much of the progress here has been spurred by federal efforts—including the well-known Energy Star program—that are setting guidelines to push manufacturers to design more efficient appliances with low standby losses.

Forward-thinking appliance manufacturers are using four major design approaches to reduce standby losses:

- Improved designs for more efficient transformers
- Moving the power switch to the input side of the power supply, to completely power it down when it's not in use
- Advanced designs that limit the number of electronic components required for standby service
- Intelligent charging circuits in products with rechargeable batteries

As electricity prices continue to escalate, and energy consumers continue to become more aware of the impact inefficient appliances have on both their pocketbooks and the environment, appliance and electronics manufacturers will continue to refine their product designs with energy use in mind. The TV set that had 30 W of standby loss several years ago likely has less than 10 W today. Thanks to programs like Energy Star, appliance design is headed in the right direction, and appliances are getting more efficient all the time.



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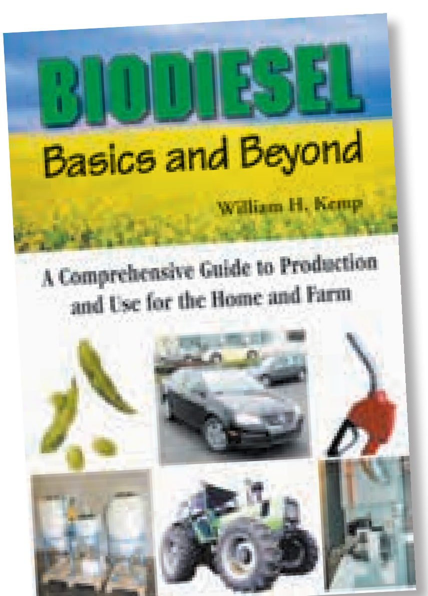
RE-SOURCES Biofuels

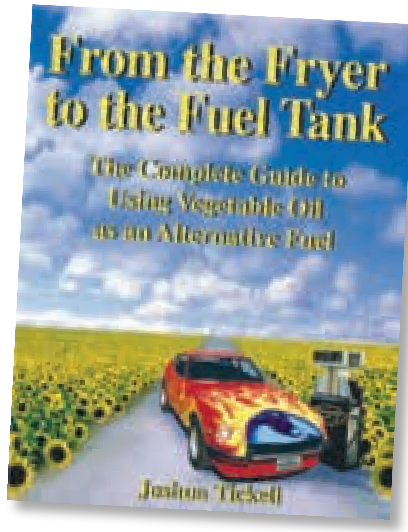
From vegetable-oil-based biodiesel to ethanol alcohol made from corn or other plants, it's getting easier to be greener on the go. Here are some resources that can help you on your way to cleaning up your car's pollution. Not only will you reduce your vehicle's emissions and reliance on foreign oil, but in many cases you'll be helping support American farmers and local businesses. Finally, a wheel revolution you can really get behind!

Get your engine started—on doughnut and french fry grease. With fewer particulate emissions, cleaner-burning **biodiesel**—made by reacting vegetable oil with methanol and lye—and **straight vegetable oil** are alternatives to dino-diesel.

▶ Learn how to turn new (or used!) vegetable oil into a less polluting fuel for your diesel car or tractor with William Kemp's *Biodiesel Basics & Beyond* (300 pages, $29.95, www.newsociety.com).



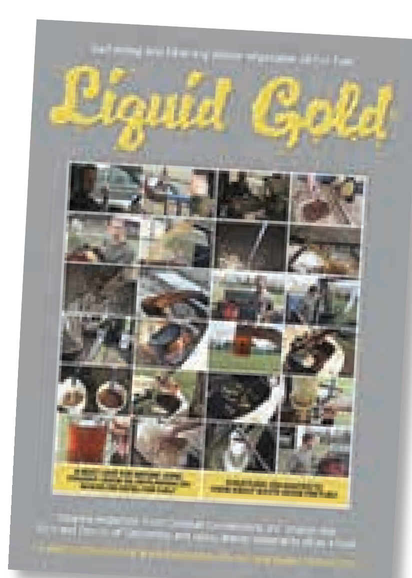
▶ Also check out Josh Tickell's veggie van odyssey and what many folks call the "biodiesel bible"—*From the Fryer to the Fuel Tank* (162 pages, $24.95, www.biodieselamerica.org). Kemp's and Tickell's books both give detailed histories of the biodiesel movement, and provide advice for making your own fuel right in your own backyard "lab."



▶ For those who'd rather tinker under the hood than in the lab, *Sliding Home* by Ray Holan (294 pages, $25, www.goldenfuelsystems.com) tells how to run your diesel vehicle on straight or waste vegetable oil (SVO/WVO) by making a few modifications to the fuel lines and tank.

▶ Do-it-yourselfers will also want to get their hands on a copy of the *Veg My Ride* DVD (79 min., $19.95, www.vegmyride.tv), a slick production that gives would-be greasers step-by-step instructions on making modifications to run a typical diesel vehicle on SVO.

▶ Learn about grease dumpster diving dos and don'ts with the *Liquid Gold* DVD (80 min., $25, www.goldenfuelsystems.com), in which SVO expert Charles Anderson shares his top tips for gathering free fuel.



Best Web Bets for Biodiesel & SVO Basics:

▶ BiodieselAmerica.org • Provides a general overview on biodiesel, interactive maps of retail biodiesel pumps, and an up-to-date listing of biodiesel-compatible cars for sale.

▶ JourneyToForever.org • A deeper look into the sustainability of biofuels. Read scientific studies, learn how to make your own fuel, and join the Biofuel e-mailing list to keep tabs on the movement.

You do the driving—let your car do the imbibing. Dabbled with in the 1970s, alcohol-based fuels, like **ethanol**, are making a comeback. Made from fermented plant sugar, this high-octane fuel is most commonly blended with 15 percent gasoline, and can reduce tailpipe emissions up to 30 percent. E85 stations are cropping up across the country and flexible-fuel vehicles are already on the market—in fact, you may already own one and not know it.

▶ For a good overview of alcohol fuels, check out *Makin' It On the Farm* (182 pages, $10–$12.95, www.buffalo-creek-press.com) and *The Alcohol Fuel Handbook* (127 pages, $19.95), which offer a historical perspective on making alcohol fuels, instructions for distilling your own fuel, and navigating government regulations.

Best Web Bets for Your Ethanol Education:

▶ Alternative Fuels Data Center • www.eere.energy.gov/afdc/altfuel/ethanol.html • Basic information on ethanol—how it's made, its benefits, incentives and laws, and quick fact sheets.

▶ National Ethanol Vehicle Coalition • www.e85fuel.com • Find out if your car is ethanol-compatible, and locate a retail E85 pump near you.

▶ Union of Concerned Scientists Clean Vehicles • www.ucsusa.org/clean_vehicles • Click on the "Truth About Ethanol" link for answers to alcohol fuel FAQs.

—Claire Anderson • claire.anderson@homepower.com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MAKING PV PAY

It's Just Good Business Sense

by Andy Kerr

Investing in renewable energy (RE) certainly makes sense for the planet and for personal quests for sustainability, but being green can *make* green, especially when you use RE to power a business.

In 2001, I commissioned a 3.2-kilowatt, grid-connected solar-electric (photovoltaic; PV) array installed on my garage roof (see *HP101*). Rather than installing and operating the system as an individual, it was a project of the Larch Company, my home-based consulting firm.

Having my company own the PV system made a lot of business sense. Both the federal and state tax credits were better for businesses than for individuals, and the equipment purchase was a deductible business expense. The projected internal rate of return for this project was 13.3 percent—not a superb business investment, but a marginally good one.

Author Andy Kerr next to the utility disconnect and the Fronius inverter, the brains of his solar-electric system.

In 2006, I decided to add more PV to the system. The first array produced 3,912 kilowatt-hours (KWH) in 2005, or 91 percent of what my home and business consumed in that year. Phase II would add enough PV to close the production–consumption gap, and also produce enough surplus electricity to sell back to the grid at a premium.

The time was right: My company had the capital to invest, and the tax credits were too good to pass up. For Phase II, the internal rate of return is 23.8 percent (as a business proposition) or 4.2 percent (as a personal investment). The return on the new system would be significantly better than the return on the first, because newer inverters are more efficient both from an engineering (higher conversion efficiency) and economic (lower cost per watt) standpoint. Plus, other system costs have generally declined, power rates have increased, and—most importantly—the federal subsidies have improved. The net result? A rate of return any investor can love.

One half of the Phase II array. (A portion of the Phase I array can be seen through the office windows.)

Number-Crunching

After specifying the equipment and getting an estimate for the new project, I developed a spreadsheet to assess the anticipated financial costs and benefits. (See spreadsheet on following page and, for a live spreadsheet, www.homepower.com/promisedfiles.) I modeled my business investment over ten years. Ten years is also the limit of the inverter warranty—since the inverter is the most complex piece of equipment in the system and the only one with sensitive electronics, it is likely to be the first (and perhaps the only) component to fail. Even so, the Fronius inverter my installer recommended has a seven-year warranty, with a three-year extension available for a mere $69.

Even though I anticipate that the new system will operate far longer than ten years (the PVs are warranted for 25), to complete the economic analysis I had to presume a "salvage" value for each component, on the assumption that each would be decommissioned after a decade. In that time, inverter technology will likely improve enough to make mine "worthless." The mounting and electrical hardware might still be worth a few bucks, but it's hard to say. General wisdom suggests that the PV modules will hold approximately half their original value after ten years, unless there is a breakthrough in PV efficiency or cost.

Now the fun—calculating the payback from my PV investment. When it comes to subsidies, the City of Ashland's Electric Department is very supportive of solar energy technologies. First, it gave me a cash incentive of $2.25 per array rated watt. Second, like many utilities, the Electric Department offers net metering, allowing the utility meter to effectively run backward when the PV system is generating more electricity than my home business is consuming. Third, the city-owned electric utility buys all my excess kilowatt-hours, and at a premium, paying me nearly $0.08 for each solar-generated

System Costs

Equipment	Cost
12 Mitsubishi PV-MF170EB3 PV modules	$9,792
Fronius IG2000 inverter	2,500
Labor	1,500
DP&W PR3-MF170 PV mounts	1,120
Miscellaneous electrical	225
Combiner box	95
Permits	80
Inverter extended warranty	69
AC disconnect	60
Miscellaneous hardware	50
Total Cost	$15,491

Assumptions & Calculations

Variables	Amount
Number of modules	12
STC watts per module	170
Array STC (W)	2,040
Net system efficiency	75%
Estimated annual PV energy output[1]	1,605
Total solar resource fraction[2]	94.1%
Estimated annual AC KWH	2,311
Utility sale rate ($/KWH)	$.07941
Estimated electricity sales income (for Year 1 below)	$183
Electrical rate annual inflation assumption	3%
Combined state & federal income tax bracket	30%

[1]Annual watts of solar production per rated system watt
[2]Shading = 2.1%; tilt & orientation factor = 96.2%

Business Payback Scenario

Revenues & Expenses	2006 Year 0	2007 Year 1	2008 Year 2	2009 Year 3	2010 Year 4	2011 Year 5	2012 Year 6	2013 Year 7	2014 Year 8	2015 Year 9	2016 Year 10
Initial system cost & salvage value[3]	-$15,491										4,896
City of Ashland cash incentive[4]		4,590									
30% Federal income tax credit[5]		4,647									
Oregon income tax credit[6]		4,725									
Federal & state tax savings (depreciation)[7]		4,856									
BEF green tags[8]		116	116	116	116	116	116	116	116	116	116
Electricity sales[9]		183	189	195	201	207	213	219	226	232	239
Income taxes		-1,467	-91	-93	-95	-97	-98	-100	-102	-104	-106
Annual net cash flow	-15,491	17,651	213	217	221	225	230	234	239	244	5,144
Accumulated cash flow	-15,491	2,160*	2,373	2,590	2,811	3,037	3,267	3,501	3,740	3,983	9,128

Business, Internal Rate of Return 23.8%

[3]Assumed salvage value after 10 years
[4]$2.25 per PV module nameplate STC watt
[5]Reduces basis for depreciation by 5%
[6]30.5%, discounted from 35%; credit was sold to third party
[7]Expensed in first year
[8]5-year contract to receive $0.05 per KWH for selling green tags
[9]Annual electricity sales and green tag sales
*Simple business payback (year cash flow turns positive)

Personal Payback Scenario

Revenues & Expenses	2006 Year 0	2007 Year 1	2008 Year 2	2009 Year 3	2010 Year 4	2011 Year 5	2012 Year 6	2013 Year 7	2014 Year 8	2015 Year 9	2016 Year 10
Initial system cost & salvage value[10]	-$15,491										4,896
City of Ashland cash incentive[11]		4,590									
Federal income tax credit		2,000									
Oregon income tax credit[12]		1,500	1,500	1,500	1,500						
BEF green tags[13]		116	116	116	116	116	116	116	116	116	116
Electricity sales[14]		183	189	195	201	207	213	219	226	232	239
Annual net cash flow	-15,491	6,922	1,713	1,717	1,721	225	230	234	239	244	5,144
Accumulated cash flow	-15,491	-8,569	-6,855	-5,138	-3,417	-3,192	-2,962	-2,728	-2,489	-2,245	2,899**

Personal, Internal Rate of Return 4.2%

[10]Assumed salvage value after 10 years
[11]$2.25 per PV module nameplate STC watt
[12]$1,500 maximum for each of four years
[13]5-year contract to receive $0.05 per KWH for selling green tags
[14]Annual electricity sales and green tag sales
**Simple personal payback (year cash flow turns positive)

KWH I sell them (its highest retail rate). Meanwhile, I pay $0.066 per KWH (its lowest retail rate) for each one I buy beyond what I have produced. Finally, though the utility arguably could have claim to the green tags (renewable energy credits; RECs) of the project, it allows me to sell them instead.

While I knew Phase II would be a business project, I designed the spreadsheet to also analyze the non-business (personal) option as well. Although the City of Ashland didn't care if it was business or pleasure, the federal government and State of Oregon did.

