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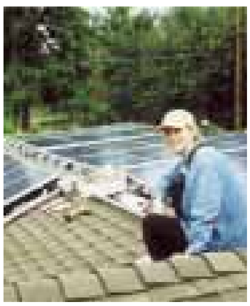
HOME POWER

THE HANDS-ON JOURNAL OF HOME-MADE POWER

Issue #93 February / March 2003

Features



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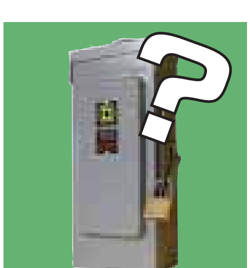

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What the Heck?

What the Heck?

A "What the Heck?" feature.

Used In: *Home Power* magazine

AKA: Huh? *or* What is that thing?

What It Is: Simple explanations of renewable energy gear

What It Ain't: Advertising or heavy, technical, RE system articles

Do you stumble on terminology and technical details in *Home Power* articles? Do you ask yourself, "What the heck is a disconnect?" or, "What the heck does this dude mean by utility interactive inverter?" You're not alone. We get lots of e-mail from new readers who read our articles but don't understand what the renewable energy (RE) pieces and parts are.

Chuck and Smitty of AAA Solar recently suggested that we should run short mini-features that explain technical gear simply, for the rest of us. We're calling this new feature "What the Heck?" and you'll find them here and there in future issues of *Home Power*. See pages 42 and 78 in this issue for the first two. Don't confuse them with ads just because they're colorful—they're educational.

"What the Heck?" cuts through industry jargon and gives readers simple explanations of esoteric hardware terminology. They're written by in-the-know renewable energy professionals in easy-to-understand language. And if you have more questions, you can e-mail the authors—they are there to help.

These short features will help *all* readers understand what specific components and concepts are, and how they fit into the big picture. But most of all, "What the Heck?" pieces are meant to bridge the communication gap between new readers and the industry's experienced end-users and professionals.

If you have an idea for a potential "What the Heck?," please send it to submissions@homepower.com. We'll try to get your idea covered in a future "What the Heck?"

—Eric Grisen, for the *Home Power* crew

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"Think about it…"

How many power generation technologies can you name that people want to put in their backyard?

— Richard Chleboski, Evergreen Solar, see page 72

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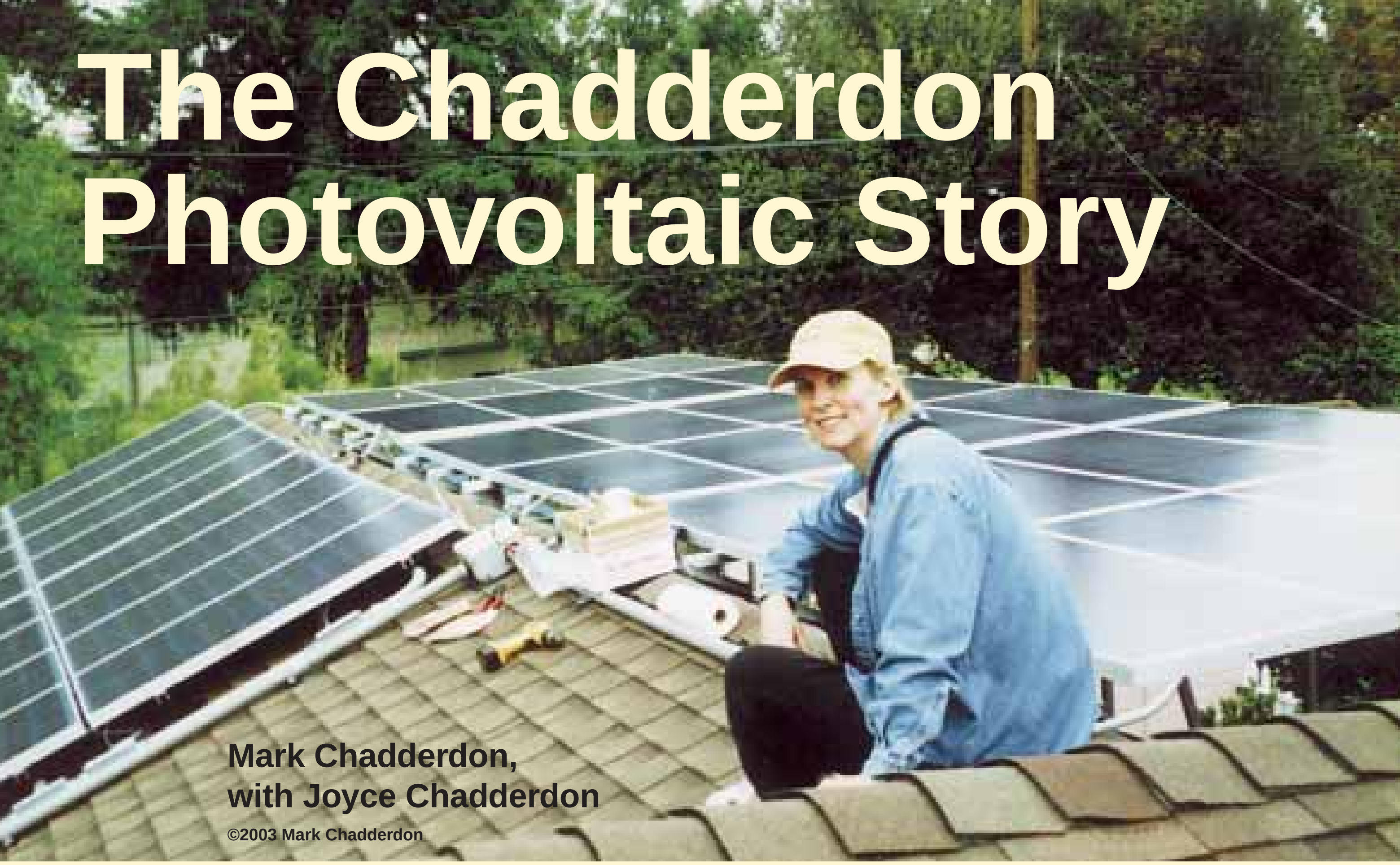
The Chadderdon Photovoltaic Story

Mark Chadderdon,
with Joyce Chadderdon



A smiling Joyce Chadderdon during the final stages of PV array installation.

From above, the full scope of the 4,800 watt array can really be appreciated.

I'm not an engineer. I have no formal training in electrical issues. But I do have a good mechanical aptitude, and I'm a bit paranoid (which helps). I'm an end user—a consumer—and I really don't want to be bothered with theories, equations, and maintenance schedules. Although I own an electric car, I'm not interested in dismantling it to see how it works. I get in, turn the key, and it goes. That's what I want from everything I buy, including my PV system.

The brains and brawn of the installation—L to R: Kingsley Chen, Mark Chadderdon, Jason Bowman, and Keith Fabisiak.

I figure that my PV system should do its thing without me interacting with it. I don't care about plotting curves and analyzing data. Weeks can pass without me looking at the charge controller or inverter displays. But I admit that every time I walk past the utility meter, I make sure it's spinning in the sell direction. I feel great about what we have accomplished and the positive impact it will have on our world.

System Overview

The system we installed is a utility intertie with minimal battery backup. The PVs are roof mounted on our 1,400 square foot (130 m^2) ranch-style, tract home in Santa Clara, California. The components consist of forty, 120 watt (rated) Solarex SX120 modules wired for 48 volts, a Trace SW5548 inverter, three Trace C40 charge controllers, eight Concorde PVX-12100T batteries (each battery is 12 VDC nominal, 100 AH capacity at the 20 hour rate), and a homemade combiner box.

We have the City of Santa Clara's great municipal utility, Silicon Valley Power (SVP), to thank for awarding us a US$6 per watt rebate through a special program initiated to promote PV installations. We received a rebate of US$24,000, the maximum available to us when our system was completed. Now, SVP administers the California Energy Commission (CEC) rebate process without local rebate money.

Starting the Process Mentally

Although we didn't begin writing checks for equipment until April 2001, our PV system was taking shape long before that. When I took delivery of my Corbin Sparrow electric vehicle in January 2000, the dealer mentioned that he had recently delivered a Sparrow to someone about a mile from where I live. I offered my e-mail address and asked the dealer to forward it to the other Sparrow owner.

The large PV array on this cute little home is almost invisible from the street.

Soon after, I met Kingsley Chen. As it turned out, Kingsley works at EcoEnergies (formerly Photovoltaics International) in Sunnyvale, California. During 2000, we got to know each other, and I came to realize that he is an RE genius! Although Joyce and I had discussed PV for our house many times, and had even picked up the California state buydown program application, it wasn't until the SVP rebate program started that we began looking seriously at the numbers and system configuration.

When the time came to draw up the plans, Kingsley was very generous with advice. Based on our modest budget, we determined that I would have to do the installation myself. I wasn't sure I could do it. I had no firsthand knowledge of what I was about to embark upon, but the fact that Kingsley was close by in case I ran into trouble gave me the courage to proceed.

Admittedly, the rebate played into our design. I figured that the amount of effort to install the system would be about the same whether we installed 2 KW or 4 KW. So we decided to go for the maximum rebate, which meant we would need to install close to 5 KW (rated) of PV. When system inefficiencies are taken into account, a system of this size will actually produce 3 to 4 KW of AC power. By installing 4.8 KW, we created a system output buffer that would guarantee the full rebate.

The top bay of the Trace Power Module, including the SW5548 inverter and four, C40 charge controllers (one is a spare).

We live in a small, all-electric house built in 1949, with electric heat. Only the water heater is serviced by natural gas (our January 2002 PG&E gas bill was US$10.03). With just two of us, our electrical usage is still pretty high, due to the clothes dryer, the stove (we rarely eat out and Joyce loves to bake), my electric car, Joyce's jewelry making equipment (including kiln), and our spa. We didn't perform the usual detailed load calculations. We've lived in the house for ten years, and our monthly utility bills show a fifteen month usage history.

Our previous twelve months of usage was 11,315 KWH—31 KWH per day average with January and February averaging about 65 KWH per day! Using "back of napkin" calculations, we determined that 5 KW of modules on a fixed mount at our location would generate approximately 8,000 KWH per year, and would cover around 65 to 70 percent of our annual electricity needs.

Being the energy conscious folks that we are, we had already insulated the attic and floor, replaced all the windows with dual panes and installed honeycomb style insulating blinds throughout the house, swapped out the incandescent bulbs for compact fluorescents, and stopped all nonessential phantom loads. Energy usage reduction is a high priority for us—in the future, we plan to modernize our appliances and have the exterior walls insulated. These additional steps will help bring our electric usage closer to break even.

Finally, even though our system would be grid connected, we didn't want to go to all this effort and not have electricity during a utility outage. So we decided to include a small battery pack that would be capable of keeping the refrigerator running, and allow us to use the microwave and some lights.

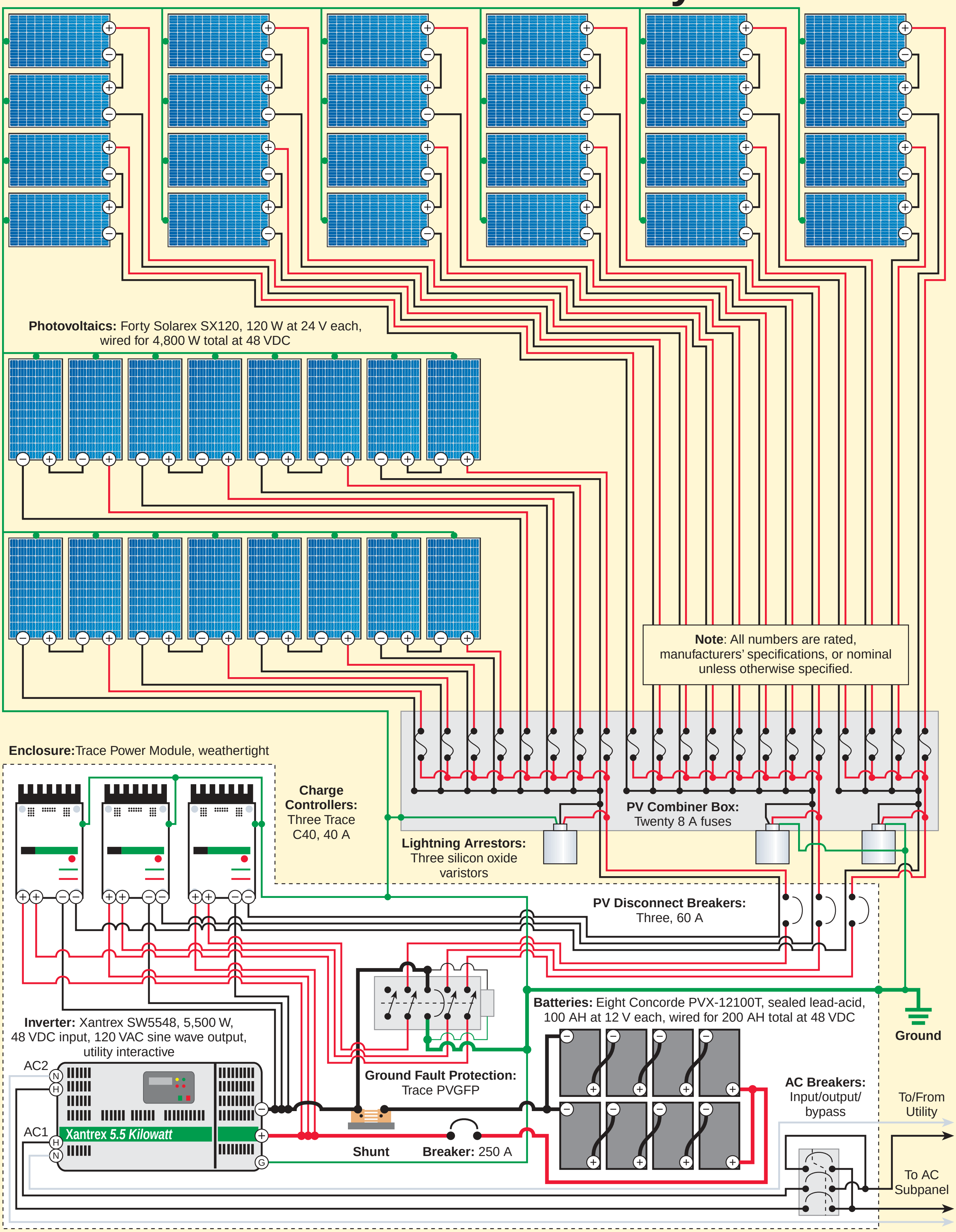
Starting the Installation

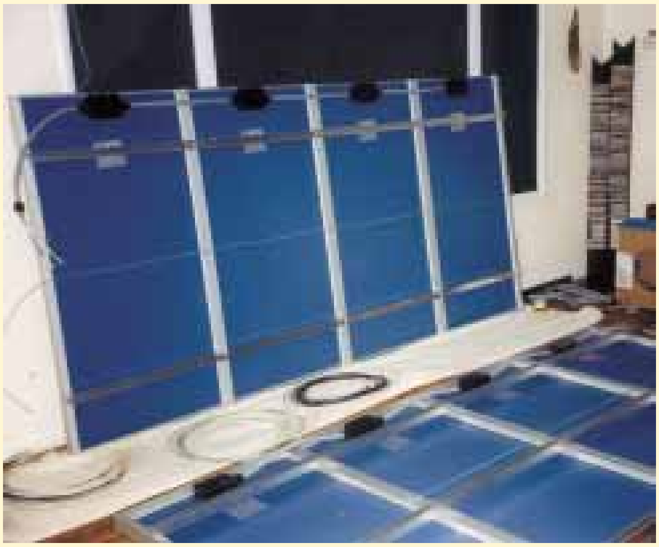
The number one thing I had going for me was that I was smart enough to know how dumb I was to attempt to do this myself! My goal was to install the PV system as inexpensively as possible, while purchasing the best equipment available, and making sure it would pass the inspections. Actually the inspections were secondary, since I'm a perfectionist and don't cut corners. I wanted this system to be better than code. If I encountered a problem, I would choose the best safe solution.