For businesses, the federal government is offering a 30 percent tax credit, at least through 2008. For residential installations, it's capped at $2,000, but for businesses no cap exists. A business can also deduct the costs as an expense. The State of Oregon offers a 35 percent income tax credit for PV systems operated by businesses, which is subtracted directly from the tax bill. My consulting firm didn't really have much tax liability, so the state allowed me to "sell" or "pass through" the tax credit to someone who would otherwise be paying that amount in taxes. The Oregon Department of Energy specifies the transfer price. My pass-through partner paid me 30.5 percent of the cost of my system and received a tax credit from the state for 35 percent of the system's cost. For the pass-through partner, that calculates to a 14.75 percent return on a very safe investment of less than one year. The state residential income tax credit is capped at $6,000, spread over four years.

Besides the City of Ashland purchasing surplus solar-produced kilowatt-hours at a premium, green tags are the other source of energy-related revenue for the project. For the older system, I have a three-year contract with 3Phases Energy Services that pays me $0.05 per KWH. They buy the "greenness" of my renewable, carbon-free solar energy, and resell it to companies and individuals wanting to make their energy consumption carbon-neutral to offset contributing to climate change. To encourage solar energy, 3Phases pays me as much for green tags as they are receiving. Most of 3Phase's green-energy portfolio is wind-powered generation, for which

Just add sunshine—solar-electric systems are a sound investment, especially for businesses.

Internal Rate of Return Potential Changes

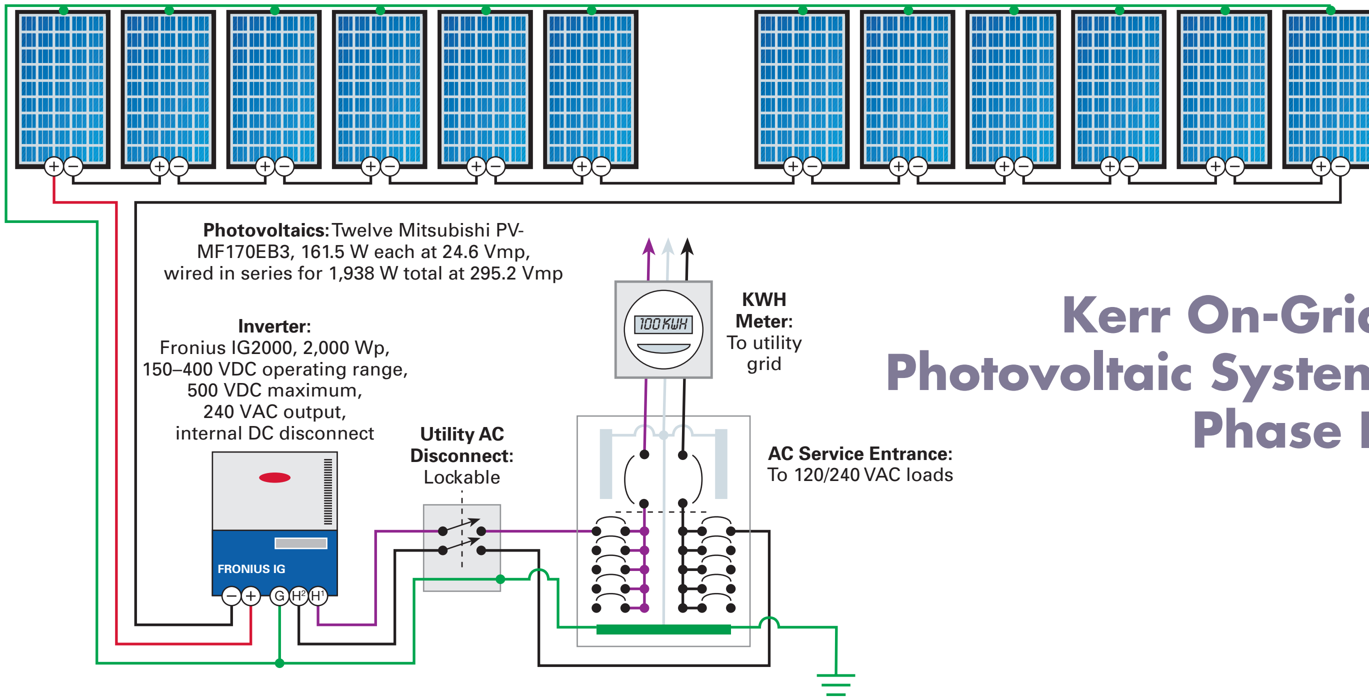
Projected Scenario	Business		Personal	
Internal Rate of Return (IRR)	23.8%		4.2%	
New Scenario	**New IRR**	**IRR Change**	**New IRR**	**IRR Change**
No federal income tax credit	8.4%	-15.4%	1.2%	-3.0%
No state income tax credit	8.2%	-15.6%	-3.8%	-8.0%
No City of Ashland assistance	12.2%	-11.6%	-0.4%	-4.6%
No green tag market	22.1%	-1.7%	3.1%	1.1%
None of the above	2.8%	-21.0%	-6.7%	-10.9%
0% Electric rate inflation	23.5%	-0.3%	4.0%	-0.2%
5% Electric rate inflation	23.9%	0.1%	4.4%	0.2%
10% Electric rate inflation	24.9%	1.1%	4.9%	0.7%

Site & System Specifics

In late 2002, when I added an office addition to my home, I was already making plans for a second PV array. I'd specified the roofline to run east–west and a roof pitch of 4:12 (18.5 degrees). In hindsight, I should have specified a 6:12 pitch (26.5 degrees), which would have been the optimal summer position (latitude minus 15 degrees) for my latitude of 42 degrees. I kept the panels parallel to the roof pitch—rather than mounting them at a steeper angle—to make the system more aesthetically pleasing. This concession to form over function only results in reducing gross annual kilowatt-hour production by about 2 percent.

In anticipation of this new project, I had 1 1/4-inch conduit installed from the attic of the new addition to the crawl space of the house. At the time, I assumed I'd need large-gauge wiring for low-voltage direct current, but the new array is wired for 295 Vmp, and the two #8 DC transmission wires and single #6 ground wire don't even begin to fill the oversized conduit.

Though I try to keep up with equipment costs and improvements, I left it to local PV guru Bob-O Schultze of Electron Connection to specify the hardware. Originally, we'd considered adding the second array to the first system's inverters, but the older Xantrex SW inverters are inefficient for grid-tied use compared to modern battery-based and batteryless inverter designs. As a result, the new system is totally independent, except that all of the renewable electricity generated goes to the same utility grid. This system separation saved some wiring and rewiring costs, and because grid-tie inverter efficiency has improved significantly since I installed my first system, I'd get a substantial increase in energy production by installing a new inverter.



Kerr On-Grid Photovoltaic System Phase II

Tech Specs

Overview

System type: Batteryless, grid-tie PV

Location: Ashland, Oregon

Solar resource: 4.9 average daily peak sun-hours

Production (estimated): 220 AC KWH per month (Phase II); 540 AC KWH per month total (Phase I and II combined)

Utility electricity offset (estimated): 144% (Phase I and II combined)

Photovoltaics

Modules: 12 Mitsubishi PV-MF170EB3, 161.5 W (guaranteed minimum at STC), 24.6 Vmp

Array: One 12-module series string, 1,938 W STC, 295.2 Vmp

Array installation: Direct Power & Water Power Rail mounts installed on south-facing roof, 18.5-degree tilt angle (parallel to roof plane)

AC disconnect: GE TG3221, 20 A, 2-pole breaker in AC service entrance

Balance of System

Inverter: Fronius IG2000, 2,000 Wp, 150-400 VDC operating range, 500 VDC maximum, 240 VAC output

System performance metering: Built-in inverter display and datalogging, utility KWH meter

green tags are cheaper. While my financial model projects the continued sale of green tags during years five through ten, it's an assumption, not a certainty, as is the price.

For the Phase II system, I decided to sell my green tags to the Bonneville Environmental Foundation (BEF), which not only markets green tags to support renewable energy, but also supports watershed restoration activities. The table on page 77 shows the projected internal rate of return with and without various government and market subsidies, as well as at higher electricity prices.

Many Happy REturns

As you can see from the IRR Potential Changes table, the money to be made is not so much in selling solar kilowatt-hours, but in collecting tax credits and deductions. In my business case, the table suggests that not all the government subsidies are necessary to achieve a modest financial return. As a personal investment, though, subsidies are critical to achieve a marginally adequate return on investment.

The minimum rate of return necessary to justify a financial investment all depends upon your "hurdle rate." In other words, how much money does your investment need to make? Businesses generally have higher hurdle rates than individuals do. In the case of Phase II, the simple business payback is one year. If I financed the PV project out of my own personal pocket, rather than from my business account, the break-even point would be *eleven* years. Far from great, but my personal hurdle rate is far lower than my business hurdle rate.

As a personal investment, the project's tax-free payback of 4.2 percent for my PV system compares very favorably against other no-risk—but *taxable*—investments such as a government-insured 5-year certificate of deposit (4.8 percent), money market account (3.5 percent), or ten-year government bond (4.9 percent). For residential PV systems to pay off, much of the return will come from tax savings, which leave you with more money in your pocket. But to take advantage of the credits, you need to have enough taxable income.

Will a PV system pay off for you? Besides the amount of sunshine your site receives, it depends on your finances, the size and cost of your PV system, the revenue it will generate, and the subsidies you can receive. Visit the Database of State Incentives for Renewables & Efficiency to learn about commercial RE incentives available in your area, and use the worksheet provided at www.homepower.com/promisedfiles to see how you can get your smart solar start. Once you gather the numbers and crunch them, you might be surprised to discover that when it comes to renewable energy, you're in business!

Access

Andy Kerr, Czar, The Larch Company • andykerr@andykerr.net • www.andykerr.net

Bob-O Schultze, Electron Connection • 800-945-7587 • bob-o@electronconnection.com • www.electronconnection.com • PV system installation

Andy Kerr's financial analysis spreadsheet • www.homepower.com/promisedfiles

PV System Components:

Direct Power & Water Corp. • 800-260-3792 • www.power-fab.com • PV array mounting hardware

Fronius USA LLC • 810-220-4414 • www.fronius.com/worldwide/usa.solarelectronics/about/ • Inverter

Mitsubishi Electric • 714-220-2500 • http://global.mitsubishielectric.com/bu/solar/index.html • PV modules

Incentives:

Bonneville Environmental Foundation • 503-248-1905 • www.b-e-f.org • Green tags

Database of State Incentives for Renewables & Efficiency • www.dsireusa.org • Incentive information

The Tax Incentives Assistance Project, American Council for an Energy-Efficient Economy • www.energytaxincentives.org or www.aceee.org • Federal & state government solar incentives

3Phases Energy • www.3phases.com • Green tags

Related Reading:

"Grid-Tied Solar in Small-Town, USA," Andy Kerr, *HP101*

"Mixing Business & Pleasure," Andy Kerr, *HP101*

"Doing Well While Doing Good," Andy Kerr, *HP86*

"Cost-Effective Hybrids," Andy Kerr, *HP113*

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Solar Water Heating
Tools of the ^ Trade

If you're handy around the house, and have some plumbing experience, a solar water heating system is within the realm of a do-it-yourself project. But before you get started, make sure you have the right tools.

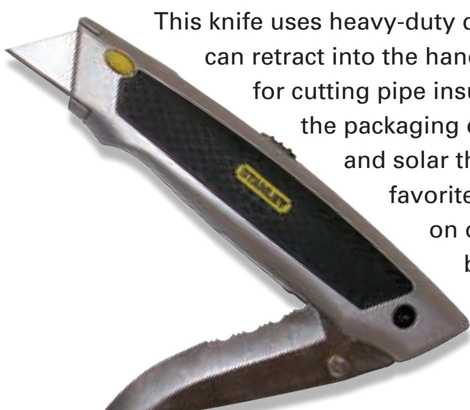
by Chuck Marken

The right tools can make the difference between a job going fantastically—or frightfully. Here's what you'll need in your toolbox to tackle a solar water-heating installation. We'll cover most of the bases for those who are newer to home improvement projects, but bypass describing and listing basic hand tools.

Besides choosing the *right* tools for the job, buy quality ones that will last a lifetime. And never try to get by with using the wrong tool for the job. This can cost you time, lower the quality of the finished installation, and might lead to some bloody knuckles—or worse!

Small, But Significant

Utility Knife



This knife uses heavy-duty disposable blades, which can retract into the handle for safety. Used for cutting pipe insulation and opening the packaging of all your new tools and solar thermal equipment. My favorite has a permanent blade on one side and disposable blades on the other. $15

Angle Finder

An angle finder (locater) allows you to set your solar collectors at the exact tilt angle to maximize the amount of solar exposure—and your system's performance. Many have a convenient magnetic base, which allows you to place the tool on the collector, leaving both of your hands free for mount adjustment. $10

Tube Cutters

Copper tubing (pipe) cutters are just what the name implies—and the small cutters fit in tight locations, allowing you to easily rotate the cutter around the pipe. Tube cutters make a very clean cut when working with copper, and clean-cut pipe-ends are the first requirement for leak-free solder joints. $20

Soldering Tools

Most solar water heaters are plumbed with copper tubing because of the high fluid temperatures they can produce. The easiest way to fit copper pipe together is by soldering. I like to keep all my soldering tools in a 5-gallon bucket with a tool organizer. Kept in the bucket are (clockwise from top): a small fire extinguisher; a Mapp gas torch (burns hotter than propane); a spritz bottle for cooling solder joints; Teflon tape; lead-free solder, flux, and brush; and a pipe tube-and-fitting cleaning brush. $100 for all

Lighter

If you're finishing an installation at night or on a rainy day, a lighter can simulate the heat of the sun. Use it to test the differential controller's sensors and controls to make sure they are working correctly before you pack it in for the day. $0.99

Torpedo Level

A torpedo level is a must in any tool kit if you want the job to look good. For leveling equipment and pipe runs, this is the tool to have on hand. You can use your angle finder in a pinch, but a level is easier to use and read in most cases. $15

The Big Ones

Solar Site Analysis Tools

These can help you find the best location for your solar collector(s) by showing you where shading will occur from buildings, trees, or other objects. Several are available, from the lower-tech, but highly reliable, Solar Pathfinder ($255; or $319 with software interface) to Wiley Electronic's ASSET, a digital camera, mount, and software package that crunches solar access data on your computer from a set of photos you shoot at your site ($699). Solmetric's high-tech (and higher-priced) SunEye is a handheld digital tool that provides solar access and shading information with the touch of a button ($1,255).