Admittedly, I didn't know where to begin. I had been reading *Home Power* magazine (my first issue purchased was *HP50*). I'd purchased and watched video tapes, and read half a dozen books that I purchased on-line (several were old and seemed out of date, but I benefited in different ways from reading each

The Trace Power Module holds system components, including batteries, in a weathertight enclosure.

The Chadderdon Photovoltaic System





Assembling PV subarrays in the living room.

one). But I was really uneasy because nobody was publishing a complete parts list or offering step-by-step instructions for the do-it-yourselfer. I knew that once I had the parts, I could assemble the system, so I decided to play it safe and purchase a package from a reputable source.

I went to EcoEnergies and explained what I wanted to do. From them, I would purchase a modified, whole house UPS, which consisted of a Trace Power Module, including a Trace SW5548 inverter, four Trace C40 charge controllers, eight Concorde PVX-12100T batteries, and all the rest of the items that complete the Power Module. Besides the UPS, EcoEnergies supplied the components to build the combiner box, the roof mounting brackets (for the flush-mounted, south-facing section), as well as all the wire that I would need for the complete system. I also paid to have one of their electrical engineers create the drawing and system schematic that the city requires for issuing permits.

None of this was at dot-com pricing—EcoEnergies is not in the business of selling parts. But we were willing to pay extra for the knowledge that we were getting a complete package of equipment from a reliable source—the same equipment that they were using for their own installations. It took a lot of the risk out of purchasing the equipment.

The next big purchase was the PV modules, which I shopped around for on the Internet. Remember, it was the spring of 2001, and California was reeling from rolling blackouts and jacked-up energy rates. Modules were in short supply. But I wanted "the best of the best," so I chose to order sixty BP585s. I found a dealer on-line (now Aaaffordable Solar, Inc.) who had a great price and said I could have the modules in six weeks. So I sent a deposit on May 1st. I was hoping to have my system up and running in time for the 4th of July—it seemed reasonable at the time. I started building the rest of the system.

I'm a trusting soul and was in no rush to get the modules, but after several missed shipments, I began to worry. Toward the end of July, the dealer called and said that he couldn't give me any firm date for delivery, and suggested that I change modules because the BP585s were in short supply. At that point, the rest of the system was already built, based on fifteen, 48 V strings.

I was stuck. I could wait indefinitely for the BP585s, or I could purchase different modules, possibly causing me

The PV combiner box brings together twenty, 48 volt subarrays, each consisting of two, 24 volt modules.

The elevated north array mount took some tricky math to build—especially dealing with the roof transition.

to redesign the system. I wanted to bring the system on line as fast as possible (we needed the rebate money to pay the bills), so I decided to change modules. The dealer found 40 Solarex SX120 modules and shipped them right away. They arrived the second week of August.

We cleared the furniture out of our living room and created a mini-PV subarray assembly plant. I wired the modules into twenty, 48 V, series circuits of two modules each, and then I rebuilt the combiner box so it could accommodate twenty circuits, instead of the fifteen I had originally planned.

Pulling It All Together

During the late spring and summer months, while I was waiting for the PV modules, I built and installed the power module and combiner box. This included pouring concrete, installing a 50 foot (15 m) run of 1$^1/_2$ inch PVC conduit under the house, and pulling seven #4 (21 mm^2) conductors between the two. My layout has the combiner box and power module at opposite ends of the house. So I decided to run the conduit in the crawlspace under the house because it's cooler than the attic. Heat decreases the ampacity of the wire.

After this portion of the system was completed, I contacted MDE Electric Company, a local electrical contractor who was experienced in PV installations, to do the AC wiring. Their electrician installed a utility subpanel for the house circuits that are connected to the inverter, and a disconnect box that the city requires. In a few hours, everything was done, and all I would have to do was flip a switch once the PVs were on-line.

Roof Mounting Made Difficult

If there was one part of the project that I underestimated, it was the mounting structure. It turned out to be the most difficult part, maybe not from a technical standpoint, but because of the physical toll the roof mount installation took on me. I didn't keep strict track of my time, but I would estimate that at least 50 to 60 percent of my total time was spent building the mounting hardware and preparing the roof for installation.

Our roof is covered with seven-year-old, forty-year-rated asphalt shingles over $^1/_2$ inch (13 mm) plywood, supported by 2 by 6 rafters. The slope is about 22 degrees. This would seem to be about the best case scenario for the do-it-yourselfer installing a flush-mounted system. If your house has a wood shingle, shake, tile, or metal roof, I would suggest having professionals do the PV install. They should have the experience and the proper tools and techniques to do it without destroying your roof.

The section of our roof that's facing south has about 210 square feet (19.5 m^2) of roof area in which PV could be mounted parallel to the roof. But the forty modules that we wanted to install would take 460 square feet (43 m^2). We fit sixteen modules onto that south roof area, using

Pacific Solar's fixed position mounting brackets, which raise the modules about 6 inches (15 cm) off the roof. (Because we felt that the roof's 22 degree angle was sufficient for year-round use, we made no provisions for the modules on the south side to have an adjustable angle.)

Elevated Array

This left us with 24 modules to mount over the north-facing roof slope. The solution was a mounting structure in which the PV panels attach at the roof ridge and project out over the north roof at a south-facing angle. The support leg length can be altered to optimize the array angle depending upon the time of year.

Because we would have 276 square feet (26 m^2) of PV suspended above our roof, the city required wind load calculations during the permitting process. They were mainly concerned about the PVs lifting off the roof in high winds. I was surprised to find out that up to about 30 mph (13 m/s), the wind actually neutralizes the weight of the PVs. In a constant 30 mph wind, there would be no load on the roof (with our design).

When discussing the design plans before receiving our permits, the inspector wanted to see spec sheets listing the pull-out strength of the screws that would be used, and wanted to know about the roofing sealant I had specified for waterproofing the penetrations (Rain Buster 700 elastomeric copolymer sealant by Top Industrial, Inc.). He specifically asked where I would be purchasing those items. He said that engineering grade supplies cannot be purchased at your local hardware store. Good advice. Fortunately, I already knew that and made those purchases at a contractors' roofing supply company. The result is a sturdy structure with no leaks after the first winter.

Most of the lower mounting brackets are directly over the house's outside wall.

The upper mounting brackets are along the roof ridge.

Mounting Brackets

Before I could start attaching the mounting brackets to the roof, there were some structural issues in the attic that I wanted to take care of. I spent one weekend putting up Simpson Strong Tie rafter supports and hurricane bracing (did I mention I'm a little paranoid?), as well as adding 1 by 10 lateral bracing to some rafters. I spent one weekend relocating plumbing vents from a bathroom, and a day measuring rafter spacing and doubling up off-center 2 by 6s.

I also spent a day adding perpendicular 4 by 4s between rafters where the mounting feet transition from one roof slope to the other roof slope, causing them to fall in between the rafters. I did these things to make sure that the structure was sound—the building inspector didn't require any of it except the bathroom vent relocation.

To support the PVs, I installed a total of sixty-two mounting brackets. I used thirty-two Pacific Solar mounting brackets that I purchased from EcoEnergies for the four subarrays (sixteen modules). These are flush mounted on the south-facing roof slope. The remaining six subarrays (twenty-four modules) are mounted on what is basically like a ground mount system, but for my roof, instead.

Placement of the mounting brackets on the south-facing side was fairly forgiving. The Pacific Solar mounting brackets were really great. They're solidly made and raise the PVs off the roof by about 6 inches (15 cm), allowing decent ventilation.

The 1 1/2 inch aluminum U-channel that the modules are bolted to locks securely into a slot in the bracket. Using a piece of U-channel stock as a guide, I positioned two supports under each module—all were screwed into rafters. When the time came to lift the subarrays into place, they dropped into the slots and locked into place with little effort.

The north-facing roof slope is a different animal altogether. My goal in designing this section was to create a hinged system in which the subarrays could tilt up and down throughout the year. I'm lucky to have a good friend who is a machinist. Kevin Hendren helped me design the mounting brackets that we used for this section. He transferred our design into his computer numerical control (CNC) system, and we spent a couple nights after work banging out the parts on his vertical mill. The result was a really heavy duty mounting system that looks much better than those universal "erector set" style systems. Best of all, the materials cost less than half of what I would have paid for a lesser quality premade system.

Because this north side is elevated, it acts like a sail, so I was worried that wind would be trapped between the array and the roof ridge. To minimize the air pressure under the array, and also to prevent any whistling noise that might occur, I introduced two design elements. First, the mounting brackets are tall—the hinge hole is 2 1/2 (6 cm) inches above the roof. Second, I left 6 inches (15 cm) of the U-channel stock at the end of each module where the U-channel attaches to the roof ridge. So the result is a large opening that allows the wind to escape.

On this north section, I installed thirty mounting brackets (fifteen along the roof ridge and fifteen below, with twelve of the lower mounts directly over the outside wall of the house). Placement was critical for the hinge to work without binding. It was tedious work that had to be done properly—the best I could do was to install four brackets per day. And it really got tricky when the mounting brackets transitioned from the roof over our addition to the roof over the main house. I had to calculate the distance between each mounting bracket and the variable support leg lengths by using the Pythagorean Theorem (Pythagorean Theorem calculator: www.1728.com/pythgorn.htm). Additionally, we milled the bottoms of those four brackets to match the roof slope.

Finishing the Prep Work

After half the mounting brackets were in place, I installed the PVC conduit on the roof. I had twenty circuits, requiring forty, #10 (5 mm^2) conductors (plus two for ground), so I installed two separate runs using 1 1/2 inch PVC conduit.

This is another area where careful planning was required. While I was assembling the subarrays, I used colored electrical tape to identify the series circuits that were coming from each subarray. Now I had to make a wiring harness that exactly matched that color coding scheme, and make sure the conductor length was proper for the conduit run associated with each subarray. As with the conductor pull under the house, Kingsley was there to help me with this brutally tough job. There were a few tricky bends, but somehow we got all that wire pulled through. I wired up the combiner box, and trimmed off the excess from the opposite ends that would attach to the subarray outputs.

Chadderdon System Costs

Item	*Cost (US$)*
40 Solarex SX120 panels	$21,324
Trace Power Module, including SW5548 inverter, four C40 controllers, and eight Concorde PVX-12100T batteries, 100 AH each	8,848
PV mounting system	2,661
Wiring & conduit	1,990
AC utility panel upgrade	900
Combiner box	798
Permits	714
Tools & supplies	527
Training (books & videos)	379
Concrete	150
Bathroom vent pipe (relocation)	95
Roof reinforcement	52
Total	$38,437

The Lift

By the first of October, the only thing left was lifting the subarrays onto the roof, setting them into their brackets, and matching up the circuit wiring. I was ready, and everything had been double-checked. I called some friends, and six of us lifted the 135 pound (61 kg) subarrays onto the roof without a hitch. They dropped into place, we matched up the circuits, connected them, and before we knew it, we were done. It took about two hours to install the first five subarrays.

But that's all we could do at that point because the building inspector wanted to see one of the elevated subarrays installed before he would okay the rest of the install. A few days later, the structural inspection went perfectly. Since the inspector made no changes, I could now install the rest of the mounting brackets and build the rest of the subarrays. That took another five weeks.

In mid-November, I called some friends again and we hoisted the final five subarrays in about the same amount of time. Kingsley and I were left to give the system one last review and then turn it on. Without any fanfare, we were spinning the meter backwards!

Mark and his electric Sparrow both get a charge out of the new PV system.

I called the electrical inspector Monday morning for a Wednesday inspection. Two inspectors came out and found two little items that I could fix in half an hour, but they wouldn't approve the system—they wanted to come back to make sure I had made the changes. So the following weekend I made the improvements, which consisted of more securely fastening a ground wire to the wall where it ran from the Power Module to the ground rod, and moving a neutral wire in the AC panel—it was attached correctly on both ends but routed incorrectly. On that Monday, I called for the final inspection. We received approval on Wednesday, November 28, 2001. Happy Thanksgiving! A year had passed since our initial planning sessions.

A Few Bugs

The system is running perfectly. All the calculations that were made during the design phase turned out to be accurate. After operating for six months, the only change that needs to be made is to the slope angle of the north section. It turns out that the modules don't drain well without a steeper slope, and dirt builds up along the bottom edge. I've been cleaning the modules every other weekend, but that's too much work.

That section was designed with minimal slope for two reasons. At that time, the city planning committee told us that if the modules could be seen from the street, we would have to go through a formal review process to determine the impact on the neighborhood. I also felt that the flatter profile would minimize wind resistance.

Fortunately, the city now allows PVs to be seen from the street. And as for the wind, we had several very windy days this past winter and the PVs were rock solid, so I feel confident that a little additional exposure is safe. My plan is to extend the fifteen vertical legs by 20 inches (51 cm), which will put them over 14 degrees from horizontal.

Considering the scope of the project and all the different manufacturers' parts that have to work together for the system to function properly, I'm extremely pleased. But I do have two minor complaints about the Trace equipment. I'm disappointed with the layout of the Trace Power Module. The SW5548 inverter lies flat, so it's impossible to read the display or see which buttons need to be pushed. And the C40 charge controllers are mounted on the back wall in such a way that you can't unscrew the bottom screws in the face plates because the inverter is in the way. It's just bad design. I'm surprised at Trace because all the equipment is theirs—it comes as a bundle—and yet it's not at all user friendly in this configuration.

Solar Progress

In the year that it took to install our system, a lot changed in the world of PV. The parts for our system came from dozens of different sources. What's considered "the best" changes daily. I'm glad to see the trend toward more consumer friendly assemblies. My combiner box (for example) is not UL approved, yet all of the individual components in it are. This caused me a lot of frustration when pulling the permits.

I'd like to see manufacturers offer a complete PV "kit" including instructions, schematics, and line drawings that can be used to get the required permits at city hall—a completely UL approved, do-it-yourselfer kit, delivered on a pallet to your job site. That said, building this PV system was a great experience. It's operating perfectly and everything worked out in the end. Our August 15th utility bill had this pleasing tidbit: "Your electric net metering account is operating from a minus 1,051 KWH balance as of this billing." We feel good going into winter with this much "in the bank."

Access

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mark@artmachine.com

MDE Electric Company, 152 Commercial St., Sunnyvale, CA 94086 • 408-738-8600
Fax: 408-738-0385 • admin@mde-electric.com
www.mde-electric.com • AC wiring

EcoEnergies, Kingsley Chen, 171 Commercial St., Sunnyvale, CA 94086 • 866-765-9463 or 408-746-3062
Fax: 408-746-3890 • watts@ecoenergies.com

www.ecoenergies.com • Balance of system components

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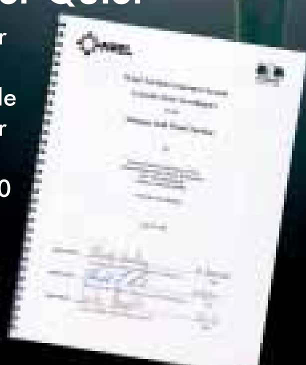

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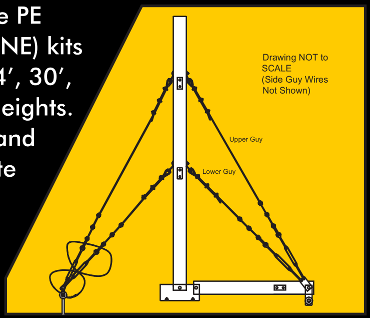

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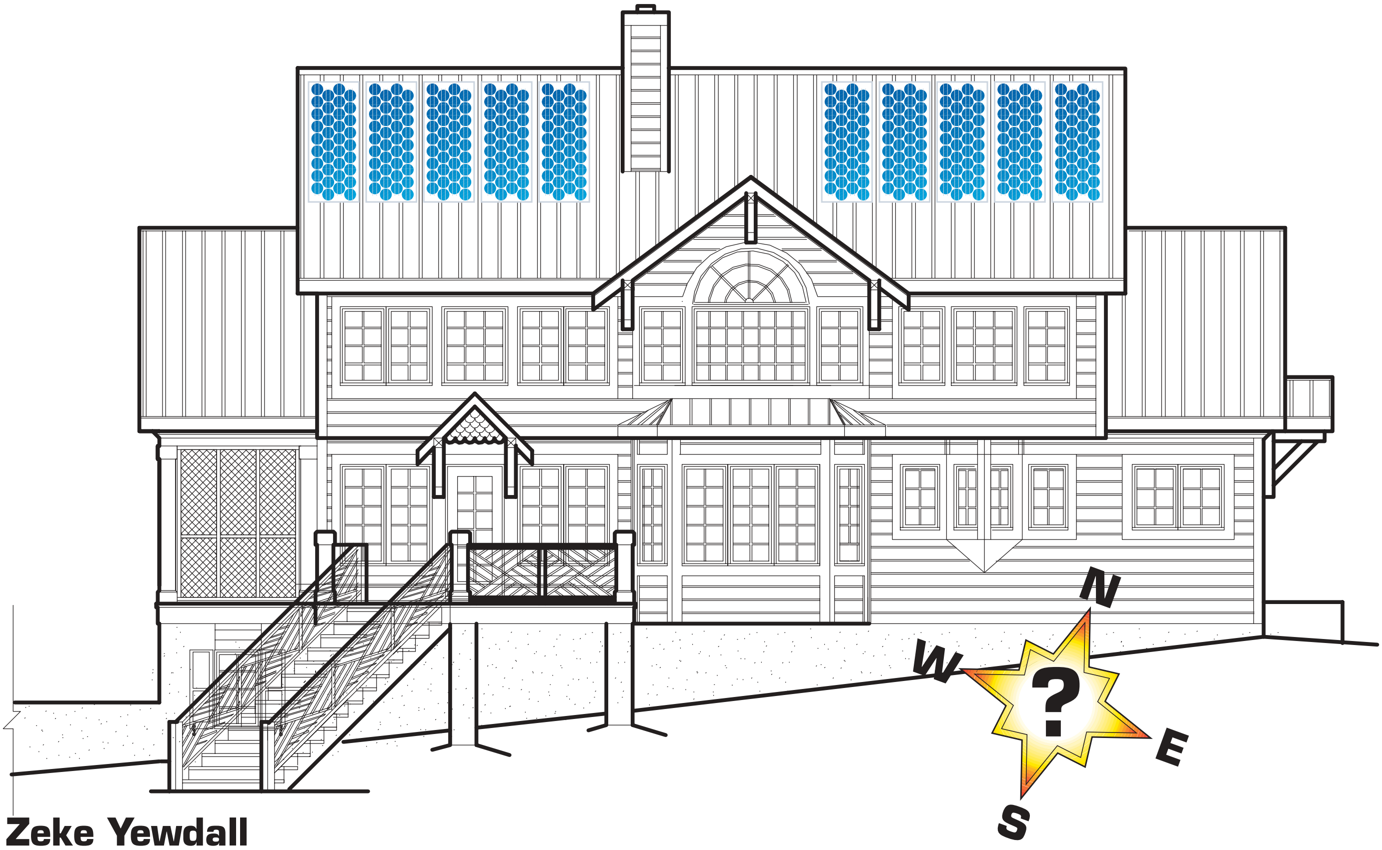
PV Orientation



Zeke Yewdall

Home design by www.sunplans.com

If you've read any how-to books on solar energy, you probably know a little about how to orient your PVs. Keep them facing true south. Make sure you've got the correct tilt, or adjustable seasonal tilt, and no shading, not even partial shading. This is all good general advice. But in some cases, true south orientation may not be quite as important as once believed.

I'm not advocating anything drastic, like pointing them north (or south, if you're in the Southern Hemisphere). Under certain conditions, the orientation can be flexible without drastically reducing the energy produced. But this depends a lot on exactly what kind of system you have. Wait a minute, you say. We always want the maximum amount of energy collection from our expensive solar-electric panels, right? Well, not always.

Depending on your specific load, climate, and other factors, computer simulations of PV systems with various orientations and configurations show that the ideal orientation for your PVs is not necessarily the standard formula. There is little documentation of actual "non-ideal" arrays in the real world, so more data is necessary to verify this. But several respected computer programs indicate that perfect orientation is not as important as once thought. If any *HP* readers have real-world data to back this up, I would be interested in working it into further research.

For the purposes of this article, orientation is defined as a combination of two independent variables.

- Tilt is the angle of the PV array from horizontal.
- Azimuth is the angle between the PV array and true south.

Typically, tilt is the only variable adjusted, and azimuth is kept at zero (pointing directly south). However, as more roof-integrated, grid-tied arrays are installed, installers and users are increasingly choosing or accepting a non-south azimuth.

Off-Grid Systems

Off-grid systems will usually produce much less usable energy per installed watt than grid-tied systems. Aside from battery losses and older, non-MPPT controllers, this is because they are usually sized for less than ideal sun conditions in the winter months. During the summer, the batteries may be completely charged by noon, so the solar-electric array is turned off by the series charge controller. The potential energy of those PVs is wasted by not being captured all afternoon.

Off-grid, we try to tilt the array at the optimal tilt, and directly south. Often, tilt angles are changed throughout the year. Take a look at the monthly and annual KWH results for different tilt angles in the two graphs. These graphs are from a computer simulation of the potential production from a 100 watt PV array in Spokane, Washington, latitude 47.8 N. The combined line graph shows monthly energy production for four tilt adjustment regimes. The bar graph shows the annual energy production for each of these four tilt adjustment regimes.

According to the simulation represented in the graphs, if you are going for a fixed array, the 40 degree tilt angle gives the best production of the two fixed regimes. Note that this is a little flatter than the standard rule—tilt equals latitude—perhaps because Spokane is very sunny in the summer, and very cloudy in the winter.

This simulation also indicates that if you are willing to adjust your array twice a year, you'll get the maximum energy with angles of about 20 degrees for summer and 60 degrees for winter. Annual energy will be 3.3 percent higher than with a fixed array. If you are willing to adjust once a month, annual energy will increase by 4.7 percent over a fixed array. This may be enough to justify the added expense of an adjustable rack.

If you have a stand-alone system, you want the energy when you need it, not just sometime during the year. Depending on the appliance usage patterns of its occupants, the electrical load of off-grid homes may be higher in the winter, the summer, or fairly constant from season to season. Since there's significantly more fuel (sunshine) during the summer months, optimizing the tilt angle of a fixed array for winter makes sense in some cases. But some off-grid systems have larger summer loads such as irrigation or air conditioning, so optimizing the array to catch winter sun is not always the best choice. Maximum annual energy production is not the holy grail of off-grid systems. What you want is maximum energy production when you need it.

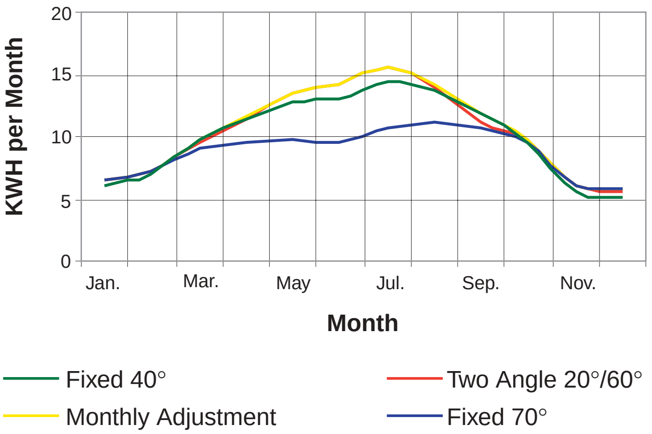
Grid-Tied Systems

Nowadays, more and more systems are grid-tied. Investing in solar electricity on the grid is cost effective for more and more places in the U.S.

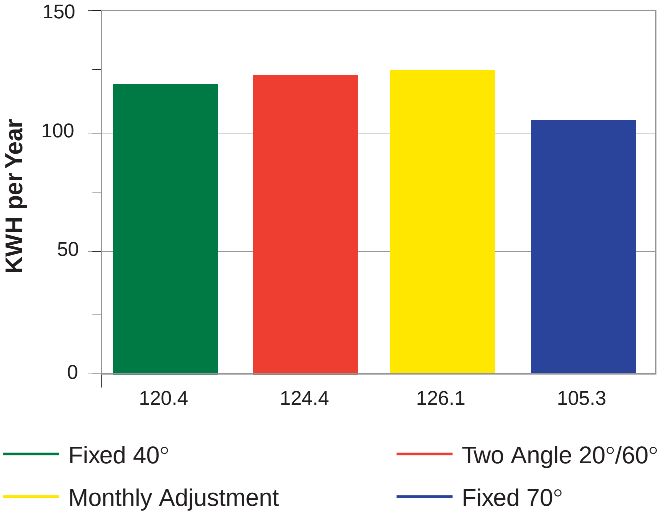
Grid-tied systems with annualized net billing have the benefit of essentially unlimited energy "storage." Any surplus put into the grid in the summer is immediately used by another utility customer, and provides energy credits to the system owner. If more energy is needed in the winter (or at nighttime), it can be purchased back from Mr. Utility. With this unlimited "battery," return on investment is maximized by putting the panels where they generate the most annual energy.

The contour plot (see next page) gives the percentage of the optimal annual energy production for different orientations for Spokane, Washington. As expected, moving far away from the optimal orientation reduces performance. What is interesting is how large the greater-than-90-percent area is. Depending on your exact location, your array could be up to 75 degrees off from solar south, or 10 or 15 degrees too steep or too shallow of a tilt, and still get 90 percent of the benefit. We've all heard of goofs when someone didn't know the difference between true and magnetic south. In most

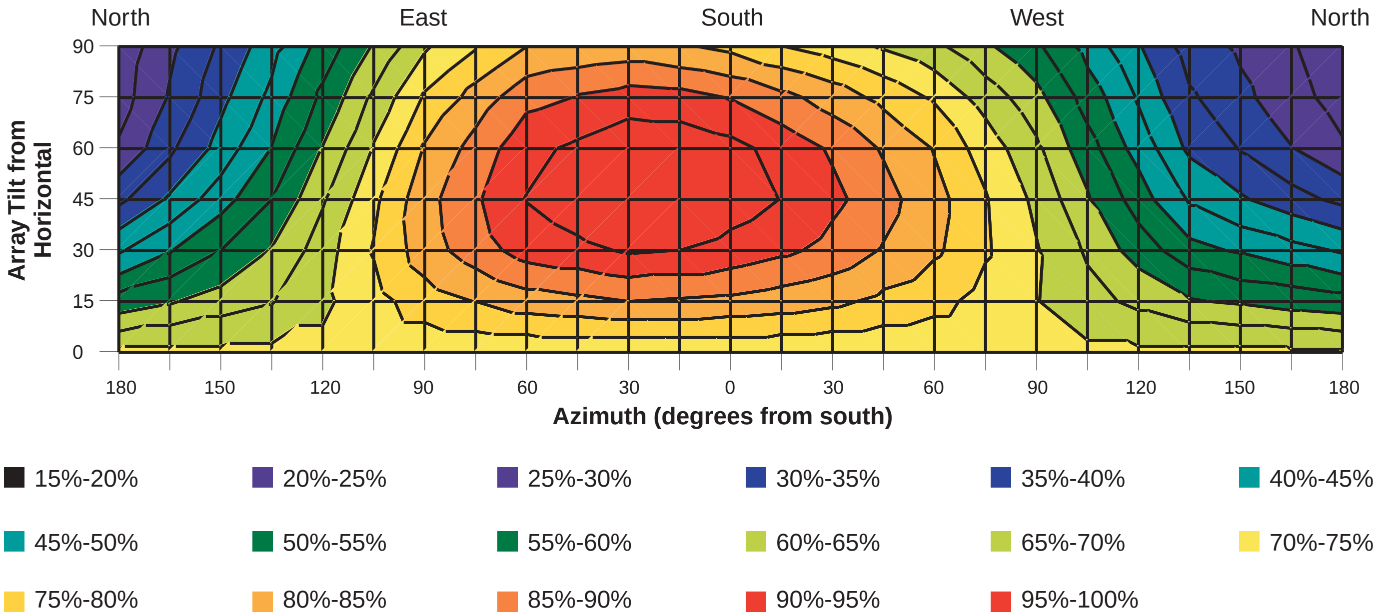
Tilt Angle vs. Monthly Array Output



Annual Array Output per Tilt Angles



Percent of Maximum Possible Solar Energy Collection vs. PV Array Orientation for Spokane, Washington



locations in the U.S., this is less than 20 degrees, so in reality, it doesn't have a significant impact on PV performance.

Interesting Orientation Details
Plots generated for various locations can show the effect of particular weather patterns. Since these are simulated with hourly weather data, the difference between using a more eastern and western azimuth can be determined. The effects of afternoon thunderstorms, such as in Spokane for example, will cause the ideal orientation to shift towards the east of true south. The effect of hotter modules in the afternoon decreasing production also contributes to this shift. Plots can also be done for each month of the year, with the ideal orientation shifting for weather conditions, such as afternoon thunderstorms and morning fog.