Cordless Drill

From drilling holes to driving lag screws for collector mounts, this tool is indispensable. Tool freaks covet the high-priced, high-capacity, lithium ion-battery drills and impact drivers, which offer high torque and the ability to drive through soft- and hardwoods, as well as metals. Some even come with a built-in LED light to illuminate your work. *$50–$400*

Cordless Reciprocating Saw

Paired with a variety of blades, this tool can make short work of everything from trimming metal collector mounts to cutting holes through roof decking for pipe penetrations. *$90–$150*

Right-Angle Drill

When you need to drill large holes in thick wood, this is the tool you want. Its design lets you work in close spaces, but be careful with these high-power brutes. A co-worker broke his jaw while drilling through two 2 x 4 top plates in a tight attic. The large spade bit hit a nail, and the drill handle spun out of his hand and clocked him in the jaw. Ouch! Tool cost—*$300.* Taking care to spare yourself an emergency room visit—priceless.

Grip It & Strip It

Lock-Jaw Pliers

Lock-jaw pliers are handy for any number of jobs. They're terrific for holding back pipe insulation on a length of tubing to allow soldering a joint. $12

Slip-Joint Pliers

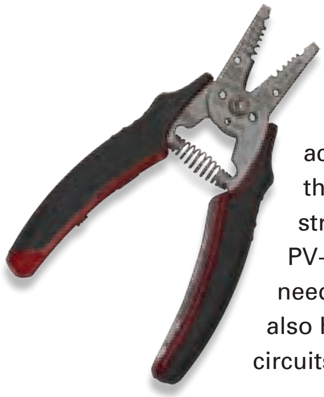
Slip-joint jaw sizes get smaller and larger by virtue of their ingenious method of varying hinge placement, to accommodate a range of material sizes. You can use these tools when working with smaller pipe and fittings, since they are much lighter and handier than pipe wrenches. $20

Lineman's Pliers

An old plumber once told me that every tool is a hammer first, and whatever else it was made for, second. Lineman's pliers are a good example. Machined from forged steel and with a heavy-duty hinge, these pliers are designed to hold up even after repeated use under extreme force on heavy-gauge wire. And although they are made to cut, twist, and pull wire, I've used them to drive small nails and staples too many times to count—two tools for the price of one! $40

Needle-Nose Pliers

The perfect tool for feeding and pulling small wires through fittings, and aligning wires in terminals for tightening. Best if they also include wire-cutting blades. $10–$40



Wire Stripper

You don't need these with passive solar hot water systems since there is no wire work involved, but all active systems have some electrical wiring to power the pump(s) or get signals from the sensors. Whether stripping wire for AC-powered system controls or for DC PV-powered systems, wire strippers are the first tool you'll need to make secure cable terminations. The tool shown also has a built-in voltage indicator in the handle to detect live circuits. $25

Adjustable-End Wrenches

These are used all the time on pipe fittings, bolts, nuts, lag screws, and mounting hardware, and when it is impractical to carry a full set of box or open end-wrenches. They are not intended for heavy-duty torquing on hardware. $20

Pipe Wrenches

Pipe wrench teeth are designed to grip pipe when pulling on the wrench and loosen when pushing on it to give a ratcheting motion. Pipe wrenches are typically used in pairs, one for holding and one for turning. If the teeth get worn, it's time for some bloody knuckles—and time for a new wrench. $25

The Finish Line-Up

Caulking Gun

A caulking gun is a necessary tool for sealing roof jacks and roof penetrations. $10

Glycol Pump & Hose

For antifreeze systems, a drill pump chucked into a drill will make filling the system a much simpler task. You'll also need a few 5-gallon buckets and a couple of washing machine hoses. $25

Testing & Inspection Tools

A few different tools are helpful for inspecting and troubleshooting solar hot water systems. Clockwise from the bottom: a propylene glycol tester indicates the minimum temperature a particular glycol solution will withstand without freezing (the floating balls are calibrated a little differently from ethylene glycol testers designed to test automobile antifreeze); calibrated thermometers are used to check water temperature; pH paper is for handy for testing glycol solution acidity; and an inspection mirror is great for doing work in hidden crannies. $45 for all

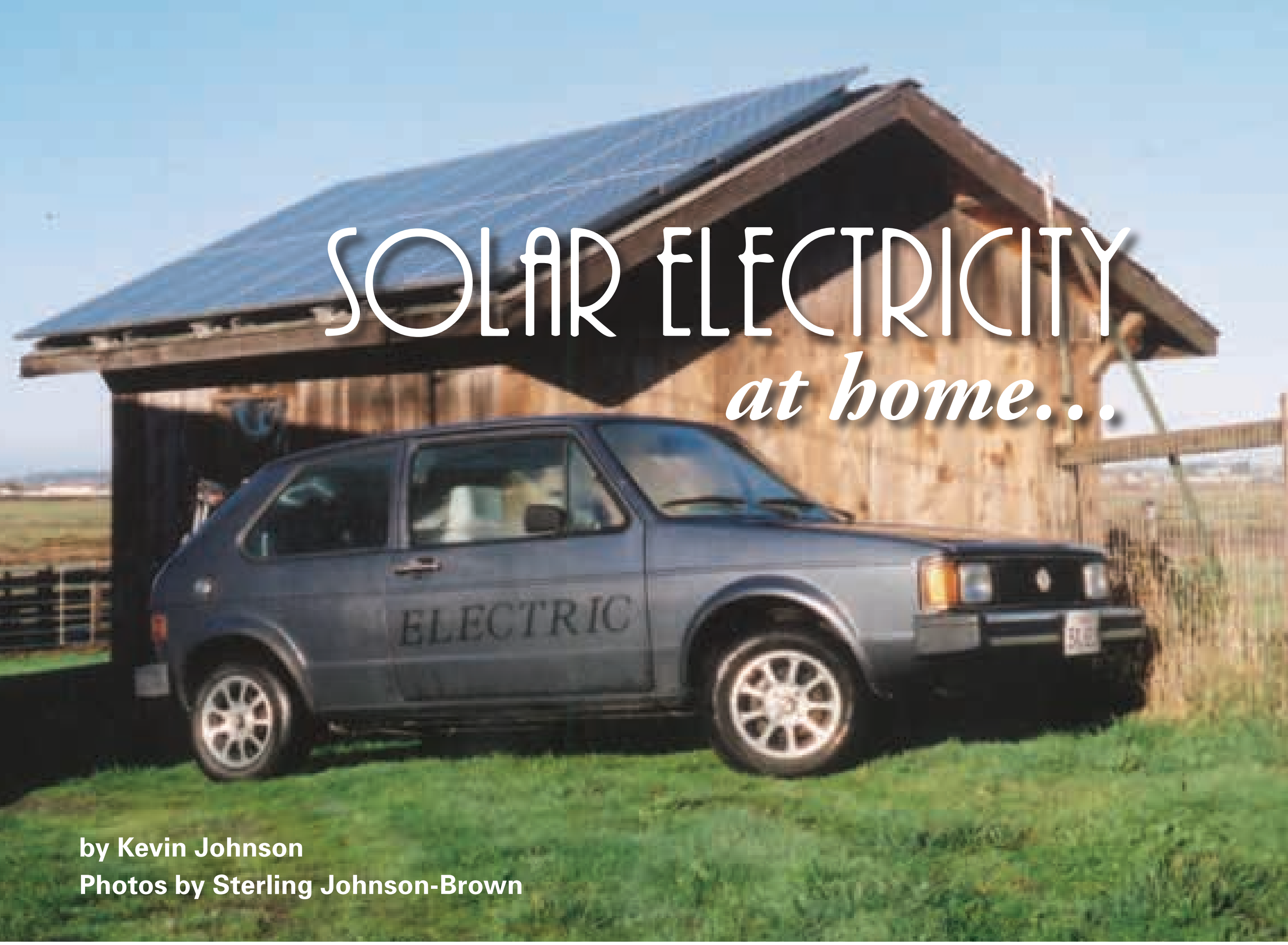
Digital Multimeter (DMM)

A solar water heating installer can get by with a fairly simple and low-cost DMM compared to solar-electric installers. But some type of multimeter is needed for troubleshooting control or pump problems. $12–$250

Access

Chuck Marken, AAA Solar, 2021 Zearing NW, Albuquerque, NM 87104 • 505-243-4900 • Fax: 505-243-0885 • chuck.marken@homepower.com • www.aaasolar.com

SOLAR ELECTRICITY *at home...*



by Kevin Johnson
Photos by Sterling Johnson-Brown

Green wheels: This Volkwagen Rabbit, converted to run on electricity, recharges its batteries from a grid-tied solar-electric system.

Our car is powered by the sun. It costs less than half as much to operate as some of the most efficient gasoline- or diesel-fueled cars, and produces zero tailpipe emissions.

Our family had been living a simple rural and remote life using very little energy—except for the vehicle we used to transport us to town, work, and school on a daily basis. Three years ago, we made a commitment to fulfill the long sought-after dream of environmentally friendlier transportation, following a move closer to town.

We came to a point where being energy conscious in our home, but driving—and burning fossil fuels—seemed completely out of balance. Over many years, we've endeavored to increase our energy independence through conservation, efficiency, and lifestyle changes. With the addition of the electric vehicle (and our solar-electric system), we were able to bring our transportation needs into this fold.

Electric Attraction

Watching the electric vehicle (EV) rallies and races at renewable energy fairs in nearby Willits, California, in the early 1990s sparked our interest. We built our knowledge base by attending a number of conversion workshops throughout northern California over the years, taught by EV experts Mike Brown and Shari Prange of Electro Automotive, and others. Shortly after the second Persian Gulf war began in early 2003, we decided that it was time to begin our search for a vehicle that would fulfill our environmental goals and meet our family's transportation needs.

We felt that our country was going to war to expand America's oil interests in Iraq and we didn't want a part in it. There was no better time for us to make the change from fossil fuel to solar energy for our transportation needs. We decided that purchasing an already converted vehicle would be our best bet for our first electric experience, so we shopped for a conversion with reliable and standardized components.

In February 2003, through the Oregon Electric Vehicle Association's Web site, we found an already converted Volkswagen "VoltsRabbit." I contacted the seller, an electric vehicle enthusiast from Portland, Oregon, and purchased a one-way bus ticket to Portland from our hometown in northern California. I bought the car for $4,200, and rented a truck with a trailer to bring it home.

The car, which has turned out to be a jewel, is a 1984, two-door, four-passenger VW Rabbit. It needed cleaning and a new headliner, but was otherwise in good working condition. It was converted several years prior to our purchase, but had been stored for a couple of years unused. Its sixteen, 6-volt Exide golf-cart batteries were still retaining a charge and continued to work for the next few years. This surprised us, since the car had been sitting for so long. It came with a 120-volt K&W onboard charger and an Advanced 8-inch DC motor with a Curtis 1221 controller. The conversion had been done by a mechanic with an Electro Automotive kit.

Solar Charging

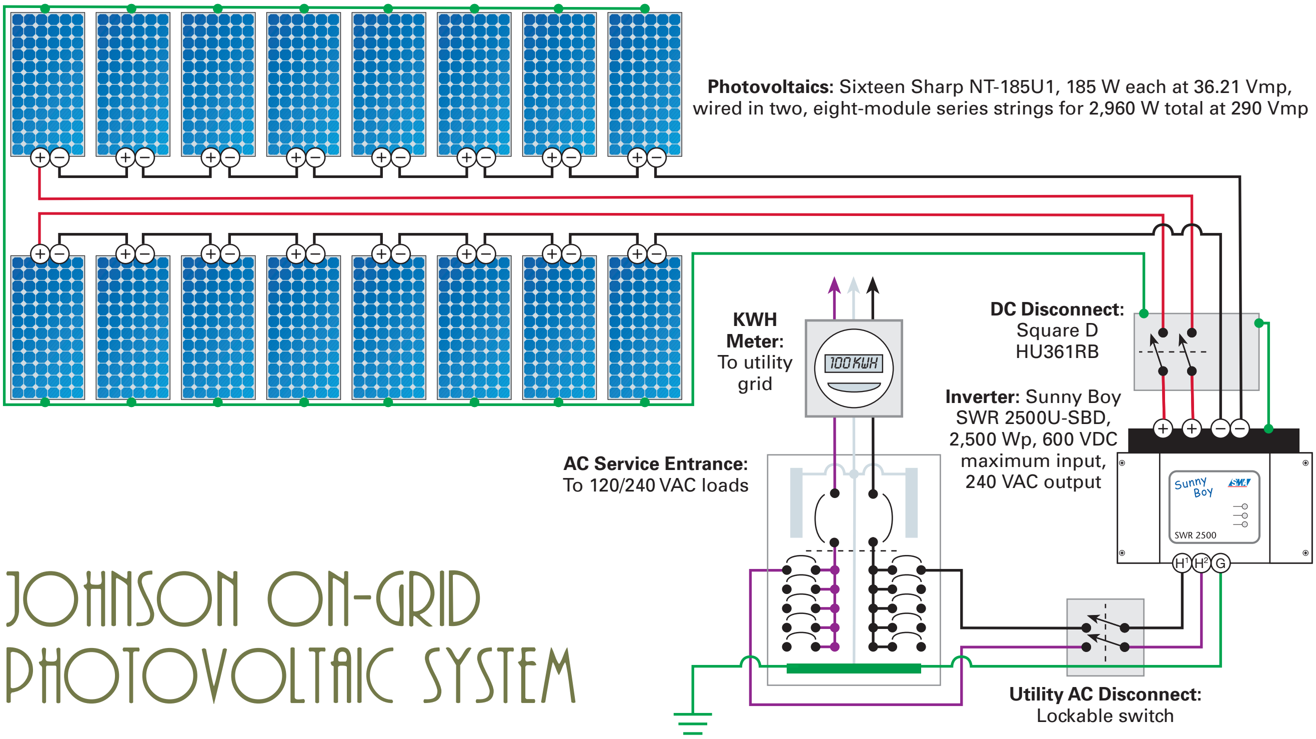
We temporarily charged the vehicle on utility electricity until we were able to refinance our home and invest in a solar-electric (photovoltaic; PV) system to power the car and our household loads. The cost to power the car with utility electricity was about 4 cents per mile. This was stunning, compared to 14 cents per mile that we had paid to fuel our gasoline-engine car. Even a car with gas mileage of 40 mpg would cost more than twice that of the electric to drive, at about 8.5 cents per mile.

Through conservation and efficiency measures, we decreased our household electrical needs to less than

VoltsRabbit owners Lisa Brown and Kevin Johnson promote EV technology by regularly taking their car to community events.

5 kilowatt-hours per day for our family of three prior to installing our PV system. We had just finished restoring our old farmhouse, which we retrofitted with conservation and efficiency in mind. The 16-cubic-foot Sun Frost refrigerator, efficient Maytag Gemini glass-top electric stove (with a small oven), Eemax electric, on-demand, under-counter water

The VoltsRabbit recharges its batteries from typical grid electricity or, in this case, from the Johnsons' solar-electric system.



JOHNSON ON-GRID PHOTOVOLTAIC SYSTEM

Tech Specs

Overview

System type: Batteryless, grid-tie PV

Location: Arcata, California

Solar resource: 4.4 average daily peak sun-hours

Production: 300 AC KWH per month

Utility electricity offset: 90+ percent

Photovoltaics

Modules: 16, Sharp, NT-185U1, 185 W STC, 36.21 Vmp

Array: Two 8-module series strings, 1,480 W STC each, 2,960 W STC total, 289.68 Vmp

PV DC disconnect: Square D HU361RB

AC disconnect: Cutler-Hammer DG-221-URB

Array installation: Direct Power & Water mounts installed on south-facing roof, 30-degree tilt

Balance of System

Inverter: SMA America Sunny Boy, SWR 2500U-SBD, 2,500 Wp, 600 VDC maximum DC input voltage, 234–550 VDC MPPT voltage window, 240 VAC output

System performance metering: Built-in inverter display and datalogging; utility KWH meter

heater for the kitchen sink, and compact fluorescent lighting throughout the house are the techno fixes we provided, as well as adding insulation and installing double-paned windows.

Additionally, we effectively eliminated phantom loads (standby electricity drawn by an appliance when plugged in but turned off) by unplugging all electrical items when not in use and using power strips for the computers. We then sized our PV system to meet our actual needs—about 5 kilowatt-hours per day for the house and 5 kilowatt-hours per day for the car.

Our 2.9-kilowatt grid-tied system was installed on our shed with our local solar electrician, Roger, at the helm. John Davis, Rowan Gratz-Weiser, Roger, and I worked on the installation, which took about three days. I was able to work off a significant amount of the labor cost by being involved in the installation and trading out my labor on other projects.

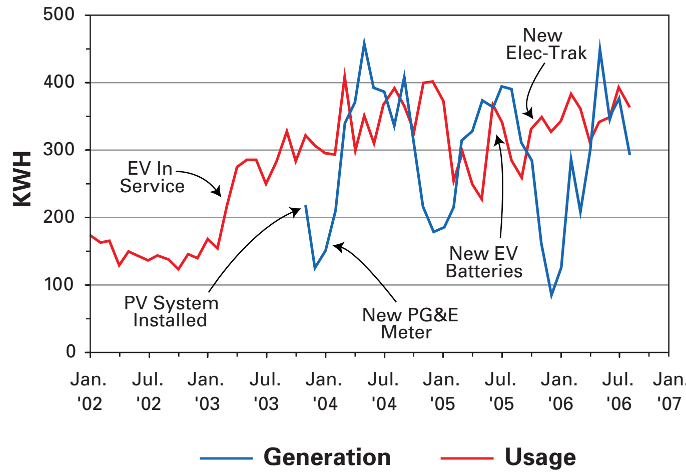
Upgrades & Benefits

Since purchasing the car in 2003, we've had to replace the original batteries that came with it. I decided to replace the Exides with Trojan T-105s. These were available locally at a good price (about $900 total) and are a dependable, long-lived battery. I found that the individual battery caps the Trojans use tend to have no leakage, keeping the battery tops cleaner.

At the same time, I decided to upgrade the 120-volt charger to a faster and more efficient 240-volt Zivan charger that has an automatic shutoff and equalization features for the batteries. The new charger takes 4 to 5 hours to completely recharge the batteries, compared to about 8 to 10 hours for the 120 V charger. Aside from adding a couple of gallons of distilled water to the batteries every few months, the electric car requires very little maintenance.

An added feature of the electric car that we hadn't really considered, but find very useful, is the mobile battery bank it provides. When the grid goes down, as it often does here in the winter, we can use the car's stored energy via a small 400-watt inverter on the car's 12-volt auxiliary battery, which is kept charged via a DC-to-DC converter from the main battery bank. We operate a small store in town, and can run our cash register, credit card machine, stereo, fax machine, and lights during utility outages. At home, we can plug into the car to watch TV or have some lighting for our evening tasks if the grid is down.

System Generation & Usage



Resurrecting EVs

Insistence by the California Air Resources Board that electric vehicles (EVs) could be the solution to California's air-pollution problems and the development of the ZEV (zero emissions vehicle) mandate in 1990 resulted in the development of General Motor's EV1 and similar electric vehicles.

EVs suffered a setback by the elimination of this mandate in 2003 and the crushing of many of these cars, but the electric car has not been killed—far from it. Its fate may best be left for us to bring to the forefront as an integral part of our renewable energy future. The electric car lives in our driveway and in the driveways of many today, and its time has come.

I work with a small group of EV enthusiasts—the Humboldt Electric Vehicle Association—to encourage and aid people in our community who are interested in purchasing or converting a car to electricity. Our goal is to replace gasoline-engine cars on the road with electric vehicles.

One of the best things that EV activists can do is to connect with other EV activists in their communities and develop support networks. It helps to meet on a regular basis with this group of folks to share information and build upon ideas for community outreach. Among the ideas we've worked with are:

- Bringing vehicles to fairs, car shows, parades, schools, and other events to showcase electric vehicles.
- Organizing workshops or conversion projects, and inviting the public.
- Working with local and regional governments to establish electric vehicle charging stations.
- Writing articles and letters to the editor about EVs.
- Sending out press releases when opportunities arise.
- Establishing a Web site for our local EV group.
- Encouraging local governments to incorporate EVs into their fleets.

In the end, *driving* your vehicle is absolutely the best way to let others know that EVs are viable, affordable, and user friendly.

For long-distance trips (beyond the car's 40- to 50-mile range), we drive a 1985 VW Jetta that gets 40 to 45 mpg. We run the Jetta on locally produced biodiesel made from restaurants' waste cooking oil.

But the Jetta spends most of its time in our driveway, since the electric car is the easiest and most enjoyable car to use for our daily errands. Driving the electric is simply a matter of turning the key and going down the road. There is no start-up, no warm-up, no fumes, no gas stations, and no engine noise to contend with. When you stop the car, it is silent. When you coast down a hill, the car uses no energy.

Electric Tractor

The newest member of our electric fleet is a 1970s General Electric Elec-Trak tractor (36-volt) with a 42-inch mower deck. Many years ago, our friend David Katz from Alternative Energy Engineering purchased a number of Tennessee Valley Authority's electric vehicles, including an Elec-Trak. I expressed to him by chance that I was looking for an Elec-Trak, not knowing he actually had one, and he offered it for free, providing I hauled it away!

The GE Elec-Trak tractor charges its batteries from the solar-electric system and keeps the orchard understory mowed to perfection.

System Cost Analysis

System Costs	Cost
16 Sharp NT-185U1 PV modules, 185 W	$10,814
SMA Sunny Boy SWR 2500U inverter, 2.5 KW	2,230
Direct Power & Water PV mounts	1,206
Tax	1,008
Misc. electrical & hardware	302
DC array disconnect	100
Permit	85
AC disconnect	55
Labor (traded)	0
Total	$15,800
Less California Energy Commission rebate	-$9,333
Less 15% California tax credit	-970
Grand Total	$5,497

Simple Payback	Amount
Recorded annual PV production (KWH)	3,585
Actual annual household electricity usage (KWH)	1,825
Present cost of electricity ($ per KWH)	$0.148
Annual household electricity costs ($)	$270
Annual mileage	5,000
Gasoline price ($ per gallon)	$3.39
Annual fuel savings (EV vs. 25 mpg gas engine)	$678
Payback, Considering Both Household & Vehicle (Yrs.)	5.8
Payback Without Vehicle, If Home Consumed All PV Production (Yrs.)	10.4
Payback Without Vehicle, Considering Actual Household Consumption (Yrs.)	20.4

The tractor had been sitting out in the weather for many years, wasn't running, and was very rusty. First I checked the main drive motor by hooking a 12-volt battery up to it to see if the motor would spin. It did! The mower deck has three motors and the bearings were shot on all of them, so I took them off and had them repaired at the local electric motor shop.

I downloaded the repair manuals and wiring diagrams from the Elec-Trak Owners Club Web site and painstakingly pieced everything back together with the help of Nick Johnston, a friend and fellow EV enthusiast. Once I knew the tractor was operable, the entire machine was stripped of its rusty yellow paint by hand. Parts that were removable were pulled and sandblasted. The bare metal was primed and recoated with a nice John Deere green. Six new 6-volt Trojan T-105 batteries completed the restoration.

Elec-Trak tractors once had numerous accessories, including a snow blower and rototiller, but ours came with just a mower deck. The tractor helps out on our farm, hauling horse manure and compost with a small trailer, and mowing the lawn and orchard. Like our VoltsRabbit, it is charged by our solar-electric system.

PV & EV Payback

Charging our electric car and mower with solar electricity from our PV system decreases the payback time for our solar-electric system, since the money saved by not buying gasoline can be included in this calculation. Our system cost was only $5,497 (remember, I traded labor!) after we claimed the California Energy Commission's "Emerging Renewables Program" rebate, which we hit at the peak refund period, and the State of California's Solar Energy System Credit (15% of the amount paid for the system, after the CEC's rebate). The electric car replaced a gas-engine Toyota Tercel station wagon that was getting about 25 mpg. For the 5,000 miles we drive each year, we save between $500 and $700 on fuel costs by driving our electric car instead of our gasoline-engine station wagon or biodiesel-fueled VW Jetta. Added to the annual electricity cost savings of $270 for our household, our solar-electric system saves us almost $1,000 each year.

At this rate, we will recoup our PV system costs in less than six years. The payback period will probably become even shorter, as gasoline and electricity prices continue to climb. The combined costs of our car and solar-electric system was far less than the cost of a typical new car. Plus, factoring in the electric car's savings on fuel costs cuts the PV system's payback time by one-third to one-half (see cost table).

Knowing that our electric car is both a smart environmental and economic choice heightens our enjoyment of driving it. Driving an electric car is sensible and forward-thinking. Our little VoltsRabbit makes an impression on all who see it. It reminds people that there is a solution to the oil dependency that plagues us. In some way, I sense that it provides some hope.

Access

Kevin Johnson & Sterling Johnson-Brown, c/o Solutions, 1063 H St., Arcata, CA 95521 • 707-822-6972 • mingo@tidepool.com

PV System:

Roger • 707-826-9901 • Solar-electric system installer

Direct Power & Water • 800-260-3792 • www.power-fab.com • PV rack

Sharp Electronics, Solar Systems Division • 800-SOLAR06 • www.sharp-usa.com/solar • PVs

SMA America Inc. • 530-273-4895 • www.sma-america.com • Inverter

EV Resources:

California Air Resources Board • www.arb.ca.gov/msprog/zevprog/zevprog.htm

Electro Automotive • 831-429-1989 • www.electroauto.com

Elec-Trak Owners Club • www.elec-trak.com

EV Trading Post • www.austinev.org

Humboldt Electric Vehicle Association • 707-822-6972 • www.heva.org

General Specialties

Universal Post Mount

by Joe Schwartz

Application: General Specialities' Universal Post Mount (UPM) is designed for secure and easily adjustable, pole-mounted solar-electric (photovoltaic; PV) arrays.

System: Two UPM mounts were installed at my rural property in the mountains of southern Oregon. (See *HP108* and *HP109*.) The local climate runs the gamut, from hot summers to deep-snow winters. High winds do occur, but infrequently. Each mount holds an array of six, 175-watt Sharp modules and faces true south.

Small Company, Specialized Solutions

Over the years, *Home Power* has evaluated a wide variety of PV pole mounts from various manufacturers. A few years ago, Steve Willey, founder and former owner of Backwoods Solar-Electric Systems, located in Sandpoint, Idaho, recommended that we work with the mounts manufactured by General Specialties, also located in Sandpoint.

General Specialties originally designed their heavy-duty pole mounts for Backwoods, who was their exclusive reseller. The mounts are now available through Backwoods or directly from General Specialties, a small, family owned business that focuses on manufacturing two high-quality products—pole mounts and roof/ground mounts for PV arrays.

General Specialties manufactures eleven different Universal Post Mount (UPM) models. The mounts' steel framework allows horizontal adjustment of the aluminum rails the modules are secured to, and is infinitely adjustable to accommodate various module lengths. Only the module mounting-hole spacing on the aluminum rails varies, based on the width of the specific modules being installed. General Specialties' pole mounts can hold from 15 to 165 square feet of maximum array area. This translates into approximately 200 to 2,500 rated watts for crystalline modules; the exact figure will vary with the power output of a given module type.