In general, the sunnier the climate, the more forgiving it will be of off-ideal orientation. The higher the latitude, the less sensitive it will be to off-azimuth error (since the long summer days outweigh winter days, and the long path of the summer sun cannot be effectively captured by any fixed array).

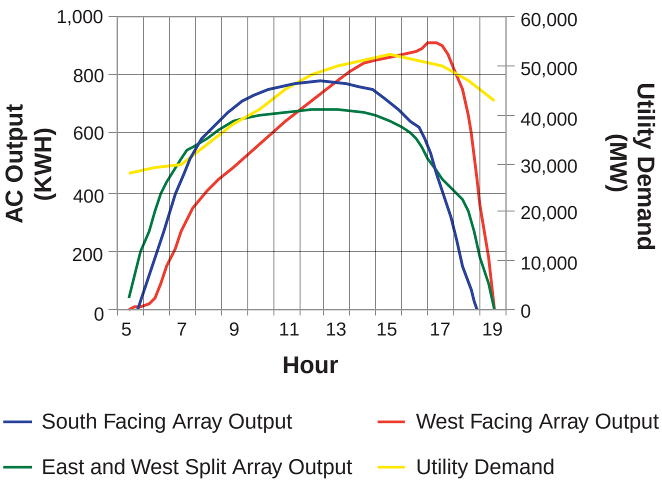
Special Considerations
Now you are thinking, "Well, I have a grid-connected array, so all I care about is how close I can get to that optimum annual energy production, without being an aesthetic liability." Not necessarily.

Maybe you are lucky enough to have time of use metering for your grid-tied system. It may pay more to aim the array significantly to the west for your peak power to coincide with the middle of the peak rates. You may even be doing the utility a greater favor by generating during peak utility demand. Not only can you offset your own load on the grid, but that of several other houses as well. By offsetting the emissions of an inefficient peaking plant, instead of a more efficient baseload plant, you may offset more carbon emissions, despite generating less total energy with your array.

A graph of the hourly production of three simulated solar-electric arrays in San Francisco, along with the statewide California peak demand of a sunny August

This installation maximizes the array's exposure to the sun, but is it worth the extra hassle and poor aesthetics?

Hourly Output of Different Facing Arrays



day is shown here. Note that the west-facing array produces 92 percent as much as the south-facing array annually, and actually produces more during the utility peak. All arrays are at 22 degrees tilt (5:12 roof pitch).

And if you have the ridge of your roof running north-south, you could just put half the array facing east and half facing west. The split array still produces 86 percent of the annual energy of an ideal south-facing array, and spreads it out during the day a little more. Note that series strings should not be broken across different orientations, since the current of all modules will be reduced to that of whichever module in the string has the least sun. Shading presents issues in this case, as well.

Suppose you have a large PV array, but unluckily for you, the utility zeros the meter every month instead of at the end of the year. If you can't carry the surplus from the summer over to the winter, it makes more sense to adopt a similar stance to a stand-alone system.

**This roof's pitch and orientation is almost perfect.
A standard roof installation made sense and looks nice.**

The SunSlate PVs are hard to spot because they're also roofing material. They were installed here with a westerly orientation—which makes sense for some utility-interactive systems.

If your PV array is off-grid, or your utility zeros out your meter each month, and your system must meet the load during every time of the year, a little more care in orientation is warranted. Tilt equals latitude is not always the best approach. Using the orientation that would theoretically give the maximum annual energy production isn't either. A careful analysis of your load is necessary to determine the best orientation, and whether tracked, fixed, or adjustable is your best choice.

Maximum Energy vs. Aesthetics

Roughly two-thirds of the new residential PV systems being installed in the U.S. are grid-tied arrays. Grid-connected PV arrays are more likely to be in towns and cities where more people will see them. And they are more likely to be on the roof than a remote mountain home's array. A beautifully done, rooftop PV array will go a long way towards convincing your neighbors that solar electricity is the energy source of the future. An unattractive array may convince them to complain to the town council.

Riding my bike around Boulder, Colorado, I found three houses with new rooftop PV arrays. One homeowner made sure that the modules wrung the maximum amount of energy from the sun. The second homeowner made the installation look nice. And the third homeowner really paid up and bought SunSlate solar shingles.

Based on simulations, the second example above will produce around 2,500 KWH per year for each rated KW. This owner was lucky enough to have an almost ideal roof orientation. The first owner didn't have the ideal roof, so stilts were used to tilt the PV rack to the ideal angle. This array will also generate 2,500 KWH per year for each rated KW. But this is only 10 percent better than if the array had been installed flat on the 22.5 degree, southwest-facing roof.

The third rooftop system will only generate 2,100 KWH per year, per rated KW since it is on a west-facing roof. But it is an example of how solar roofing is the future. No one is going to call the city council about this roof. In fact, I didn't even recognize it the first few times I saw the house. Which system does more to advance PV as a viable technology for residential electricity generation?

Research Method

The monthly tilt analysis simulations were done with PV F-Chart. This software was developed by the University of Wisconsin Solar Lab, and uses a monthly correlation method to predict performance. In sunny climates, it is within a few percent of PVFORM (described below), but it can overestimate up to 15 percent in some cloudy climates. It costs US$400, and a demonstration version is available. The user interface is good, but geared a little more towards theory than practical application. (You enter PV area and efficiency rather than the rated wattage, for example.)

The contour plots discussed were generated with simulations from the computer program PVFORM. Developed by Sandia National Lab in the 1980s, it is still one of the most respected programs for hourly PV system simulation. The simulated system was four AstroPower, 120 watt modules connected to a 1 KW grid-tie inverter. Results will vary depending on which grid-tied system is used, and depending on how sensitive the modules are to heat.

PVFORM is a public domain, DOS-based program, and takes a little while to get used to. Generating the correct 8,760 hour weather file for each location is tedious.

PVFORM was compared extensively with real world data when it was being developed by Sandia in the early 1980s, and is probably the most respected program in research circles because of this. It starts with a physics-based model of a PV cell and the sun's path through the sky, and uses "typical" hourly weather data, which is generated from 30 years of data for more than 200 sites around the U.S.

PV F-Chart is based on a correlation approach instead of a physics-based approach. Many of the correlation constants were determined using physics-based programs such as PVFORM. PV F-Chart is accurate to within 2 to 15 percent (compared to PVFORM) for monthly values, although it tends to be closer to real world results in sunny climates than cloudy climates.

Access

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Sandia National Laboratories, David Menicucci, Mail Stop 0753, Albuquerque, NM 87185 • 505-844-3077
Fax: 505-844-6541 • dfmenic@sandia.gov • PVFORM software

F-Chart Software, Box 44042, Madison, WI 53744
608-836-8531 • Fax: 608-836-8536 • info@fchart.com
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See "PV Module Angles," by Richard Perez & Sam Coleman, in *HP36,* page 14, available on *Home Power's* Solar1 and Solar2 CDs.

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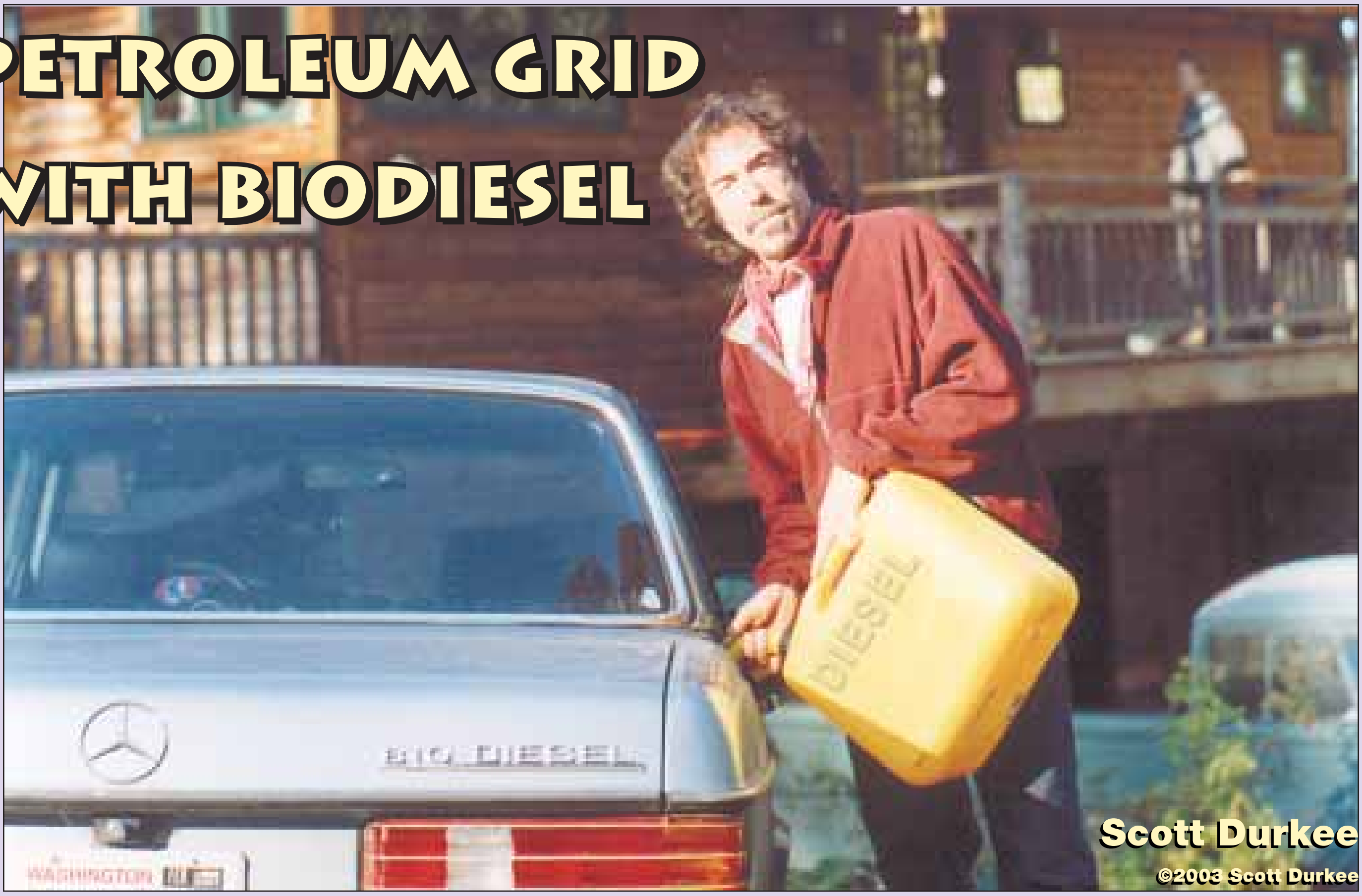
Getting Off the Petroleum Grid with Biodiesel



Scott Durkee topping off his rig with home brewed biodiesel.

Everyone in the renewable energy world talks about "getting off the grid." We all know that it means unhooking our electric umbilical cord from the central power company and making our own electricity. We do it well, harnessing the power of the wind, water, and sun. But what about fuel for our vehicles?

There's another grid that we're all hooked up to, and like energy junkies, hooked on: the petroleum grid. From exploration and drilling to refining and delivery, the petroleum grid is our lifeline.

Imagine a power outage. People on the grid are sitting in the dark, but you have some solar-electric panels, a wind turbine, batteries, and an inverter—and you know how to conserve. Now imagine the same outage, only this time it's an outage of petroleum products—gasoline and diesel.

"D" Is for Diesel

How long will the gas in your tank last? Don't worry, the shortage might not be long. But what are you going to do in the meantime? I don't know about you, but I use my car almost every day. I depend on my car. That's why I bought a 1982 Mercedes 240 D; the "D" is for diesel.

I am a carpenter by trade, and I live on Vashon Island in Washington State. I designed and built my own energy efficient house out of low-impact and recycled materials. One of my goals in life is to live simply and to leave a small footprint on our planet.

As a Peace Corps volunteer working in Nepal and training the local folks in appropriate technology, I lived among people who grow all of their own food, walk everywhere, and harvest firewood for heating and cooking. They use a tiny fraction of the energy that we Americans use. I, too, lived this way for over two years, though I have to admit it's impossible to do it in the United States. Even those of us with the most simple lifestyles don't even come close to the Nepali people.

So we all do the best we can. Since I bought the Mercedes, I've only put homemade biodiesel in the fuel tank. My car runs better and cleaner than ever, and I can fill it up at home. The biodiesel I make replaces diesel fuel in all ways, except that the exhaust from my car smells like cooking french fries! Some people are even using biodiesel in their oil furnaces.

"B" Is for Biodiesel

Biodiesel is fuel made from vegetable oil. The oil can either be purchased new from a supplier in 55 gallon (208 l) drums, or be obtained used from the fryer of a restaurant (nearly every restaurant has a fryer). My friend Dan Little and I made an arrangement with the local supermarket to collect the used oil from the deli, which we then process into fuel to run our diesel vehicles. The deli produces 26 gallons (98 l) of waste oil per week. We're fortunate that it's canola oil (good for fuel) and that it's changed twice a week. They also strain out the bits of french fries for me, so the oil is clean and relatively pure.

As the test batch settles, two layers appear: biodiesel fuel on top and glycerin on the bottom.

I first discovered biodiesel in the great Northwest, here on Vashon Island. Every year on Vashon, there's a festival called the Island Earthfair, and as the coordinator of the renewable energy exhibits, I had contacted Mike Pelly, a "self-proclaimed, shade-tree chemical engineer." He drove up from Olympia in his biodiesel powered Nissan pickup, towing a trailer with his latest biodiesel-making contraption to demonstrate how to turn used fryer oil into pure biodiesel fuel.

As colorful flags fluttered and a Seattle band played on a solar powered stage, Mike talked to people about his system and his formula. At first it sounded too complicated, but as I listened to him describe the process, I realized that I could do it too.

The best book on the subject that I've seen is *From the Fryer to the Fuel Tank* by Joshua Tickell. This book lays out the whole process, from oil procurement to handling substances to processing glycerin to driving away on your homemade fuel. The recipe I use comes from this book.