Evaluated Mount

The model UPM8X mounts received were well packaged for shipment, and arrived unscathed. Most UPM mounts are shipped via United Parcel Service, with only the two largest models requiring motor freight shipment. With the exception of the schedule-40 steel pipe that the UPM8X rests on, all structural members, assembly hardware, and module mounting hardware are included.

The UPM mounts are easily installed by a single person, and go together quickly and securely. The rails' holes are custom-punched, based on the mounting-hole layout of the

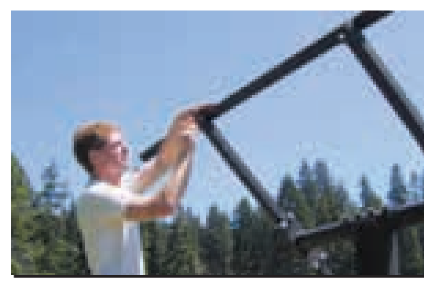
Features

- Extremely stout, painted-steel framework
- Adjustable design accommodates a range of module lengths, and reduces the need for dealers to stock a large number of different models
- Easy and secure array tilt-angle adjustment
- All individual mount components can be positioned by a single installer
- Slotted rails make for easy adjustment of PV module bolt locations
- Complete model line offers compatibility with most PV modules currently manufactured

Base pipe and tee.

Steel vertical rails.

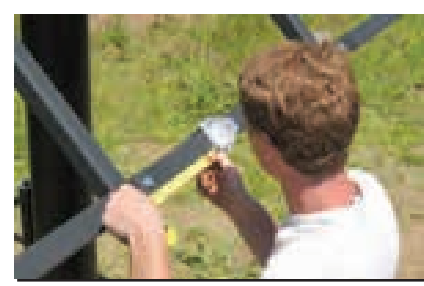
modules you're installing. These rails are attached to steel horizontal members via aluminum standoff brackets to zinc-plated U-brackets, which are secured with self-locking nuts. The distance between the rails is specified by the mount manufacturer, and depends on the modules you're using. Simply use a tape measure to correctly space and position the rails.



Steel horizontal rails.

Pole-Mount Positives

While roof-mounted PV arrays are the most common installation approach, pole-mounted arrays can be preferable, depending on your site and needs. If your roof does not have good solar exposure due to shading from vegetation or other buildings, pole mounts can offer some siting flexibility, allowing you to locate your array in the most shade-free location on your property.

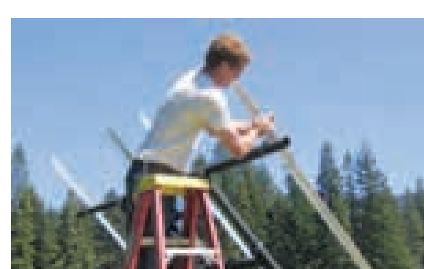


Aluminum rail brackets.

General Specialties Pole Mounts

Model*	Maximum PV Area (Sq. Ft.)	Base Pipe Size (In.)
UPM2	15	2.0
UPM3	21	2.5
UPM4	28	3.0
UPM3X	35	4.0
UPM6	42	4.0
UPM4X	47	4.0
UPM8	56	5.0
UPM6X	72	5.0
UPM8X	93	6.0
UPM10X	115	6.0
UPM12X	165	8.0

*X designates model numbers for modules 170 watts and greater



Aluminum rails.

Photovoltaic modules.

Specs

Model evaluated: UPM8X, holds up to 93 sq. ft. of module area

Main mount structure: Painted steel tubing and pipe (electroplated and hot-dipped galvanized also available)

Module mounting rails: Aluminum alloy angle

Module mounting hardware: All stainless steel, or zinc plated, with self-locking nuts

Engineering: Designed for 40 pounds per sq. ft. wind load—100 mph plus

Cost (retail): $675

Pole mounts also make for easy adjustment of an array's tilt angle for maximal energy production season to season. While most system owners do not go to the trouble of adjusting the tilt angle of roof-mounted arrays, or even installing adjustable racks in rooftop installations, pole mounts make seasonal tilt-angle adjustment easy. Adjusting the array's angle four times a year can increase output by about 5 percent annually depending on your site's latitude.

In addition, pole mounts can make it easy to clear stubborn snow from your array in wintry climes, or dust or pollen buildup, if that's an issue at your site. Finally, pole- or rack-mounted arrays will operate at cooler temperatures than most roof-mounted arrays. Array output drops as module temperature increases, and the increased airflow around pole-mounted arrays can keep the modules operating at lower temperatures. In some climates, this can increase array output during warm seasons by 5 to 10 percent compared to roof mounts with minimal standoff (less than 3 inches) between the roof surface and the module backs.

Racked & Stacked

To the end user, pole mounts might seem like a relatively simple piece of hardware to design and manufacture. But over the years, there has been ongoing improvement in mount design flexibility, ship-ability, and durability. Some sturdy mounts are currently manufactured using a lighter-weight, mostly aluminum framework, and they perform very well. General Specialties has opted to rely on the "school of heavy metal"—a heavy-duty steel mount infrastructure. These racks should last for generations.

Access

Reviewer: Joe Schwartz, *Home Power*, PO Box 520, Ashland, OR 97520 • joe.schwartz@homepower.com • www.homepower.com

Pole-mount manufacturer: General Specialties, 25 Jana Ln., Sandpoint, ID 83864 • 208-265-5244

Primary reseller: Backwoods Solar Electric Systems, 1589 Rapid Lightning Creek Rd., Sandpoint, ID 83864 • 208-263-4290 • info@backwoodssolar.com • www.backwoodssolar.com

View From the Top

Living our Off-Grid Dream

by Tracy & Amy Dahl

Nearly fifteen years ago, my wife Amy and I first started looking to flee the noise and traffic of city life, and find a piece of rural property. While living in Boulder, Colorado, we stumbled upon a piece of land that captured our imaginations and our hearts: a mesa, or flat-topped mountain in the Sangre de Cristo range of southern Colorado, an hour from the nearest town of Trinidad. The property is 36 acres, with about 5 acres at the top resting in meadow and open forest. Yes, we own our own mountain—albeit a small one.

It was a significant investment for us. But our windfall came when some friends pointed out a newspaper article about a company that contracted with the National Science Foundation's Antarctic program. It was contract work in Antarctica, and although the pay was not outstanding, there was nothing to spend it on—other than the mortgages back home—which allowed us to save up a substantial chunk of change. As soon as we returned from our first stint on "the ice," our Boulder townhouse went up for sale.

Clockwise from lower left: Off-grid authors Tracy and Amy Dahl; the power shed–greenhouse with the PV array on the upper roof; a bird's eye view of the Dahls' mountain home site.

Building the Dream

We moved to the land in spring of 1995 and started building what we thought would be our "temporary" home. The original two-story cabin is of pole construction, with treated posts running down to bedrock and up to the top rim joist where the roof sits. The walls in this part of the home are 2 by 4 stud frame in some areas, and double 2 by 4 in others, which allows for R-26 insulation with no thermal bridging through the wall. As a result, the framing doesn't conduct heat from one side to the other. In walls with single 2 by 4 construction, a layer of plastic-bubble reflective insulation boosts thermal performance by reflecting heat—either back to the outside of the home in the summer (as in our attic) or back into the living space. The manufacturer claims the equivalent of R-19 in certain applications. While these claims seem optimistic, this insulation is quite effective when used in conjunction with conventional insulation. We also installed reflective insulation in the ceiling and attic, in addition to fiberglass batt insulation.

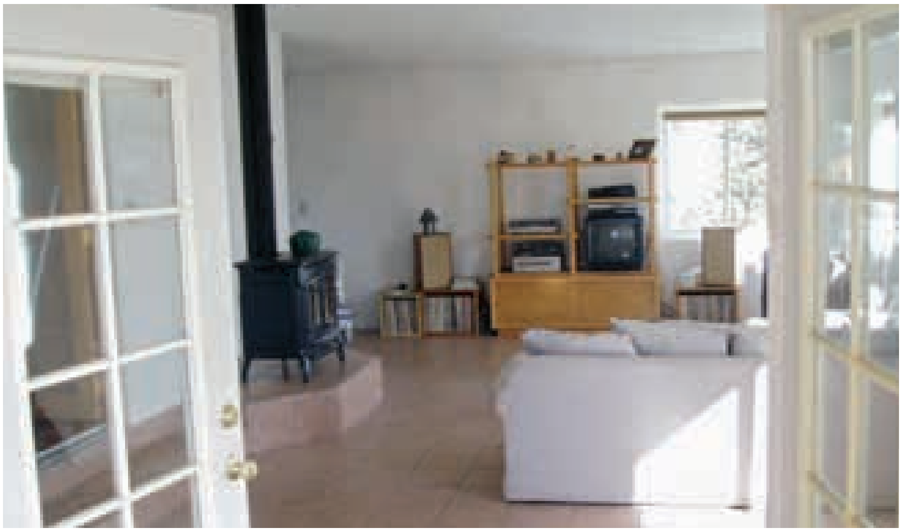
Whenever possible, we used rough-cut lumber from our local sawmill. The lumber is a bit more difficult to work with, but provides exceptional value and uses a product grown, harvested, and milled locally. In terms of constructing a building with low embodied energy, this is one of the prime strategies—use local products whenever possible.

After one winter in the cabin, we decided it was time to expand the living quarters. We opted for nonload-bearing straw bale construction for a 675-square-foot addition. A post-and-beam superstructure hidden within the straw bale walls carries the roof load. This extra-beefy architecture may be overkill for some sites, but we experience winds that often exceed 100 mph on our mountaintop. Straw bale construction uses what would otherwise be a waste product to create a beautiful and energy efficient home. The relatively high insulation value of a straw bale wall, combined with its ability to reduce thermal bridging, keeps the home warm in the winter and cool in the summer.

Two woodstoves provide backup heating for the home. Fuelwood is sustainably harvested from the Dahls' property.

One error was not to include a major passive solar element in the house. Here in southern Colorado at our elevation of 8,200 feet, the sun is intense, and subsequent structures we built proved that incorporating good passive solar design strategies could provide the majority of the space heating, even in a fairly cold mountain climate like ours. But although there was no concerted effort toward incorporating passive solar design strategies, our home stays warm, even in midwinter when nighttime temperatures routinely drop below zero. Between the large thermal mass of the 6-inch-thick, perimeter-insulated, concrete slab foundation, and the well-insulated walls and ceiling, our home responds very slowly to outdoor temperature changes.

Thick straw bale walls provide ample insulation, keeping living spaces warm in the winter and cool in the summer.



When we're home, two wood heaters—a cast-iron Hearthstone Bennington that sits in the living room, and a Napoleon C1100 in the dining room—help keep the home comfortable. These noncatalytic heaters are both certified by the U.S. Environmental Protection Agency to meet emissions standards. Because of the care we took in our building envelopes, we only use about two cords of wood annually to heat all of our structures, which include our home, the power shed–greenhouse, and a garage–workshop space. The wood is sustainably harvested from our

The solar-electric system's power wall includes an inverter, transformer, battery monitor, charge controller, and equipment disconnects.

land by thinning out our overcrowded forests. It's a win–win scenario. While we get an almost-free source of heat, we also reduce fire danger and improve the overall health of the forest.

Free Electricity

With more than 300 sunny days per year, we have a superb solar resource. Compared to our location, homes in most other parts of the country would require larger solar-electric (photovoltaic; PV) arrays to generate an equivalent amount electricity on a daily basis. To take full advantage of our resource, we selected our household appliances with maximum efficiency in mind, and get by nicely with 720 watts of PVs. The array consists of six, 120-watt BP Solarex modules mounted on the roof of the power shed–greenhouse located next to our house.

When we built the house, we ran AC and DC wiring throughout. This "old school" strategy for off-grid systems can still be effective, especially if the PV array is small, or you are trying to minimize backup engine generator run time. First, running DC loads is ultimately more efficient, as it eliminates inverter conversion losses, which average about 15 percent. Second, we don't have to worry about sitting in the dark, having no water pressure, or lacking telephone service if our inverter ever fails. Many of our lights, the household water pressure pump, and the telephone all run on DC. (Currently, a conventional, tank-type propane water heater provides our domestic hot water, but we plan to integrate a solar hot water system in the future.)

Homestead Costs

Buildings & Land	Cost
Land, 36 acres	$40,000
Straw bale addition, 600 sq. ft.	40,000
Cabin, two story, 1,150 sq. ft.	35,000
Power shed/greenhouse	25,000
Garage	10,000
Total, Buildings & Land	$150,000

Energy/House Systems	
PV system, 720 W	$12,000
4 wood heaters	10,000
PV water pumping system, 320 W	6,200
Cistern, 1,250 gal.	2,500
Rainwater catchment system	1,500
Greywater system	500
Propane-fired tank water heater	200
Total, Energy/House Systems	$32,900
Grand Total	$182,900

Off-grid...At a Glance

Location: Sangre de Cristo Mountains, Colorado

Solar resource: 6.3 average daily peak sun-hours

Property size: 36 acres **Main house:** 1,825 sq. ft.