Equipment

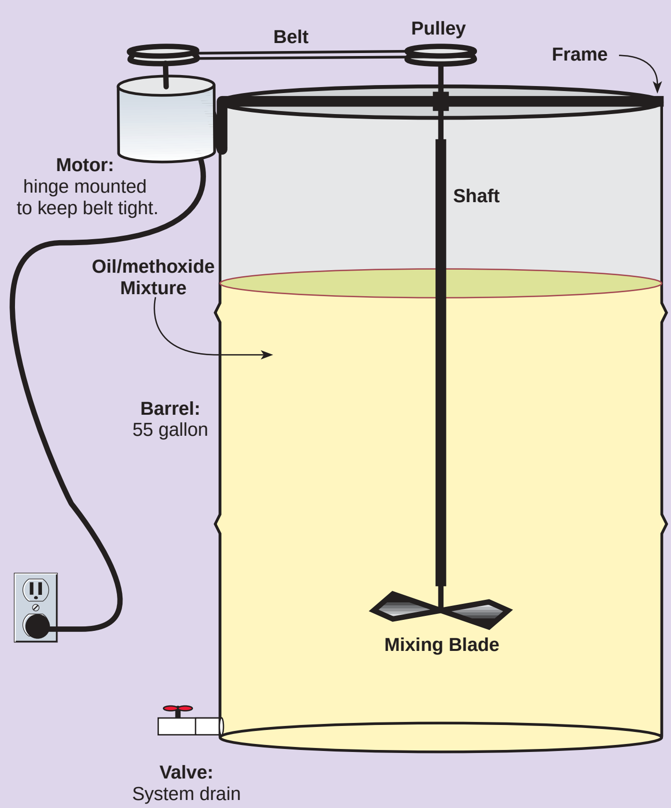
The basic tools and apparatus you will need for making biodiesel are:

- A container for mixing the oil and chemicals
- Some 5 gallon (19 l) plastic buckets
- A device to churn the oil/methoxide mixture

Fifty-five gallon drums (metal or plastic) are pretty easy to come by and work well for mixing the biodiesel. If possible, install a faucet or valve at the bottom of the barrel to drain out the final products. For churning the mixture, I use an old washing machine motor with a belt that turns a shaft. The shaft has a little blade on the bottom that agitates the whole barrel very well—like a big, upside-down blender.

But lately, I've found that it's easier to churn up the oil mixture by using a pump that's suitable for thick oil. Mike Pelly does it this way by pumping the mixture out of the barrel and then right back in. A water pump is mounted above the barrel, with 1 inch intake and outflow hoses in the barrel; switching on the pump begins the agitation. This method thoroughly blends the ingredients with excellent results. Mike bought his pump for US$35 through a catalog called Northern Tool, which also sells suction hoses for US$20 each (one

Biodiesel Mixing Barrel



hose cut in half is sufficient for agitating the oil in the barrel). The pumps are also available through Harbor Freight Tools.

The equipment and supplies necessary to make a 1 liter test batch.

My latest purchase is an American-made, 1/6 hp Water Dragon submersible utility pump that I got for US$80 from the Vashon True Value hardware store. I lower it into the barrel with the oil mixture and plug it in. It works very well to agitate the mixture—and it'll pump out a flooded basement, too! I used this pump, without any hoses attached, to make a 47.8 gallon batch, and the pressure was perfect. For a smaller batch, the pump might need to have a garden hose attached to the top to redirect the spray back into the drum; a smaller pump is also available. I found this solution to be very clean, simple, safe, and easy, though I don't know how well this pump will hold up over time.

Because the making of biodiesel is not yet common, there is no specific design for an agitator, no ready-made equipment for making biodiesel at home. Mike Pelley has been working on processors for over five years and has come up with a nicely refined unit that he hopes to make available for sale soon. So if you don't feel like making your own apparatus, maybe he can provide you with a self-contained unit that will make biodiesel either in batches or continuously. But at present, it's pretty much a do-it-yourself deal, so you'll need to be creative and willing to experiment a bit.

The cost of your equipment depends both on your design and on whether you buy the parts new or used. Check out the cost table for an idea about prices. Again, because there is no set design, you may be able to make your own equipment, using your own design, for less than either Mike or I have done.

The Ingredients

The process of making biodiesel is easy, but it takes some care. The proportions are as follows:

- 5 Parts used or new oil, strained through a window screen
- 1 Part methanol
- Crystal lye, amount determined per batch by testing

In the making of biodiesel, the proportions are very important. Before I begin the mixing process, I determine how much lye to use. This process, called titration, is not difficult, but I'm always very careful to be accurate in my measurements.

To do the titration, I use the following:

- A scale that's accurate from 0.1 to 500 grams
- Graduated pipettes, such as eyedroppers, marked in milliliters from 1 to 25
- Isopropyl alcohol, 99 percent pure
- A 0.1 percent lye/water solution (thoroughly dissolve exactly one gram of lye in one liter of distilled water)
- A small ceramic, stainless steel, or glass bowl for mixing the ingredients
- A small sample of the oil you're using
- Litmus paper to measure the pH (acidity)

To do the titration process, I measure out 10 ml of the isopropyl alcohol into the small bowl, and then add 1 ml of the oil sample and 2 ml of the lye solution. I mix it well with a small stirring stick, and then test the pH with the litmus paper. It will be somewhere around 7 or 7.5. By adding small amounts of the 0.1 percent lye solution—0.5 to 1.0 ml at a time, testing the pH each time—I bring the pH up to between 8 and 8.5.

Once I reach a pH near 8.5, I stop adding lye water. Now, including the very first 2 ml, I note the total amount of lye solution that I used, in milliliters, to reach a pH of 8.5, then I add 3.5 to that number. This is the number of grams of crystal lye per liter of oil that it takes to cause the chemical reaction. This amount could change with every new sample of oil, so I titrate every time I make a batch.

The Test Batch

Before I commit myself and my precious vegetable oil to a full-on batch, I next do a test batch. I do a test batch every time to make sure that the oil separates properly.

Here's how I do it: Using an old blender—one that won't be used to prepare food ever again—I mix 1 liter of used vegetable oil, 0.2 liters of methanol and X amount of lye. (Every batch is different, but it's usually between 5.5 and 6.5 grams of lye per liter of used vegetable oil, and 3.5 grams for new vegetable oil.) First, I mix the lye and the methanol together in the blender, put on the lid, and run it on low for about 5 minutes until the lye is completely dissolved. Then I pour the liter of oil into the methanol solution in the blender.

I run the blender on medium for about 15 minutes. When the time's up, I turn off the blender, pour the mixture into a clear jar, and let it sit for a couple of hours. After an hour or so (this is the fun part), the oil begins to separate into two layers: a heavy, dark layer at the bottom and a honey-colored layer on top.

Measuring lye for the test batch. The red spray bottle contains an acidic vinegar solution to neutralize any spilled lye.

Safety first—mixing the methanol and lye.

The dark substance at the bottom is mostly glycerin with a little wax and some other impurities. Have you heard of glycerin? Do you know what it's used for? One product is soap. You can use this brown glycerin to clean up the mess you've made while making biodiesel in your garage! Glycerin breaks up grease and oil like nothing else on Earth. It's a miraculous symbiotic relationship. (Remember to wear your gloves, when handling the glycerin, until all of the methanol has evaporated off.)

If there is a light-colored middle layer, it is made up of soaps. This layer is not typical and is caused by either

! CAUTION !

You must use safety precautions when mixing the lye and methanol. This is a very dangerous process! It's important to respect both the volatility and the caustic nature of the elements you're working with. You *must* wear a respirator and work in a very well-ventilated room. Wear chemical retardant gloves, long sleeves and long pants, good shoes, and safety goggles. Some folks like to use a chemical resistant apron and long-sleeved gloves for an extra measure of protection. If any of the methanol or lye gets on your skin, wash it off immediately. It's wise to have a spray bottle of vinegar handy to neutralize the alkaline lye mixture. Mixing methanol with lye creates sodium methoxide, which can cause nerve damage. *Don't breathe it!*

Scott Durkee going for a big batch—adding the sodium methoxide to the used vegetable oil that will soon be biodiesel fuel for his Mercedes 240 D.

using too much lye (catalyst) or by water somehow contaminating the mixture.

The top layer is biodiesel fuel. It's a pale, honey-colored liquid and, after settling for five or six days, it is ready to pump right into your fuel tank.

Now the Real Thing

If the mixture from the blender separated properly, it's time for the real thing. Using the same proportions as I did with the test mixture in the blender, I can mix a full batch. Any size batch is okay, as long as the proportions are the same. For example, using 100 liters of oil mixed with 20 liters of methanol and 550 to 650 grams of lye, the same separation will happen. But because it's in a barrel, I won't be able to see the layers.

When making the full batch, I'm always sure to mix the lye into the methanol very well. I pour the methanol into a 5 gallon bucket, then the lye, and then I churn the clear mixture with a paint stirrer in my drill motor. (See Caution sidebar.) I've drilled a hole in the lid of my 5 gallon bucket, and I put the paint stirrer through the hole before I put it in the drill. Then with the bucket covered, nothing sloshes or splashes out of the bucket while I'm mixing.

Once the lye is completely dissolved, I carefully pour the clear methanol/lye mixture into the drum of oil—still wearing my respirator and protective clothing—and then turn on the agitator or pump to begin the agitation. After it's been churning for 90 minutes, I turn off and remove the agitator or pump, then let it sit quietly to allow the mixture to separate out into biodiesel fuel and glycerin.

Partial separation will occur after about 5 hours; 99 percent separation could take as long as 24 hours. At some point—depending on the oil, the amount of lye used, and the temperature—the glycerin will begin to harden, to gel. Just before this happens, it's possible to drain off the liquid glycerin into a bucket. That's why it's good to have a valve on the bottom of the barrel. I can open the valve and drain out the dark brown, liquid glycerin.

Mike likes to use a water heating element in the barrel to keep the temperature at around 130°F (54°C), both to speed up the chemical process and to ensure that the glycerin will still be in liquid form after 24 hours. This electric element is available at any hardware store for under US$15 and can be plugged into a 120 VAC outlet. I think it's a good idea, and during the winter, I will heat my barrels, too.

But currently I just let the mixture settle overnight in the production barrel, then pump it into a settling barrel to sit for a week or so. From the settling barrel, I pump it into my car. Since most of the glycerin settles in the first 24 hours, at the bottom of the production barrel there is a thick disk of gelled glycerin that I slice into quarters and, wearing rubber gloves (because it still contains some methanol), scoop out. After a week, at the bottom of the settling barrel there will be some traces of glycerin, so it's important not to take the fuel from the very bottom of the barrel.

Remember, the top of the barrel has been cut open to allow access for the shaft or pump, so it's easy to reach to the bottom to get at the glycerin. Hey, at least the cleanup is easy: It's all soap! You will, no doubt, have your own experience with the glycerin and biodiesel, and you will learn how to deal with the separation.

Durkee Biodiesel Start-Up Costs

Equipment	Cost (US$)	Yellow Pages Heading
Shaft, frame materials, & welding	$145	Welding/Welders
Scale, 0.1 to 500 grams	125	Laboratory Equipment
Motor, 1/2 hp	100	Electric Motors
Bilge pump	55	Marine Equipment
2 Drums, 55 gal.	50	Barrels/Drums
2 Pulleys	40	Bearings
Respirator	25	Hardware
Electric water heater element	20	Hardware
Filter canister	15	Gasoline & Oil Marketers
4 Plastic buckets, 5 gal.	14	Hardware
Drill, used	10	Thrift Shops
Paint stirrer	7	Hardware
Fan belt	7	Auto Parts
Gloves, chemical resistent	7	Hardware
Valve	5	Hardware
Blender, used	5	Thrift Shops
Filters	5	Gasoline & Oil Marketers
Litmus paper	4	Pharmacies
Safety glasses	3	Hardware
Bowl	2	Grocers
Spray bottle	2	Hardware
Vinegar	2	Grocers
Graduated pipettes	1	Laboratory Equipment
Total for Equipment	$649	
Ingredients		
Methanol, 55 gallons	$102	Gasoline & Oil Marketers
Lye, 510 grams	4	Grocers
Isopropyl alcohol, 99% pure	1	Pharmacies
Used vegetable oil	0	Grocers or Restaurants
Total for Ingredients	$107	
Grand Total	$756	

Clean, simple, and safe—a pump can be used to agitate the oil mixture too.

Cleanly into the Fuel Tank

If I am able to drain the bottom layer from the barrel, I'll see the color change from dark brown to honey-colored; that's when I close the valve. I set the glycerin aside and get out my fuel can because the next thing to come out of the barrel is biodiesel fuel. (If there is a soapy layer, the fuel may need to be washed with water, a process explained on the journeytoforever.org Web site.)

For each batch of fuel I make, I consistently get about 85 percent biodiesel and 15 percent glycerin; I get almost no soaps because the oil I use is so clean and I titrate very carefully. A good rule to estimate your yield is that the amount of fuel produced will be equal to the amount of vegetable oil used in the process.

When I use a pump to mix the oil and methanol, I drain it afterwards, and then flush it out with plain vegetable oil; otherwise the glycerin will set up inside the pump. But, if the glycerin sets up in my new submersible pump, it's no big deal because I can just place the pump in a warm water bath, melt the glycerin, and then wash it out. The pump will be a lot cleaner too!

I don't worry if there is any glycerin in the fuel at this stage because it will always separate out and sink to the bottom; then I can recover the pure biodiesel from the top. I put only the pure biodiesel in my fuel tank! Using a little 12 volt marine bilge pump, I transfer the fresh biodiesel into another 55 gallon drum to let it sit for a week, so that any excess glycerin and other impurities can settle to the bottom of the barrel. These can easily be washed out once the fuel is pumped or syphoned into another barrel.

When I need a fill up, I pump it through a filter and a meter right into my Mercedes. Pumps, filters, and hoses are available at pump equipment supply stores. The cost of a hand-cranked pump is about US$100. A filter and refills are US$25 and US$5, respectively. Pumps are not absolutely required, but they make the job easier.

So, does it save me any money? I buy methanol for US$1.85 a gallon (3.8 l) and I use 7.8 gallons in a 47.8 gallon batch—that's 40 gallons (150 l) of

Function and education on the go—Mike Pelly and his biodiesel trailer.

Automotive Tips

After running your first tank of biodiesel, you will have to change your fuel filter. Biodiesel cleans out all the petroleum sludge in your fuel system, which can then clog up the filters. While you're at the parts store, you might as well buy two filters; you'd be surprised how dirty petroleum diesel is! I recommend buying a little clear glass filter with a removable element that can be cleaned using biodiesel. Install this filter in front of the engine's stock filters. Once the filters are cleaned, you probably won't have to clean them again for quite a long time—as long as you don't use petroleum diesel again.

Older diesel engines—from the late 70s and earlier—are equipped with rubber hoses and seals. Over time, the methanol in the biodiesel will dissolve these parts. But in newer engines the hoses are synthetic and are not affected by methanol. The rubber parts in older engines can be easily replaced with synthetic parts.

Like petroleum diesel, biodiesel will gel in colder weather, but at a slightly warmer temperature. Fuel additives to prevent gelling—winterizing agents—are available at auto parts stores, and can be used with biodiesel just as they are with petroleum. I've had a jar of biodiesel in my fridge for several days at 37°F (3°C), and it has remained beautifully liquid—without the addition of any antigelling agents. Depending on the type and quality of the used vegetable oil, the amount of lye used, and the resulting fuel quality, biodiesel could begin to gel at 45°F (7°C). More impurities will cause the fuel to gel at a higher temperature.