Energy system: Off-grid, battery-based PV; Average monthly electricity production: 100 AC KWH

Water systems: PV-direct water pumping to 1,250-gallon cistern; rainwater harvesting and catchment for irrigation

Space heating: Wood heaters (two in house; one each in power shed and garage); Annual wood use: 2 cords

Photovoltaics

Modules: 6 BP Solarex MSX120, 120 W STC, 17 Vmp, 12 VDC nominal

Array: Six modules in parallel, 720 W STC total, 17 Vmp, 12 VDC nominal

Array installation: Direct Power & Water rack, mounted on north-facing roof (panels facing south), 50-degree tilt

Energy Storage

Batteries: 3 Surrette (Rolls) 4KS 21PS, 4 VDC nominal, 1,104 AH at 20-hour rate, flooded lead-acid

Battery bank: 12 VDC nominal, 1,104 AH total at 20-hour rate

Balance of System

Charge controller: Trace TC60, 60A, PWM, 12 VDC nominal input voltage, 12 VDC nominal output voltage

Inverter: Trace PS2512, 12 VDC nominal input, 120 VAC output

System performance metering: TriMetric battery monitor

An older Trace (Xantrex) inverter, which is no longer manufactured, provides AC electricity. While most large off-grid systems are now designed to operate at a system voltage of 48 VDC nominal, we chose to go with a 12 VDC system because of the wide range of lighting and appliances available at 12 volts. One major disadvantage was the requirement for larger gauge (and more expensive) wiring between the PV array and battery bank, to minimize power losses.

Three large Rolls-Surrette flooded lead-acid batteries make up the battery bank. These 4-volt batteries are wired in a single series string for a nominal 12 VDC, 1,104 amp-hour capacity battery pack. I cycled them deeply a couple of times when they were first installed just to exercise them, but since then I have rarely seen the battery monitor display a state-of-charge status below 90 percent. These batteries should last for fifteen to twenty years given the easy life they lead. On the rare occasions when we have multiple snowy, overcast days in the winter, I fire up our 15-year-old Honda EB5000 gas-engine generator for an hour or so to recharge the batteries.

The balance-of-system components, including the generator, reside in the power shed–greenhouse, which sits northwest of the house. Three-wall polycarbonate panels on the lower, south-facing roof and a set of south-facing clerestory windows provide a significant portion of the overall space heating requirements. The generator sits in a workshop space inside the power shed, with the exhaust piped through the wall, so we get rudimentary waste heat recovery when the generator is running, which boosts the efficiency of burning a fossil fuel.

Amy Dahl shows off the neatly constructed, insulated battery box.

Chop Wood, Pump (& Save) Water

After many years of hauling water from town, we finally decided to drill a well. In this area, that is both an expensive and uncertain proposition—by no means were we guaranteed to find water. We got lucky, and hit water at 350 feet, but we continued down to 450 feet to have a more reliable source. The well produces sweet water at 2 gallons per minute. Not exactly a gusher, but not bad for this area.

The perfect fit for a low-production water well is a 48 VDC solar-direct submersible pump coupled with a cistern. We bought an EtaPump, which offered good reliability with only one moving part, and a high resistance to abrasion from sand and corrosion. At the time, it was also the only pump available that could pump from that depth.

The pump's power system consists of a 320-watt, pole-mounted PV array, with four BP 585U, 85-watt PVs wired in series for 48 VDC

Homestead Loads

DC Loads	Volts	x	Amps	=	Watts	x	Hrs. / Day	x	Efficiency Factor	=	Watt-Hrs./ Day
Water pressure pump	12		15.00		180.0		0.3		1.20		54
Computer monitor	12		4.00		48.0		6.0		1.20		346
DC lights	12		1.20		14.4		6.0		1.20		104
Cell phones (two)	12		0.40		4.8		30.0		1.20		173
Fan	12		2.25		27.0		2.0		1.20		65
AC Loads											
Computer	120		0.85		102.0		6.0		1.35		826
Satellite modem	120		0.40		48.0		6.0		1.35		389
CF lights	120		0.15		18.0		6.0		1.35		146
Television/stereo	120		1.00		120.0		1.0		1.35		162
Washing machine	120		3.00		360.0		0.2		1.35		97
Microwave	120		8.00		960.0		0.2		1.35		259
Vacuum cleaner	120		5.00		600.0		0.1		1.35		81
Greenhouse fan*	120		8.00		960.0		1.0		1.35		1,296
Power tools	120		13.00		1,560.0		0.5		1.35		1,053
									Total Daily Watt-Hours		5,050

*Thermostatically controlled greenhouse fan only runs in midsummer in full sun conditions

Trouble in Paradise

After over a decade of pouring our hearts, souls, and all of our available cash into developing our peaceful mountain homestead, coal-bed methane (CBM) production has come to our area, and we are directly in the path of massive industrial development. Like 85 percent of the land in Colorado, ours was sold as a "severed estate," and the companies that own the land's mineral rights can tap its resources at any time, providing us only one-time monetary compensation for use of the surface.

CBM production is a high-impact process, and its effects are far ranging. Heavy industrial engines and compression facilities running day and night ruin the solitude of our woodland setting, continual traffic on our dirt roads creates noise and dust, and all of those industrial engines create serious air-quality issues. The contaminated water that results is most often released into the streams, which alters the biota that normally lives in and around the riparian areas. There are reports of diminished crop yields and buildup of salts in the farmlands that use this water for irrigation downstream. The process also poses some very serious threats, like methane seeps, coal fires, and the contamination of domestic water wells like our own.

Amy and I have done everything we can to try to minimize CBM's impact on our lives. We have worked out Surface Use Agreements for our ranch association, and involved ourselves in citizen activism. Most of all, we are searching inward to find a place of peace. We are uncertain whether or not our water well will remain viable and unpolluted, and whether the noise and traffic we fled the city for will make life here untenable in the near future. We hope that Colorado's recent change of leadership will lead to more enlightened policies regarding energy development.

nominal. DC disconnects, the pump, and its controller round out the system. We pump water up the well, then 150 feet horizontally to a 1,250-gallon plastic cistern.

Our combined household water usage is probably one-fifth of *one* average American's use—we use about 25 gallons per day between the two of us. The bulk of our water use goes to washing clothes, even with our efficient Staber washing machine. We installed low-flow fixtures, and are careful not to overdraw our well by using water faster than it can be replenished. We also harvest rainwater that's channeled from the painted metal roofs on the house and outbuildings, and collected in several 55-gallon plastic barrels for fire suppression and to water the garden beds. Outgoing water (greywater) from the kitchen sink, washing machine, bathroom sink, and the shower is routed through buried $2^1/2$-inch schedule-40 PVC pipe to a patch of heavily mulched Gambel oak trees, a bed of irises, and other water-loving plants.

Instead of using a typical flush toilet and septic system for disposing blackwater, we use a moldering composting toilet that eventually decomposes human manure and sawdust into a safe end product—compost. Moldering toilets like ours rely on a long retention time to kill any potential pathogens that might be lurking. Our toilet has two containment vaults. In about ten years, when the first vault is full, we'll move the seat over the top of the other vault, and seal off the first one and let it continue composting. In another ten years, it will be time to switch over the seat again, and by that time, what will remain will be nothing but compost.

A Wide-Awake Life

For us, off-grid living means that we are acutely aware of the world around us. If skies are overcast for several days, we carefully monitor our electricity consumption. If it's cold, we burn more wood—and chop and stack—rather than turn up the thermostat. We know where every tree came from and have lengthy discussions about which ones get the axe. We know where our water comes from (both the well water and the catchment water) and monitor its usage closely. Again, a bit different from just turning on the tap. With the food we grow, we know what went into it. This is not an easy place to garden, and takes a lot of time and effort. We live a minimalist lifestyle, and are very conservative—in the true sense of the word. Mind you, we also recognize that we still have impacts.

With our lifestyle, we find that the advantages of off-grid living are huge. It would have cost more than twice the bill of the entire PV system to run utility power up here, so our system has already paid for itself twice, in savings, from the moment it was installed. Every winter there are numerous power outages for the folks on the grid. In 1999, we had a very heavy spring snow that resulted in flooding, and our neighbors in the valley were without power for six days. When the snow finally melted enough to check things out in town, we were quite surprised that we had missed this major inconvenience. We have had just one power outage in the past six years, and that was operator error. Finally, there is the independence. We feel like it is a key value, and one well worth striving for.

Access

Tracy & Amy Dahl • polarsolar@hughes.net or amyonice@yahoo.com • www.polarpower.org

Oil & Gas Accountability Project • 970-259-3353 • www.earthworksaction.org/aboutogap.cfm

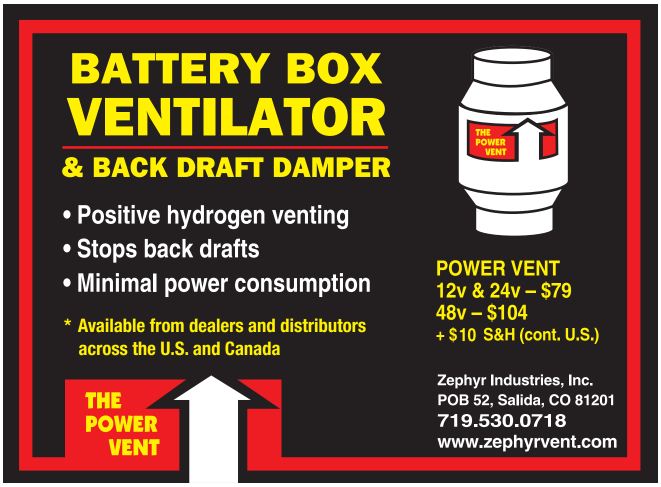
System Components:

BP Solar • 800-521-7652 or 410-981-0240 • www.bpsolar.com • PVs

Conergy (formerly Dankoff Solar Products Inc.) • 888-396-6611 or 505-473-3800 • www.conergy.com • Well pump with PV system

Rolls Battery Engineering • 800-681-9914 • www.rollsbattery.com • Batteries

Xantrex Technology Inc. • 800-670-0707 or 604-422-8595 • www.xantrex.com • Power panel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PV Odds & Ends

by John Wiles

Sponsored by the U.S. Department of Energy

My presentations on PV and the *National Electrical Code (NEC)* take me all over the United States. This regular input from PV professionals serves as an ongoing source of information related to the equipment, hardware, and installation techniques being used by PV system designers and installers across the country to streamline the installation of safe and effective systems. A few recent items of interest follow.

PV on Metal Roofs

Section 250.110 of the *NEC* requires any exposed, non-current-carrying, conductive surface that may become energized be grounded to minimize electrical shock hazards. These surfaces include the PV module frames, metallic module mounting racks and, in the case of some roof-mounted systems, metal roofing material.

Some PV systems may operate at close to 600 volts and can pose a significant shock hazard if they are allowed to energize conductive exposed surfaces that may be touched. Effectively bonding these conductive surfaces together and grounding them will minimize shock hazards.

PV arrays installed on metal roofs should be grounded in a manner that limits potential shock hazards.

There are two primary wiring methods for connecting PV modules together—using exposed single-conductor cables, and using conduits. Each dictates a different grounding method, but in either case, PV modules must always be grounded properly. (For more information, see "PV Array Grounding" in *HP102*.)

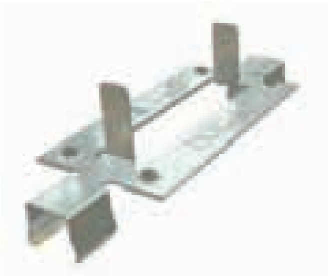
Exposed, single-conductor cables that connect PV modules together can come into contact with the module mounting racks. Movement of the cables from wind, rain, and ice could compromise the conductor insulation and potentially energize the racks and metal roofing. Where exposed single conductor cables are used, the racks and the roof should be grounded. One technique is to install an appropriate grounding terminal/lug on each seam of a standing-seam roof, and connect an appropriate grounding conductor to those terminals and the equipment-grounding system. Since many standing-seam roofs are coated with a durable paint, it is usually necessary to make a connection to each panel of the roof and to make sure each of those connections penetrate the paint of the roofing panels.

When conduit is used between the individual modules and there are no exposed, single-conductor cables, then it is unlikely that either the module racks or the roof would require additional grounding. The module frames should always be grounded and the conduit that surrounds the conductors effectively protects them from damage. The conduit may be of an insulating type, like rigid nonmetallic conduit (RNC), or a metal type, like electrical metallic tubing (EMT). The EMT requires grounding; the RNC would not be grounded, but both would provide the desired physical protection. If the conductor insulation should fail, the conduit would prevent the rack or the roof from becoming energized. In this case, neither the metal racks nor the metal roof require grounding, except in the event that significant PV module damage could be expected. Such damage could cause the internal connections of a shattered PV module to contact the rack or the roof.

New Grounding Methods & Materials

Although listed PV modules are marked for grounding at specific points, hardware instructions do not generally address grounding the module at the mounting holes or at other locations besides the specified marks. Section 110.3(B) of the *NEC* requires that the instructions and labels provided with a listed product be followed.

New PV module grounding devices designed to minimize installation time and material costs are entering the market from Wiley Electronics, UniRac, and others (see Access). Unfortunately, even though a few PV manufacturers may furnish tech bulletins that detail the use of alternative module grounding points, all available techniques may not have been reviewed by Underwriters Laboratory (UL). The UniRac and Wiley products are not listed for use with any specific PV module, and there is no clear indication of compatibility with a particular module or mention of these grounding devices in most of the current PV module instruction manuals. As a result, it's up to the local electrical inspector, or "authority having jurisdiction" (AHJ), to approve or reject the use of these new products.



UniRac Grounding Clip.

I have been making formal and informal inputs to UL for several years concerning module grounding and asking UL to encourage module manufacturers to "tighten up" their grounding instructions and procedures. I have also been directly encouraging module manufacturers to have their modules tested and listed by UL with these new grounding products, and to provide that listing information in the instruction manuals, so the inspectors won't have any questions about determining the code compliance of this technique.

Securing Exposed Conductors

Most PV modules are manufactured with generously long (40 to 48 inches) output pigtail leads with connectors on the ends. The excess lead length must be securely fastened to the module frame or array mounting rack to prevent abrasion and damage by exposure to the elements.

Above: Black UV-resistant cable ties used to secure array wiring. At right: Stainless steel "loop clamp" and hardware.

Most installers use black plastic wire ties (cable or "zip" ties) as an easy and quick method to secure the extra length. This fastening method meets *NEC* requirements for good workmanship and protects the conductors from damage. Although black plastic cable ties marked "UV resistant" are suitable, in the hot and sunny Southwest, some fail after only a few years. (White cable ties are not resistant to ultraviolet radiation and should not be used.)