There's a simple test I do for impurities in the fuel. I pour 1/2 cup of water and 1/2 cup of my biodiesel into a small glass jar with a lid. After shaking the jar thoroughly, I set it aside in a quiet place. After an hour or so, the mixture will begin to separate out into three layers: biodiesel on the top, a thin layer of impurities in the middle, and water on the bottom. Since the oil I use is so clean, the middle layer in my jar is always paper thin.

If biodiesel is not made using the proper proportions, the resulting fuel could be damaging to the engine. For example, if too much lye is used, a thin skin of gel will form over the fuel in the barrel; and after it's skimmed off, it will form again and again. This fuel should not be used. If too little lye is used, the reaction won't take place fully and the separation will be incomplete.

Burning biodiesel will reduce the overall emissions from your car or truck substantially. The only element in your exhaust that may increase is nitrous oxide, which is one of the irritants in diesel exhaust. But, by retarding the timing in your engine, you can eliminate this increase, too. In Europe they use a catalytic converter, which reduces the nitrous oxide to below normal levels. There is sometimes a 5 percent loss of engine power, but that's made up by a more lubricated, smoother running engine.

Scott's used veggie oil collection rig with barrel and pump.

used canola oil and 7.8 gallons (30 l) of methanol—for a total of US$14.43. Lye costs about US$4.00 for a 510 gram bottle and I use 6.25 grams per liter of oil, which equals 937 grams per batch. That's US$7.35 in lye. The oil is free. Total cost of the ingredients? US$21.78 for about 40 gallons of biodiesel, which works out to 54 cents a gallon (14 cents per liter). Not bad!

Don't be surprised if, while you're pulling into a parking lot in town, someone comes up to you to ask about the smell coming from your car. My friends find it hard to believe that I actually run my car on recycled vegetable oil. I don't make biodiesel to save money—although if I don't figure in labor or overhead, it certainly does. I do it so that I can run my car on a sustainable fuel, one that can be created in one season (on a farm) as opposed to over millions of years (fossil fuels)—and I do it to reduce air pollution.

Since I started making biodiesel, I've found that my driving habits have changed a little, too. Though I still try to combine my errands so that I only have to make one trip into town, I don't mind driving my children across the island to play with friends or volunteering to be the one to do the carpool. I figure it's better if I drive because, unlike the other cars on the road, I'm off the petroleum grid. My car runs on renewable energy.

Access

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renewablenergies@yahoo.com

From the Fryer to the Fuel Tank: The Complete Guide to Using Vegetable Oil as an Alternative Fuel, by Joshua Tickell, ISBN 0-9707227-0-2, 176 pages, US$29.95 from BookMasters, PO Box 388, Ashland, OH 44805
800-266-5564 or 419-281-1802 • tickell@veggievan.org
www.veggievan.org

Island Earthfair, PO Box 404, Vashon, WA 98070
206-463-1725 • www.islandearthfair.org

Northern Tool & Equipment Co., Inc., PO Box 1499, Burnsville, MN 55337 • 800-556-7885 or
952-8994-9510 • Fax: 952-882-6927
www.northerntool.com • Pump and hoses

Harbor Freight Tools, Inc. • 800-444-3353 or
805-388-3000 • Fax: 800-905-5215 or 805-445-4912
cs@harborfreight.com • www.harborfreight.com

Good biodiesel Web site:
www.journeytoforever.org/biofuel.html

Solar Energy International

Strawbale Construction

Workshops:

- Introduction to Renewable Energy
- Photovoltaics Design & Installation
- Photovoltaics 2
- PV Design On-Line Distance Course
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- Biodiesel Fuel
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Upcoming Workshops:

In Colorado

Solar Water Pumping	April 26-27

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Tucson, AZ	February 3-8
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Summertown, TN	April 14-19
Woodstock, NY	April 21-26
St. John, USVI	April 28-May 9
Grass Valley, CA	March 10-15
Austin, TX	March 24-29

Women's Workshops

PV Design & Installation, Santa Cruz, CA	March 3-8

Other Workshops Outside Colorado

Utility Interactive PV Systems, Sacramento, CA	March 8-9
Utility Interactive PV Systems, San Diego, CA	March 29-30
Biodiesel Fuel, Cleveland, OH	May 5-9

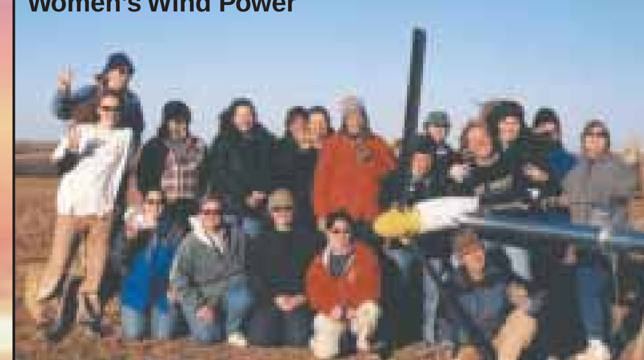
San Juan Island Series on Guemes Island, WA

Intro to Renewable Energy Systems	April 5
PV Design & Installation	April 7-12
Micro-Hydro Power	April 21-24
Homebuilt Wind Generators	April 14-19

Distance Courses on the Internet

PV Design	January 13- February 21
Solar Home Design	January 27- March 7

Women's Wind Power



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What the Heck?

Non-Islanding Inverter

A non-islanding inverter will not sell electricity to the utility if the grid suffers a significant disturbance or outage.

Used In: Grid-connected PV systems
AKA: Anti-islanding inverter
What It Is: An inverter that can shut off PV generated power to the utility
What It Ain't: An inverter that doesn't work in the Caribbean Islands

An inverter converts direct current (DC) electricity to alternating current (AC) electricity. A non-islanding inverter is a sine wave inverter that is designed to safely sell electricity to the utility grid.

If a utility has to shut down a distribution line for repair or maintenance, or the line is damaged, the inverter needs to stop selling electricity to the utility. A non-islanding inverter senses that the line it is connected to has been de-energized, is under or over voltage, or has a significant disturbance for whatever reason. When this happens, it automatically shuts off the power to the utility grid or diverts it elsewhere, thereby not becoming an electrical generating "island."

Most, if not all, utilities in the United States require non-islanding inverters for installations that sell electricity to the utility. *The National Electrical Code (NEC)* requires non-islanding inverters in what it terms "interactive systems" (connected to the utility grid).

Chuck Marken, AAA Solar Supply Inc. • info@aaasolar.com



UV Water Purification

A Simple Solution

Robert Rau

**The MSF clinic in Myanmar uses a UV purifier and sand filter.
The lack of clean, safe drinking water is a major problem in Southeast Asia.**

In Honolulu, all municipal water company trucks carry signs that say, "Pure Water—Man's Greatest Need." I've often been tempted to ask the authors of this slogan to hold their breath for 15 minutes and then see whether their views about humanity's greatest need have changed. Nitpicking aside, the need for pure water is critical in many locations at home and abroad, and some new, more economical solutions to the problem are available.

I first became aware of the need for a more cost effective water treatment process during my involvement with Bio-Sol Technologies, Inc., a Hawaiian research and development company working to produce new technologies in aquaculture for developing countries. Following an assignment with the Ministry of Public Health in northern Thailand and after earning a Master in Public Health degree, I began researching the types of commercial water purifiers available, and realized that efficient units could be built at much lower cost.

Using off-the-shelf materials and a lot of trial and error, I arrived at the design shown here. With funding from the Winfried Farmer Aid Fund, I worked with NGOs in Southeast Asia where we tested these devices in the field over a period of three years. Readers are welcome to use these plans for noncommercial homebrews, but commercial rights are reserved.

UV Water Disinfection

An efficient way to disinfect water is to expose it to ultraviolet (UV) radiation from a special germicidal lamp. This type of UV will quickly kill typhoid, paratyphoid, dysentery, cholera, and other harmful bacteria and viruses in the water. UV adds no taste or harmful effect to the water, no matter how long the exposure, and it can treat large volumes in a short time. This method of water purification should be considered for any situation where biological contamination is suspected.

The two other main ways to disinfect water—chemicals and boiling—are effective. But chemicals are chemicals, and boiling is slow, requires fuel, and is difficult to use for disinfecting larger quantities. Although filtration is possible, extremely fine porosity is required, treatment volumes are small, and the filters can clog very quickly.

UV has been used for many years to disinfect drinking water, but the problem is system cost. The design used in commercial water purifiers places the UV lamp inside a quartz glass sleeve. The sleeve, with lamp inside, is mounted inside a tube through which the water flows. Both the quartz sleeve and the outer tube have to be watertight. These units must be custom manufactured because of the need for specially fabricated components. Consequently, they are very expensive.

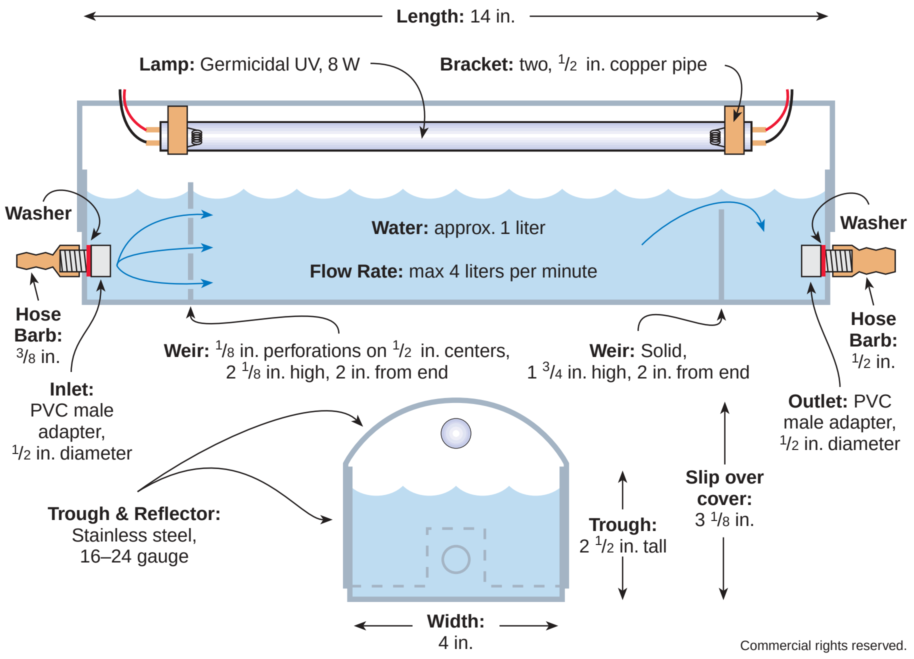
A Simple Design

Fortunately, it is possible to construct a very effective UV purifier with hand tools and simple materials for a fraction of the cost of the commercial models. By suspending the UV lamp over the water instead of submerging it, the quartz glass sleeve and its specialized fittings can be eliminated. This substantially reduces costs and construction complications.

The only drawback is that the output from this design is via gravity flow, rather than pressure. Water entering the purifier can be from either a pressure or a gravity feed system, however. Treatment rates are identical for both designs.

An 8 watt UV purifier with a 12 V, 100 AH battery (in box) and a slow sand filter (top barrel), in an MSF clinic.

Ultraviolet Lamp Water Purifier



Germicidal UV lamps are available from most major lamp manufacturers, such as GE, Sylvania, and Phillips in various sizes from 4 to 40 watts. Make sure to specify "germicidal" UV lamps when buying, since there are other types of UV lamps on the market that will not work for disinfecting water. For home use, the 8 watt size is probably the best choice—it's small, but will treat 4 liters (1.06 gal.) per minute. That's 60+ gallons per hour!

The design specs for this gravity flow purifier with an 8 watt UV lamp are shown in the diagram of the trough-style, UV water treatment unit. While a complete discussion of the design parameters is beyond the scope of this article, the dimensions shown will achieve the proper dosage of UV radiation.

Like these clinic patients in Myanmar, the whole community benefits from safe drinking water.

The trough and slip-over reflective cover are made with stainless steel sheet metal; corners are soldered using lead-free solders. The capacity of the chamber below the area where the UV radiation is emitted is one liter. The trough is 14 inches (35.5 cm) long by 4 inches (10 cm) wide, with an inlet opening of $^{3}/_{8}$ inch. The upstream weir height is $2^{1}/_{8}$ inches (5.5 cm), and the downstream weir has a height of $1^{3}/_{4}$ inches (4.5 cm). The outlet opening is $^{1}/_{2}$ inch.

Notice in the diagram that the upstream weir is perforated, while the downstream weir is shorter and solid—these specifics are necessary to prevent the water from running too quickly across the tops of the weirs. The recommended spacing in the trough before the upstream weir and below the downstream weir is 2 inches (5 cm), but this is not a critical measurement.

The combination of these flow controls (with perhaps some adjustment to incoming water pressure) should limit the flow rate through the trough to the maximum rate of 4 liters per minute for effective treatment. This rate allows each liter of water to receive 15 seconds of UV radiation while traveling under the filaments of the 8 watt lamp.

At that rate, with the UV lamp suspended just above the flowing water, the water will be exposed to at least 30,000 microwatts of UV radiation. This dosage includes a safety factor, and it is more than what is necessary to inactivate harmful bacteria and most viruses. It meets the recommendations of regulatory agencies worldwide.

Limiting Factors

Unfortunately in life, few lunches are totally free, and UV water purification is no exception. Use of germicidal UV lamps for water treatment comes with two prerequisites and two limitations.

The first prerequisite involves reducing any iron in the water to less than 1 part per million. Greater amounts will absorb the UV rays and impair their germicidal effectiveness. Kits to test for iron in water can be purchased from laboratory supply firms, but most people are usually aware if there is iron in their water. If iron is present, it can be removed very effectively by a slow sand filter, sized to match the desired flow rate. The basic design of this type of filter is explained in the companion article in this issue.

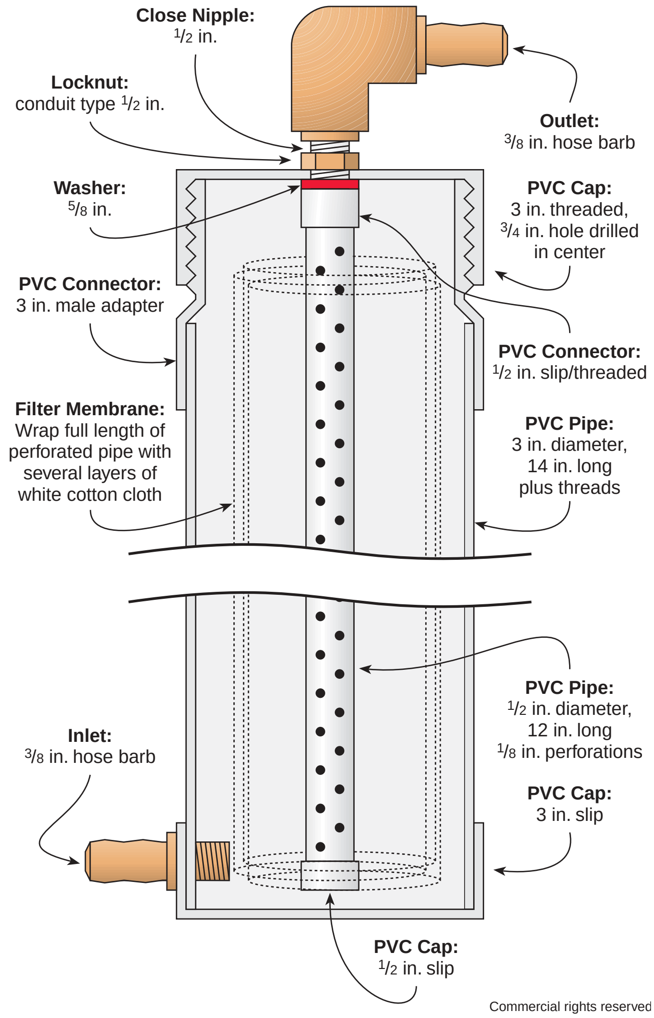
Slow sand filters are somewhat maintenance intensive, due to the need to wash the upper sand layer periodically when the flow rate begins to diminish. Sand filters have an added advantage since they will remove potentially harmful cysts and eggs in the water that would otherwise survive exposure to UV radiation. They also help kill bacteria.

The second prerequisite is pretreatment via filtration to remove particles in the water that can absorb or cause shading of the UV rays. A slow sand filter will efficiently remove particles, as will standard commercial cartridge filters. In a pinch, two or three layers of T-shirt material over a bucket works tolerably well.

Alternatively, a very satisfactory particle filter using PVC pipe and cloth as the filter element can easily be built, which avoids the expense of replacement filter cartridges. Design details for this cloth filter are shown in the diagram. Nine layers of white cotton flannel, rolled over a perforated PVC pipe inside the filter chamber, will remove particles with an efficiency better than that of 5 micron commercial filter cartridges. If cotton cloth is used, it should be washed with soap and rinsed thoroughly each week; it can be reused many times.

The major limitations to using UV are the lack of residual germicidal effect and reductions in UV intensity in cold weather. "Lack of germicidal effect" means that the water can again become contaminated after exiting the UV purifier. All catch containers must, therefore, be free of contaminants.

Cotton Cloth Particulate Filter



Substantial decreases in UV intensity occur if the lamp is operated in temperatures below 70°F (21°C). (Maximum output actually occurs at 90°F; 32°C). If a UV water purifier is used in a location where the temperature is 50°F (10°C) for instance, UV intensity is reduced by a whopping two-thirds! The purifiers should not, therefore, be used outside in a cold winter environment. Finally, in all UV applications, you should avoid exposure to the UV rays; otherwise eye damage and severe sunburn can occur.

Electrical Requirements

A UV purifier, of course, requires electricity, either 120 or 240 volts AC, or 6 or 12 volts DC. Most standard fluorescent ballasts, rated for the lamp size and voltage used, will satisfactorily power the UV lamp. The lamp ballast is what converts the supply voltage to whatever voltage the bulb requires to activate the gases inside.

With a DC ballast matched to the particular UV lamp wattage, any UV purifier can be operated with DC from a solar-electric system. The electrical consumption is low. In a 12 VDC nominal system, the 8 watt lamp will draw about 0.75 amps. This should not unduly burden most PV systems.

You can easily operate an 8 watt purifier for an hour or two at midday with just a 10 watt photovoltaic module, running through a 4 amp-hour motorbike battery. A controller can be used for hassle-free operation, or the panel can be manually disconnected from the battery an hour or so after the UV lamp is turned off. This prevents overcharging and discharge at night.

Although the 10 watt panel's output (0.69 amps) is slightly less than the consumption of the ballast (0.75 amp), the panel can make up this difference very quickly when the lamp is not operating. The battery is necessary to stabilize fluctuations in current from the panel and ensure that UV intensity stays at the maximum.

For rural applications where there is no grid electricity or PVs, but a car or truck is available, the UV purifier can

A slow sand filter, cloth filter (blue tube), and 8 watt UV purifier at a secondary school in Vientiane, Laos.

be powered by the vehicle's starting battery. A car battery in good shape can run the purifier an hour or two each day without problem, as long as the vehicle's alternator is working properly and the car is driven daily. Another alternative is to use an automobile alternator, driven by at least a 3 horsepower gasoline engine or by other means, like the suspended rear wheel of a motorbike.

Costs

Material costs for a gravity purifier are minimal. The main expenses are the stainless sheet metal, the UV lamp, and the ballast. The cloth filters require only the cloth and a few PVC fittings. The cost for this homebrew UV water purifier and the filter is just over US$50, considerably less than commercially available systems.

The only item needing periodic replacement is the UV lamp, because UV radiation gradually declines with lamp usage. How often to replace depends on the particular lamp manufacturer's specifications. The usual recommendation is to replace the lamp every 12 months. It is important to be aware that the visible blue light from the lamp is not an indication that adequate UV intensity is being emitted.

Quality, 8 watt lamps are available in most major cities throughout the world for US$5 to $10. Larger lamps must usually be ordered; they cost about US$40 for the 40 watt size. Ballasts for 8 watt bulbs run about US$4 (AC) to $18 (DC).

Field Trials

The Winfried Farmer Aid Fund has tested the slow sand filters, cloth filters, and gravity UV purifiers in schools, hospitals, and clinics in Myanmar (formerly Burma) and various locations in Laos since 1998. The fund is named to honor Winfried Farmer, a retired commodities broker from Kansas who traveled extensively in Southeast Asia and was very sympathetic to the plight of the poor there. Win passed away in 1999, but his support made my work with the UV water purifiers in Myanmar and Laos possible.

This work was done in association with Medecins San Frontieres (MSF) in Myanmar and the Women's Union in Vientiane Municipality, Laos. These countries were selected because of their level of poverty and the considerable problems they have with contaminated drinking water.

In Myanmar, for example, semiannual treatment of some of the wells with chlorine is the only treatment method used, even though it provides only limited residual benefit (2–3 days). In Laos, most of the water is not treated. In both countries, commercial, 8 watt, UV purifiers are available at a cost of about US$400.

MSF is doing a fantastic job in Myanmar, but unfortunately, there are very few relief organizations in the country, and the need is great. Another agency, UNICEF, has recently initiated plans to build and install 240 of the 8 watt purifiers each year in schools throughout the country.

Field Tribulations

A reasonably good supply of municipal electricity is available at our project sites in villages near Vientiane, the capital of Laos. In Myanmar, however, the bugaboo is the unreliability of electricity.

At the beginning of the project in Myanmar, the municipal power system in the village suffered regular gray-outs, but with voltage stabilizers, we were able to keep the UV purifiers running at full intensity. Now, the

UV Purifier Costs

Item	*Cost (US$)*
Sankyo Denki G8T5 UV lamp	$7.50
Robertson SP48 ballast, 120 VAC	6.25
Stainless steel sheet metal	6.00
Feed bucket	3.50
Valve, 1/2 in.	2.50
2 PVC threaded connectors, 1/2 in.	1.98
2 Hose barbs, 3/8 x 1/2 in. npt	1.98
3 PVC male adapters, 1/2 in.	1.40
Plastic tubing, 3/8 in. x 3 ft.	1.20
Hose barb, 1/2 x 1/2 in. npt	0.98
3 Rubber washers	0.45
3 Conduit locknuts, 1/2 in.	0.45
Total	$34.19

Cloth Filter Costs

Item	*Cost (US$)*
Male adapter, 2 1/2 in. PVC	$2.95
Threaded cap, 2 1/2 in. PVC	2.95
Slip cap, 2 1/2 in. PVC	2.45
White cotton flannel, 1/3 yard	2.00
2 Hose barbs, 3/8 x 1/2 in. npt	1.98
Pipe, 2 1/2 x 14 in. PVC	1.80
Close nipple, 1/2 in. brass	0.98
Slip/thread connector, 1/2 in. PVC	0.95
Threaded elbow, 1/2 in. PVC	0.95
Pipe, 1/2 x 12 in. PVC	0.40
Rubber washer	0.15
Conduit locknut, 1/2 in.	0.15
Total	$17.71

grid there is so badly overloaded that the village is without electricity for months at a time. As a result, no UV purification is possible. We tried batteries, but problems arose with keeping them properly charged. Using PV appears to be the only practical answer.

Interestingly, our efforts to introduce solar energy in Myanmar in 1999 were rejected as “too complicated.” Now that UV purifiers have proven successful and the users have become comfortable with them, the lack of electricity has stimulated a new interest in PV. We are working with MSF and UNICEF to incorporate photovoltaics as quickly as possible.

With acceptance and feasibility established, additional installations of these UV purifiers are planned for other countries in South and Southeast Asia in the near future. Contact me if you would like more information concerning these projects or more detailed design information.

Access

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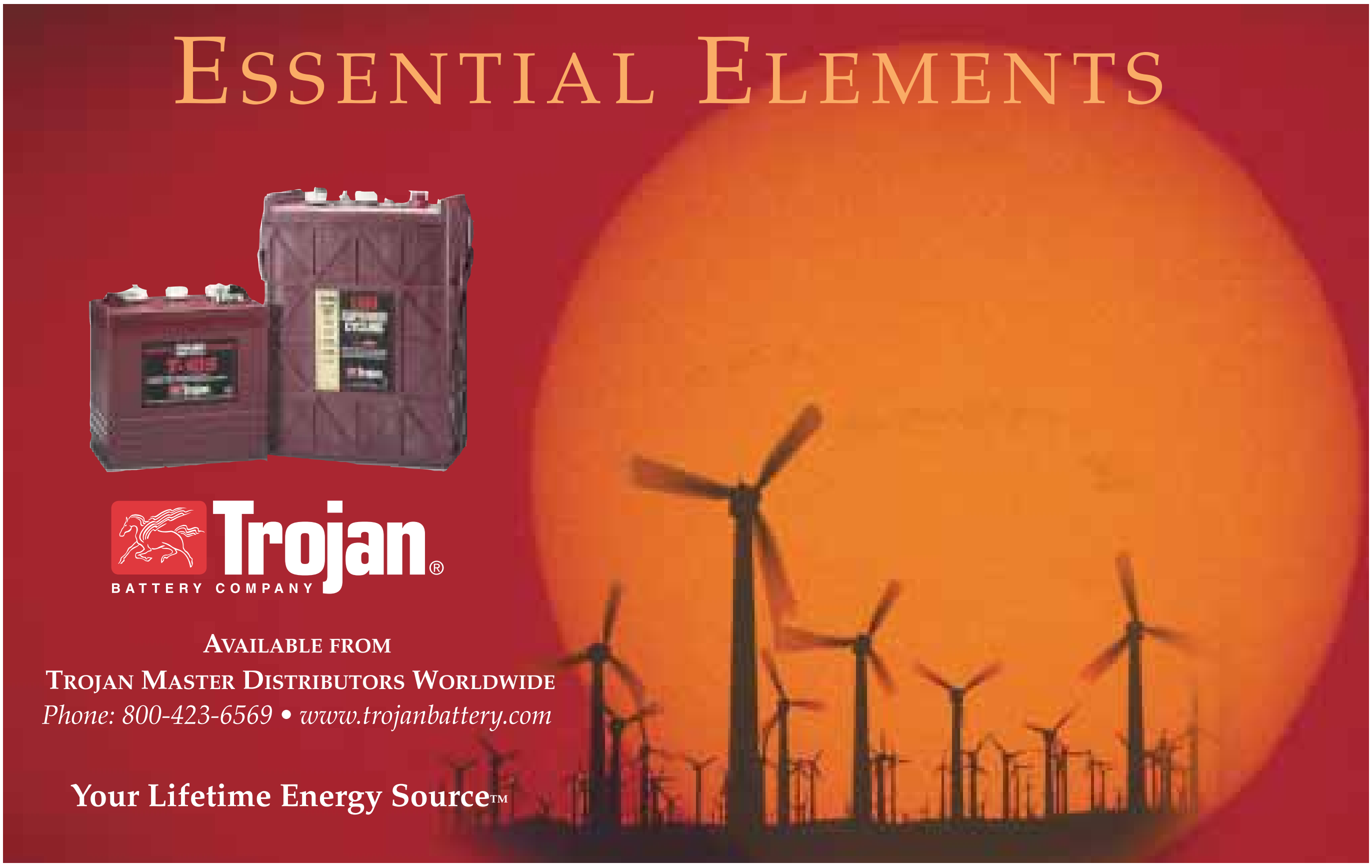
Fax: 909-597-9826 • info@hipco.com
www.harringtonplastics.com • PVC and polyethylene fittings

TEC/West (USA), Inc. 6344 Arizona Circle, Los Angeles, CA, 90045 • 800-421-7215 or 310-216-0273
Fax: 800-505-1134 or 310-216-7296
info@tecwest.com • www.tecwest.com • Germicidal UV lamps

Iota Engineering, PO Box 11846, Tucson, AZ 85734
800-866-4682 or 520-294-3292 • Fax: 520-741-2837
iotaeng@iotaengineering.com
www.iotaengineering.com • DC ballasts

Solar Electric Inc., 5555 Santa Fe St. #D, San Diego, CA 92109 • 800-842-5678 or 858-581-0051
Fax: 877-842-5678 or 858-581-6440 • solar@cts.com
www.solarelectricinc.com • PV modules and system components



Complex Simplicity: A Slow Sand Filter for Drinking Water

Robert Rau

The companion article in this issue, "UV Water Purification: A Simple Solution," refers to using slow sand filters to eliminate iron that may be in your water. While these filters will readily accomplish this, they can also be used as water purifiers on their own, if properly constructed and maintained. They are cheap and easy to build—all that's needed is sand, gravel, a container, and a few pipe fittings.

A slow sand filter (top container) is the first phase of a water purifying system in Myanmar (previously Burma).

Although not quite as reliable as UV or some other treatment methods, these filters will kill more than 99 percent of pathogenic bacteria and viruses in drinking water, and will also remove potentially harmful eggs and cysts. They can be used independently, or as a complement to other treatment systems.