For our installations here at New Mexico State University and elsewhere, we have started using a rubber-cushioned, stainless steel loop clamp attached to the array rack with stainless-steel hardware (1/4-inch bolt, nut, and lock-washer). The loop clamp's EDPM rubber coating protects the conductor insulation from the clamp's sharp edges. (See Access for recommended brands and suppliers.)

Other Questions or Comments?

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

Access

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

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

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

Photovoltaic Power Systems & the 2005 National Electrical Code: Suggested Practices • www.nmsu.edu/~tdi/Photovoltaics/Codes-Stds/PVnecSugPract.html • Manual, 144 pages

Hardware Suppliers:

McMaster Carr • 562-692-5911 • www.mcmaster.com • Loop clamps (part numbers between 3325T22 and 3225T35)

UniRac • 505-242-6411 • www.unirac.com • Module grounding clips

Wiley Electronics • 845-247-2875 • www.we-llc.com • Module grounding products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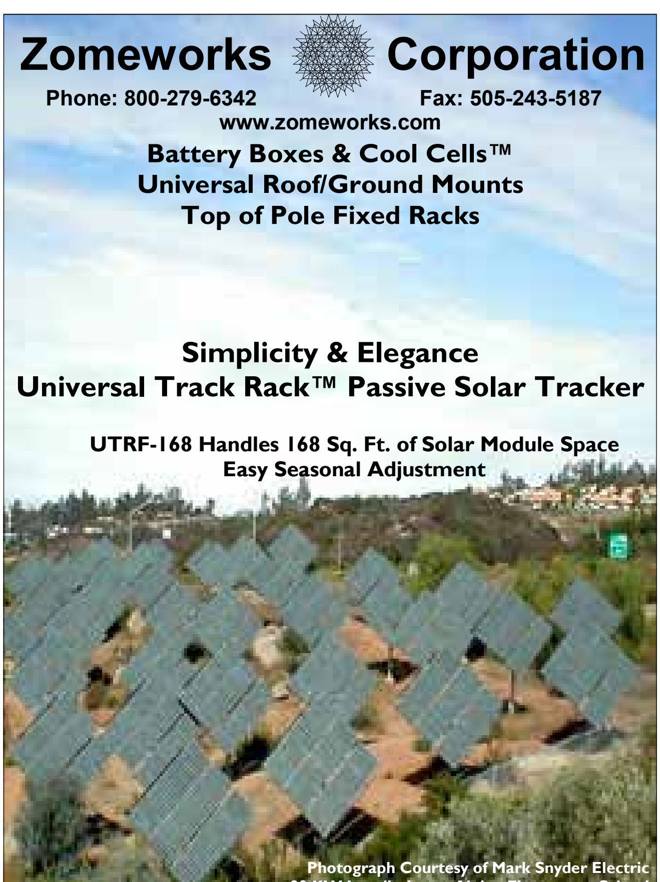
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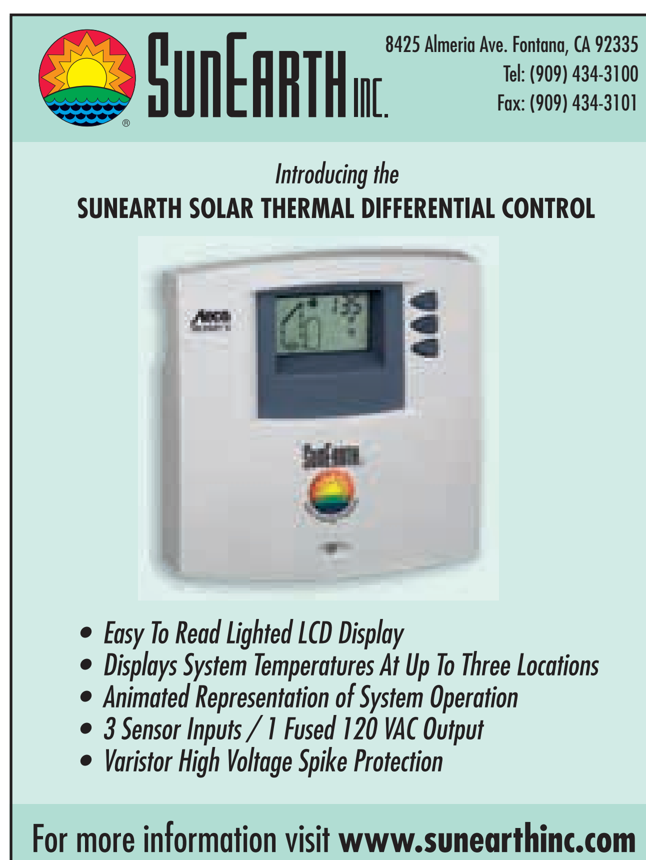
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Incentive Programs

& PV Performance

by Don Loweburg

The amount of electricity a PV system can generate—its primary performance over its lifetime—depends on three main factors: 1) how much solar energy the array receives; 2) the system's overall efficiency; and 3) the system's life span. Assessing and improving PV performance is critical to system owners and installers—and, in the case of incentives, to the coordinating agencies that use ratepayer or public funds to support their programs.

Several studies have evaluated PV systems that were funded, in part, by incentive programs, and have found lower-than-expected outputs due to shading or soiling, equipment and installation defects, and "deviations from module manufacturers' specifications."

An October 2006 white paper by Berkeley Lab and the Clean Energy States Alliance broadly examined 32 prominent PV incentive programs in the United States and their strategies for promoting PV system performance, noting that because public monies fund these programs, system performance is crucial both to administrators and recipients.

The following is a list of recommendations made in the study. The authors temper their recommendations by acknowledging that costs and benefits must be balanced based on the funding and staffing constraints of each program. Not surprisingly, many of the suggestions are incorporated into California's new PV incentive program, the California Solar Initiative (CSI). Two of the eight topics they identified have been previously discussed in this column—equipment and installation standards (see *HP112* & *HP114*).

Identify critical performance issues. Inaccurate module ratings, improperly sized inverters, elevated cell temperatures associated with the type of mounting structure used, excessive shading, and soiling can all plague PV performance. The authors suggest that programs collaborate and share performance data like the International Energy Agency does in Europe, to better quantify and to search for solutions to these performance issues.

Educate consumers. Though net metering provides a financial incentive for owners to keep an eye on their PV systems, many may not have sufficient understanding of how to read their meters or interpret the data. Seminars and consumer guides, requirements that installers provide customers with basic information and training, metering requirements, and diagnostic tools would all help build customer capability in monitoring system performance.

Adherence to codes. Ideally, local building code officials and the *National Electrical Code* help installers design and install safe and reliable PV systems, but these codes are sometimes not understood well—by either party. Installer and code official training programs, specifying minimum requirements for installers, and requiring code officials to sign off on a project before the incentive can be claimed are all proposed solutions to making sure codes are followed.

More rigorous warranty requirements. Beginning in 2008, the CSI requires that all systems funded through the state's incentive programs carry a 10-year warranty. The warranty also covers inverters, the major component most vulnerable to failure.

Certifying modules to new ratings criteria. The California Energy Commission's New Solar Housing Program proposes that a tighter module rating standard be used, and that manufacturers' nameplate ratings "represent a guaranteed minimum output at standard test conditions (STC)." Programs could adopt this new module standard to assure that both customers and incentive programs get what they pay for.

Adopt a new capacity rating convention. Incentive programs that use a PV system's capacity rating to determine payment should seek to use ratings that most accurately reflect a system's output under peak sun conditions. In most cases, a module's PTC (PVUSA test conditions) rating more accurately represents module output compared to nameplate ratings at STC. The California Energy Commission has PTC ratings for all the modules eligible under its program, as well as detailed inverter efficiency ratings.

Support NABCEP's installer certification programs. The North American Board of Certified Energy Practitioners (NABCEP) has developed national standards for certifying PV installers in an effort to provide some assurance of high-quality PV installations. In addition to requiring NABCEP certification, the authors suggest paying higher incentives for certified installers, or providing financial or other forms of support to installers for obtaining certification.

Require post-installation testing. These tests would help identify improperly installed systems or defective equipment from the get-go, and only add a small cost if incorporated into the post-installation inspection.

Focus on incentive-based approaches. While standard capacity-based buy-down programs calculate their one-time payment on the system's rated performance capability, incentive-based structures, such as expected performance-based buy-down (EPBB), presume that performance can be predicted based on accurate component ratings, proper installation, and designing the system to local conditions. According to the paper, "standards-based approaches are most effective as a tool for protecting PV system owners… by ensuring that PV systems meet a minimum level of acceptability."

Incentive-based strategies, however, could stimulate innovation and lead manufacturers to develop products that go beyond meeting just the minimum requirements. The authors state that performance-based incentives (PBIs), which account for a wide range of issues, including a system's conversion efficiency and continued performance, may be an even more effective incentive tool in ensuring high-performance systems. (PBIs provide financial rewards for the system's generation of solar electricity, rather than one up-front, lump-sum payment.)

Improving Performance

The nearly simultaneous publication of the draft handbook of California Solar Initiative Program and the Berkeley study should not be too surprising. Given that the California PV program is the largest in the United States, it is expected that many of the lessons learned would become incorporated into the handbook. For instance, capacity-based incentives will no longer be used, and systems that are 100 KW and smaller will have the option of choosing from two performance-based incentives, either EPBB or PBI. Systems greater than 100 KW must receive the PBI. The CSI also will require spot checks of installed systems, and installers whose systems repeatedly fail to pass muster will be excluded from the program.

The continued focus on PV performance serves not only the PV customer and the agencies administering incentive programs, but also the installer and the PV industry in general. High standards of performance will help build confidence in PV technology and perhaps propel this industry to levels only dreamed of a few years ago.

Access

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

"Designing PV Incentive Programs to Promote Performance: A Review of Current Practice" • http://energy.lbl.gov/ea/emp/reports/61643.pdf • Review of PV incentive programs and performance recommendations

California Solar Initiative program • www.gosolarcalifornia.ca.gov

Heroic Effort Required

by Michael Welch

In the United States, we have a strong history of heroic governmental intervention at critical junctures— Franklin D. Roosevelt's New Deal, designed to end the Great Depression, and his Manhattan Project to develop nuclear weapons to end World War II; Lyndon Johnson's New Society program, which targeted poverty and racial injustice; and John F. Kennedy's Project Apollo, meant to land Americans on the moon before the Russians.

Success or failure, good or bad, history proves that when the political will is there, resources can be found to do a big job.

New RE Deal

Once again, it is time to devote our national resources to heroic action. We find ourselves in a situation that may be more important to the future of humanity than any in recorded history. The possibility that human-caused climate change can radically disrupt life on Earth calls for massive action on our part. We need a major U.S. initiative to decrease our use of fossil fuels, and set an example for the rest of the world. To achieve this goal, we must increase energy and vehicle efficiency, substitute renewable energy (RE) for polluting technologies, create jobs, and find ways to live more sustainably. Many state and local governments are pursuing this goal, but large-scale change will not occur until we put pressure on our federal government to overhaul its energy policy and fully support renewable technologies.

It's up to us as individuals to help politicians make that change, and it's going to take work to make it happen. Although the reality of human-caused climate change makes renewable energy an easier sell to politicians than in the past, we still must overcome the influence on our representatives from big campaign contributions and an army of automotive and fossil-fuel industry lobbyists supporting nonrenewables.

A Call to Action

"Get off our butts"—renewable energy advocate Chris LaForge told me it's as simple as that. Those of us who understand the need to change our national energy policy need to help make it happen. We do not have the luxury of resting on the laurels of past RE accomplishments. We must pressure our government representatives to make decisions in the public's best interest, not for that of industry giants. It takes hearing from hundreds of us to overcome the effects of one lobbyist or one corporate campaign contribution. It is not asking very much of each of us to contact our representatives and let them know how important it is to support RE, energy efficiency and conservation, and much higher requirements for automobile fuel economy. Next, we have to become active in our communities, encouraging others to do the same.

This is how we can create the political will to foster sweeping changes in our country's energy policy. Hearing from us—with a persistent, loud voice—is one way our representatives will work in our favor. Although the RE industry has a few of its own lobbyists and groups, they by themselves will not be able to overcome the effect of the powerful and plentiful oil and gas lobbyists who have gained so much influence in our government through direct ties to administrators and representatives, and by using their big budgets for campaign contributions and other favors. Again, it is up to us as individuals to exercise our power as citizens to get our government to take the heroic actions that are needed.

Supporting Heroic Effort

There are two good initiatives that will help move us in the right direction. Both seek to change our energy future, and both borrow their names from John F. Kennedy's campaign to put humans on the moon. First, the Apollo Alliance, an organization that unites a diverse group of interests for the common goal of creating good-paying, meaningful jobs and energy independence by promoting clean energy programs. Allied are environmental and labor organizations, and economic, social justice, and faith-based groups. Through partnerships with businesses and support from various foundations, their plan is to create investments of $300 billion in new clean energy technologies and energy efficiency over ten years. They are working from the local and state levels, and intend for the money to come from private capital, utility public benefits funds, bonds, and municipal tax incentives.

Another effort that borrows the Apollo name specifically targets action at the federal level. House Resolution 2828, The New Apollo Energy Act, was introduced in June 2005 to "ensure that the United States leads the world in developing and manufacturing next-generation energy technologies, to grow the economy of the United States, to create new highly trained, highly skilled American jobs, to eliminate American overdependence on foreign oil, and to address the threat of global warming." The bill was introduced by Rep. Jay Inslee (WA), and has 43 House sponsors, but is still in committee.

Although this bill may not be heroic in the context of the discussion here, it is an important bill to support—and a good starting place for the huge amount of work to be done. It needs the sponsorship and efforts of your Congressional representative to move it through the system and onto the floor for debate and voting. Again, we citizens will be the ones to keep this bill from languishing in committees, or being killed outright. With new leaders in Congress already talking about global warming and the need for RE, clean-energy supporters have a great shot at finally bringing bills like this onto the floors of Congress for the consideration they deserve.

We're the Heroes

When a powerful politician finally takes up the banner that individual, environmentally aware citizens have been flying for years, they will be labeled the hero for helping keep Earth habitable. But we will all know what it really took to get the job done—each and every one of us renewable energy advocates getting off our backsides to make those phone calls, write those e-mails, and send those faxes and letters. Let us heroes get this job done.

Access

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

The Apollo Alliance • 202-955-5665 • www.apolloalliance.org

The New Apollo Project • www.house.gov/inslee/issues/energy/apollo_new.html

HR2828 • http://thomas.loc.gov/cgi-bin/bdquery/z?d109:h.r.02828:

Mangled Terms

Nitpicking Word-Nerd Power

by Ian Woofenden

As with any field, the renewable energy industry has its jargon—and its misuse of jargon and terminology. In this column, I'll survey a few key terms that are mangled or misused, starting with obvious errors and moving toward some personal preferences. Let's see if you're as much of a nitpicker as I am…

First, some words and phrases that are just plain wrong:

Photovolactic. This too-common mispronunciation of "photovoltaic" is sometimes used jokingly by industry insiders. The real term comes from the Greek root *phot*, meaning light, and *volt*, so it means electricity from light. The phrase "solar photovoltaic" seems redundant to me, since almost all photovoltaic applications are designed to use sunlight.

Watts per hour. This nonsensical phrase tops my electrical terminology pet peeve list. A watt is a rate of energy generation, transfer, or use—it stands for joules per second, so it already has a time component built in. You will *never* see an appliance or device rated in "watts per hour," nor will you see this phrase in any textbook—it's just plain inaccurate. See my columns in *HP71* and *HP72* for more explanation. Also avoid writing watt-hours as "watt/hours" or "W/H." That implies "watts per hour" and furthers the confusion.

Amps per hour. While this one is just as wrong as "watts per hour," it's a little more understandable that people make this error. "Ampere-hour" sounds almost like "amp per hour," but is actually named after nineteenth-century French physicist André Marie Ampère. An ampere-hour, or amp-hour for short, is a measure of the quantity of charge cycled through a circuit or battery.

Deep-cell battery. The correct phrase here is "deep-cycle battery," describing a chemical energy storage device that is intended to be discharged deeply. All batteries include a cell or cells, the building block of these electrochemical storage devices. But the physical depth of the cell is not important, while the cycle depth—how much you can discharge them without damaging the battery—is crucial.

Anenometer. Many otherwise fluent people make this pronunciation mistake, swapping an "n" for the first "m" in this word. *Anemometer* (remember your mom when you say it) is based on the Greek word *anemos*, which means spirit or wind. *Meter*, also from Greek, means to measure. An anemometer measures the wind. This word should get the tongue-twister award.

Now we move into the realm of personal preference and style:

Modified sine wave. This phrase, invented by inverter marketing departments, tries to make a stepped AC wave sound smoother. It would be more accurate to call this waveform "modified square wave," but it's harder to sell inverters that way, since it sounds like a lower quality waveform. The savvy consumer won't be swayed by the phrase, but will look for inverters that produce a smooth sine wave. This only applies to battery-based inverters, not batteryless, grid-tie inverters, which all produce high-quality, grid-synchronous sine waves.

Power. Technical nitpickers (ahem) still would love to see this term used in its technical sense—the rate of energy generation, transmission, or use. But in common speech, we use it to mean energy, electricity, and political pull, among other things. I suggest that we be careful in the way we use this word in electrical circles, so we don't entirely lose the technical distinction between power and energy. Often, we mean "electricity"—a perfectly good word, which we should use.

Solar. I think that this word should remain an adjective, and not become a noun. My response to someone who wants to "get some solar" is that I might decide to buy some lunar instead. 'Nuff said?

Solar panel. This phrase is so common, but so confusing. It could mean a solar-electric module, a solar thermal collector, a breaker panel for a solar-electric system, or a group of my esteemed colleagues speaking at a conference. Let's be specific about what we mean, so others can understand us.

Solar system. I'd rather *live* in a solar system than buy one. Again, what does it mean—planets rotating around a sun, a solar-electric system, or a solar hot water or air system?

Wind tower. I can't explain why this phrase bugs me—maybe I've been exposed to too much wind. I prefer to say "wind generator tower," since that's what the tower supports. But I suppose we could start talking about radio wave towers, patriotism poles, or other such phrases that don't very accurately describe the item. Additionally, using "windmill" as a synonym for a wind turbine is quaint to me, but not very accurate, since wind generators don't mill anything.

Alternative energy. We might continue to view renewable energy technologies as an alternative—and not the standard—if we continue to use this phrase. Renewable energy has a much longer history than "conventional" energy, and the sun is the source of almost *all* energy. So it's the short blip of our reliance on fossil fuels that should be seen as the alternative—perhaps renewables should be called "normal energy."

Of course, using renewable energy is more important than using the terms correctly. If you have to make a choice between installing an anemometer and pronouncing the word correctly, I'd much prefer the former. But with a little care and attention, we can implement renewable technologies *and* describe them in clearer ways, to advance the renewable energy movement in an intelligent and understandable way.

Access

Have you heard other mangled RE terms or phrases? Drop me a line at: Ian Woofenden, PO Box 1001, Anacortes, WA 98221 • ian.woofenden@homepower.com

Another Clucking Adventure

by Kathleen Jarschke-Schultze

In *H&H109*, I regaled readers with a story about raising an orphaned chick, whom I named Chiclet. I kept her alive by the heat of the single, watt-sucking (and, in this case, life-saving) incandescent lightbulb, and she imprinted on us, rather than her fellow hens.

Most Favored Poultry

There came the day when Chiclet got too big to stay in her cage, but not big enough to hold her own with my big hens. I brought her to my sister Mary's house. Mary has small chickens, Bantys and the like, so they were closer to Chiclet's size. Plus her chickens range freely, so Chiclet could avoid most altercations with the hens there.

Alas, Mary's flock was no more accommodating than mine would have been. Soon, the inhospitable brood had pecked off all of Chiclet's neck feathers. Chiclet would emerge in the morning with all the other birds, but then follow whoever had opened the coop door back to the house, warbling all the way.

Mary and her partner Jer would let her in the house to eat toast crumbs while they drank their morning coffee. Then she would hang out and eat bugs while Mary and Jer weeded or planted seeds in the garden. She would lounge around and peck at the sleeping dog while they ate lunch on the deck. Whatever outdoor project was in progress, she'd just tag along.

In the summer heat, when they walked to the pond to swim, Chiclet would follow along. While they swam, she would stand on the dock and snap at bugs flying close. On the way home, when she was tired, they would pick her up and carry her the rest of the way. She still loved to be held.

Never fully accepted by the flock, Chiclet became a pet. She had her own little coop with a locking door by the front porch. She knew it was her roost and returned to it every evening. In Jer's shop, a wooden lug box, turned on its side and cushioned with straw, served as her nest. She would go there to lay a daily egg. Mary said Chiclet was her most reliable layer.

Wild Kingdom

Mary and Jer's rural property borders Lassen National Forest, and they have had more than their share of wild-animal encounters, most to the detriment of their domesticated animals. They've lost two goats to a cougar. A bear has rifled their chicken coop on several occasions, and forced them to put an electric fence around their beehives. They refer to the homestead as their "Wild Kingdom," à la Marlin Perkins.

One evening, Mary and Jer heard Chiclet cry out. Since it was after dark, she was in her private apartment in front of the sun room, but her door was open and unlocked. Jer usually locked her door right before they retired for the night, and that hadn't happened yet. Jer ran outside, shouting, "Hey, HEY! Get away from here!" to scare away whatever wild varmint it might be. Their dog Tenzing Momo (Divine Dumpling) was right beside him, barking furiously. Jer stopped at Chiclet's little house to check on her. It was empty. Momo kept right on barking and ran around the corner of the house. Momo chased something across the creek and away. Jer quickly followed. Mary came a moment later with a flashlight. That's when they found Chiclet. She was lying on the ground with an ugly gash in her thigh. Jer picked her up and carried her, unprotesting, into the house.

Everyone was very upset, except Chiclet. She remained calm while her wound was inspected. The very upper end of her left thigh had a deep gash and no feathers. She did not lose much blood and remained calm after getting rescued.

Mary sutured the thigh muscle then closed the wound with '00' silk thread. She did not have dissolving sutures, so she used what she had. After applying Betadine and an antibiotic ointment, she set Chiclet on a towel in a box on the hearth and positioned a heat lamp overhead. Chiclet settled into her new home just fine. The next day, Jer and Mary were relieved to find her clucking good morning to them. They figured that if she made it through the night, she would have a good chance of making a full recovery.

Game Hen

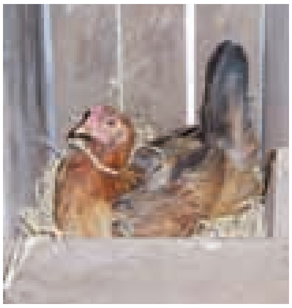
Every day, Chiclet got a little better. She ate and drank and lay around. She attempted to stand a couple of times, but held her left leg up tight to her body. She would then settle back down. Mary broke an antibiotic tablet into little chunks and fed her a bit each day.

We were all amazed that she was still alive. Mary and I figure she may have fared so well because she had bonded with people and was not terrified when she had to be handled after her injury.

When Chiclet began to get a little dirty, Mary bathed her and then used a blow dryer to dry her quickly. They would take her outside for a half hour every day to let her peck at things in the dirt.

Then she started letting Mary know when she had to poop by making little warbling noises, from her recovery box. Mary would take her outside, where she would poop and then wait to be carried back inside. Now that's a great chicken.

Care & Stewardship



Chiclet in recovery.

Chiclet has recovered enough to be moved to a shed, where her friend Bunny also lives. Like Bunny, she mostly hops, using her good leg for launching, and both legs for landing, with some wing action. She does leg-lifts (landing gear down, landing gear up) and is healing well, but still seems to be uncomfortable using her injured leg.

When you move to your homestead, when you get those animals, when you plant that garden and orchard, when you live with renewable energy, you are signing on for a position of active stewardship. The land, the animals, the plants and trees, RE systems—all of it is in your direct care. You will become completely invested in your lifestyle and all that entails. And this is a wonderful thing.

The challenges are many. The learning potential is great. And, once in a while, you take part in a seeming miracle that makes you feel downright victorious.

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

RE happenings

U.S.A.

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

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

CALIFORNIA

Feb. 20–21, '07. San Francisco. Clean Energy Project Finance. How to overcome the financial challenges of small-scale sustainable energy project development. Produced by the CA Energy Commission. Info: Green Power 2006 • info@greenpowerconferences.com

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

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

COLORADO

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

FLORIDA

Mar. 31, '07. Marathon, FL. Green Living & Energy Education EXPO. Workshops, vendors & speakers. RE, energy efficiency & water conservation. Food & entertainment. Info: GLEE, PO Box 754, Key West, FL 33041 • 305-293-7658 • info@keysglee.com • www.keysglee.com

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

ILLINOIS

Mar. 16–18, '07. Chicago. Consumer Alternative Fuel & Energy Eff. Expo. • www.consumeralternativefuels.com

IOWA

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

MASSACHUSETTS

Mar. 13–15, '07. Boston. Building Energy '07. Conference & trade show for RE, planning & building professionals. Workshops, speakers & exhibitors. Info: Northeast Sustainable Energy Assoc. • www.buildingenergy.nesea.org

MICHIGAN

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

MONTANA

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

NEW MEXICO

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

NEW YORK

Apr. 7, '07. Photo contest deadline for the 2007 New York State Envirothon, which this year focuses on RE. Info: www.envirothon.org

NORTH CAROLINA

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

OREGON

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

PENNSYLVANIA

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

TEXAS

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

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

WASHINGTON STATE

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

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

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

WISCONSIN

Jun. 15–17, '07. Custer, WI. RE & Sustainable Living Fair (aka MREF). Exhibits & workshops on solar, wind, water, green building, alternative transportation, energy efficiency & more. Home tours, silent auction, Kids' Korral, entertainment, speakers. Info: See MREA listing below.

Custer, WI. MREA '07 workshops: Basic, Int. & Adv. RE; PV Site Auditor Certification Test; Veg. Oil & Biodiesel; Solar Water & Space Heating; Masonry Heaters; Wind Site Assessor Training & more. MREA • 715-592-6595 • info@the-mrea.org • www.the-mrea.org

INTERNATIONAL

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

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

AUSTRIA

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

CANADA

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

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

CHINA

Mar. 15–17, '07; Shanghai. 2007 Asia Solar Energy Exhibition. PV, wind & solar thermal. Info: Ms. Angel • 86-21-65-28-9597 • angel@aiexpo.com.cn

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

COSTA RICA

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

FRANCE

St. Laurent de Cerdans. Solar Electricity Design Course: May 14–18, Jun. 11–15 & Sep. 10–14; Intro to RE: May 7–11, Jun. 4–8 & Sep. 3–7; Info: Les Amis de Numero Neuf • www.lesamis9.org • info@lesamis9.org

GERMANY

Jun. 21–23, '07. Freiburg. PV Industry Forum 2007 & Intersolar 2007. PV markets forum followed by solar developments exhibition & forum. Info: www.pvindustry.de & www.intersolar.de

ITALY

Apr. 19–21, '07. Verona. SolarExpo & GreenBuilding exposition. Info: 39-04-39-84-0922 • exhibition@solarexpo.com • www.solarexpo.com

Sep. 3–7, '07. Milano. European PV Energy Conference & Exhibition. Info: WIP Renewable Energies • 49-89-720-127-35 • pv.conference@wip-munich.de • www.photovoltaic-conference.com

SPAIN

Jun. 26–28, '07. Madrid. RE Europe. Future RE technologies & concepts. Info: REE • 44-0-1992-656-632 • aijaz@pennwell.com • www.renewableenergy-europe.com

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