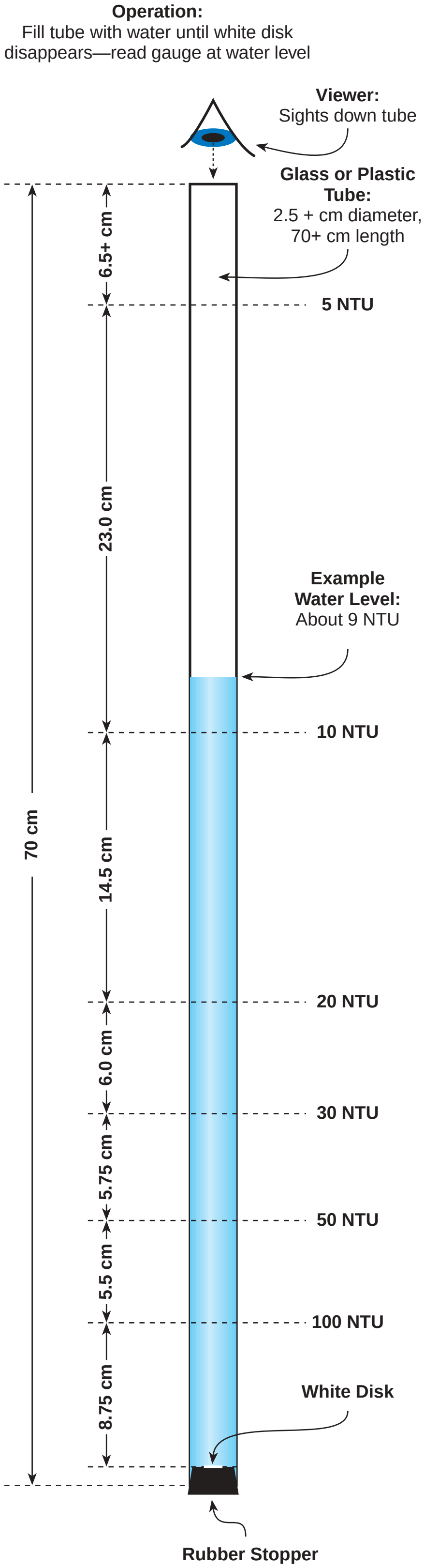
If sand, gravel, and a suitable container are available, the cost of building a slow sand filter will involve only the sections of pipe and a few fittings. Built for as little as US$10, it is one of the world's greatest bargains, considering the work it will perform.

Testing Your Water

First, you need to determine whether your water is clear enough for a slow sand filter by measuring its "NTU." NTU is a term commonly referred to in connection with drinking water. It stands for "nephelometric turbidity units," a very simple means for measuring and describing turbidity (color and sediment in the water). Although sand filters can handle occasional turbidity up to 50 NTU without excessive clogging, the ideal input quality is much lower (less than 25 NTU) if you want to minimize having to clean your sand filter.

Electronic turbiditimeters are available for precise testing (see Access), but they are very expensive. An alternative in the form of a tube for manual use can be purchased from the Robens Centre for Public and Environmental Health at the University of Surrey in England for 37 pounds sterling (US$58). Or, this device can be constructed as an easy homebrew project.

Nephelometric Turbidity Gauge



Use of a turbidity/NTU tube involves taking the NTU measurements by looking through water inside a section of tubing that has the NTU markings on its side. A homebrew NTU tube can be constructed using a section of clear glass or plastic tubing 70 cm in length (28 in.) and 2.5 cm (1 in.) or greater in diameter. The NTU levels of turbidity are marked on the side of the tube with a marking pen at the intervals shown on the diagram.

One end of the tube is closed with a black rubber stopper that has a small white disk cemented on for contrast. Readings are made by filling the tube with a sample of the water and stopping at the point where the white disk is just barely visible to your eye looking down through the tube, and then noting the NTU marking nearest the water level. A reading of 50 NTU or less is necessary for the water to be an acceptable candidate for a slow sand filter. Water with greater turbidity (i.e., an NTU reading over 50) will cause the filter to clog rapidly, and should first be allowed to stand awhile to allow for particle settling before introduction to the sand filter.

Filter Design

Sand filters use a complex combination of biological, biochemical, and physical processes. When properly operated and maintained, they can be very effective. Iron is removed by conversion to hydroxides, which attach to the sand particles. The biological/biochemical functions occur primarily in the upper layers of the filter known as the "schmutzdecke" or filter "skin." Schmutzdecke is a German word that translates literally as "dirty layer." This skin is first developed by microorganisms in the water, which will then consume other bacteria as they pass through in the water.

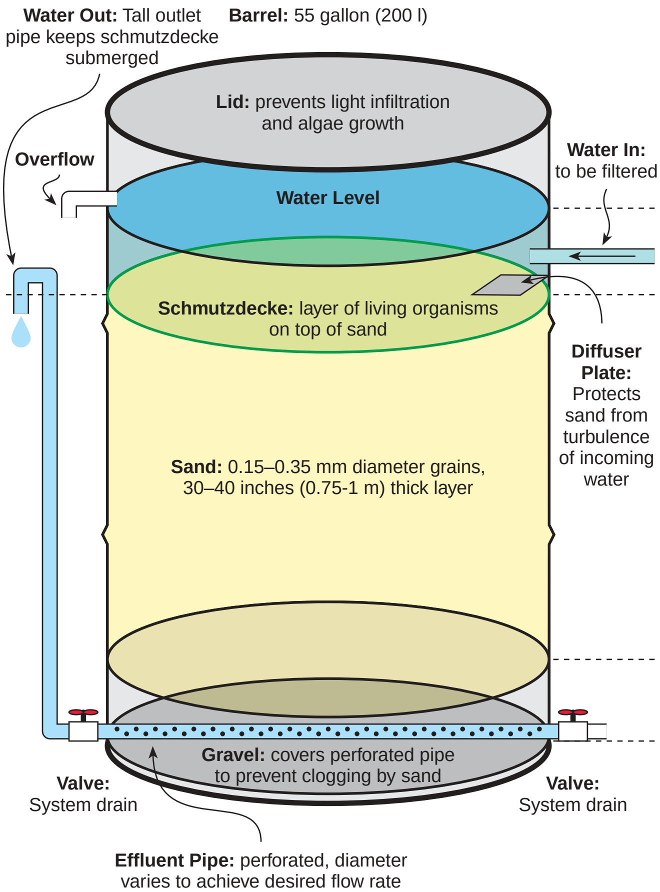
The basic design of a slow sand filter is quite simple. A layer of fine sand (0.15 to 0.35 mm) approximately 0.75 to 1 meter (2.5–3.2 ft.) in depth is laid over a supporting layer of crushed rock at the bottom of the filter, which encloses the outlet. Allowance should be made for a continuous cover of water above the surface of the sand. The water level must be maintained at all times to preserve the life of the schmutzdecke. The filter operates at maximum efficiency with a continuous downward flow of water. Interruptions in flow should be avoided.

Design parameters include ensuring that:

- Inflowing water is equally distributed across the surface of the filter and does not disrupt the upper layer of sand.
- Provision is made to keep a constant amount of water at least 10 cm (4 in.) deep above the layer of sand to prevent it from drying out.
- The sand is of the correct size and quality.

A large slow sand filter (structure on left) in a village in Myanmar.

A Slow Sand Filter in a 55 Gallon Barrel



Given the biological nature of the operation of the slow sand filter, a period of approximately two to three weeks is required after the initial watering before the filter will be fully effective. This ensures that the organisms in the water passing through the sand may become sufficiently established to be an effective schmutzdecke.

Filter Construction

Slow sand filters can be constructed from a variety of materials ranging from small drums to large, concrete-lined facilities. A design of a typical slow sand filter using a 200 liter (55 gal.) barrel is set out in the diagram.

The filter inlet can be from a pressure line or via gravity flow from a feed tank, but it must be the correct rate of flow and must not disturb the sand. A diffuser plate above the sand should be used to prevent incoming water from disturbing the schmutzdecke. Placement of the outlet 5 cm (2 in.) or so above the top of the sand will ensure that the sand is always submerged. Rock or broken tile is placed on the bottom of the tank over a perforated outlet pipe to prevent it from being clogged by the sand.

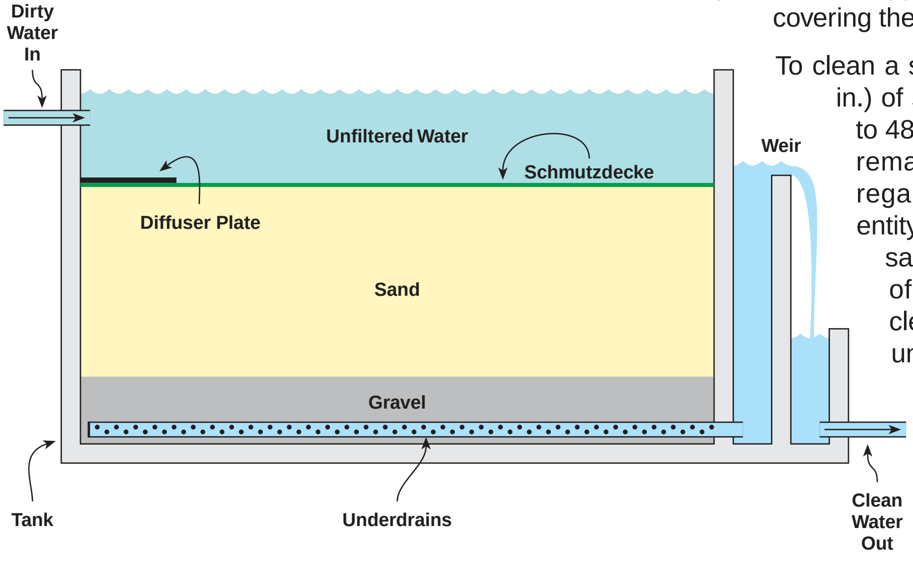
The filter will set its own output flow rate. The inlet flow rate must match the output flow rate. With too much input, the filter will overflow; with too little input, the sand will dry out and the schmutzdecke will be damaged or destroyed. Slow sand filters operate within certain flow ranges—1.5 to 3 liters per minute (0.4–0.8 gpm) per square meter (11 sq. ft.) of sand surface. The desired flow rate is set by increasing or decreasing the surface area of the filter.

For example, assuming (conservatively) a filter flow rate of 1.5 liters per minute (0.4 gpm) and a desire to achieve a flow rate of 4 liters per minute (1 gpm), you should provide a minimum of 2.5 m^2 (27 sq. ft.) of sand surface. Some experimentation with outlet and inlet pipe openings may be necessary to achieve the desired flow rate.

Both grain size and quality of the sand are crucial to the effectiveness of a slow sand filter. Quality of sand refers to the absence of silt, which causes turbidity in the effluent. Grain size is important since larger or nonuniform sizes result in removal of less iron from the

Building a small, slow sand filter with charcoal as the base. Gravel will complete the bottom layer.

Basic Elements of a Large-Scale Slow Sand Filter



water, and create the necessity for removing more of the sand during cleaning due to deeper particle penetration.

Although the ideal sand size is 0.2 mm, sand between 0.15 and 0.35 mm is acceptable. If laboratory sieve analysis is not available to accurately measure grain size, an approximation of the correct sand size can be made by passing a sample through window screen with openings of 0.75 to 1 mm. If most (90 percent) of the sand particles pass through the screen, and the screened sand is then washed (which will remove the small, undesirable particles), the remaining sand may be suitable for use in a slow sand filter.

This approximation will result in a sand size that is larger than the recommended limits of acceptability, but if allowed a sufficient time for maturation, it should perform satisfactorily. Analysis of the treated water may be necessary to confirm the effectiveness of the treatment.

Maintenance, Cleaning, & Rebuilding
Proper maintenance and daily monitoring of a slow sand filter is essential to make sure that the rate of water flow to the filter is correct, and that the intake and outlet openings are clear of debris and are functioning properly. You'll know when to clean it when there's a substantial reduction in the flow through the slow sand filter. This can occur anytime from a few days to three or more months, depending upon the turbidity and bacterial load of the water source.

In general, the need for cleaning is indicated when the outlet valve cannot be opened farther to maintain the original target flow rate. You should also check for growth of algae on the surface, which can increase premature clogging. This growth can be prevented by covering the surface of the filter to exclude sunlight.

To clean a slow sand filter, scrape about 2 cm (3/4 in.) of sand from the top of the filter. Allow 24 to 48 hours after removal of the sand for the remaining schmutzdecke to "ripen" and regain its effectiveness as a biological entity. You may want to have more than one sand filter, so that a properly filtered flow of water can be maintained during the cleaning and ripening operation of each unit..

A filter can be cleaned a number of times until the sand depth reaches 50 cm (20 in.), and then the sand bed should be rebuilt. To rebuild the filter, remove and wash all the remaining sand, add some new sand, and then place the original sand on top of the new sand to the point of the original elevation. Using some of the original sand will facilitate earlier ripening of the newly built bed with existing micro-organisms. You should not have to rebuild the filter until after 20 or more scrapings. After rebuilding, as with a new filter, a period of 2 to 3 weeks should be allowed for the schmutze-decke to become established

It is important to remember that water collected from a slow sand filter can be recontaminated. Make sure that the filtered water is not allowed to come into contact with sources of contamination.

Simple, Effective, & Energy Efficient
Slow sand filters are one of the oldest devices used to treat drinking water. They deserve serious consideration, since they avoid the need to boil

Performance of Slow Sand Filters

Impurity	*Purification Effect*
Color	30–100% Reduction
Turbidity	Generally reduced to less than 1 NTU*
Fecal coliforms	95–100% Reduction
Cercariae	Virtual removal of schistosome cercariae, cysts, & ova
Viruses	Virtually complete
Organic matter	60–75% Reduction
Iron & manganese	Mostly removed
Heavy metals	30–95% Reduction

* Nephelometric Turbidity Units, a measurement of how much suspended solids will scatter light

‡ Data source: *Slow Sand Filtration for Community Water Supply*

contaminated water or treat it with chlorine or other potentially harmful chemicals. They are also appropriate devices for areas with no electricity to power a UV water purifier.

Access

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Robens Centre for Public and Environmental Health, University of Surrey, Building AW02, Guildford, Surrey, UK, GU27XH • 0148 368 9209 • Fax: 01483-689-971 s.pedlay@surrey.ac.uk • www.eihms.surrey.ac.uk/delaguarcpeh.htm • Turbidity tubes as an accessory to their Oxfam-Del Agua Water Testing Kit

Hach Company, PO Box 389, Loveland, CO 80539 800-227-4224 or 970-669-3050 • Fax 970-669-2932 orders@hach.com • www.hach.com • Water testing equipment

Further Reading

Many slow sand filters are in existence world-wide in sizes from 20 liters (5 gal.) to huge lakes. They are used to treat water for large cities (London, is one example). Many publications have been written on this subject, a few of which are cited here.

The Success of Household Sand Filtration, Waterlines, Vol. 20, No. 1. July 2001, £6 + £3 shipping to the U.S. from ITDG Publishing, 103-105, Southhampton Row, London, WC1B 4HL, UK • +44(0)20 7436 9761 Fax: +44(0)20 7436 2013 • orders@itpubs.org.uk www.itdgpublishing.org.uk

Slow Sand Filtration for Community Water Supply, Visscher, J.T., et al, Technical Paper No. 24, 1987, ISBN 90-6687-009-5 • International Water and Sanitation Centre (IRC), PO Box 2869, 2601 CW Delft, The Netherlands • +31-15-219 29 39 Fax: +31-15-219 09 55 • general@irc.nl • www.irc.nl

Manual of Design for Slow Sand Filtration, 1991, ISBN 0-890867-551-0 • American Waterworks Association Research Foundation, 6666 West Quincy Ave., Denver, CO 80235 • 303-347-6100 • ereese@awwarf.com www.awwarf.com

Blending with Ki

Benjamin Root
Photos by William Wisdom

While maintaining a balanced posture, Sensei Darrell Bluhm redirects his attacker's energy down and away.

Aikido is a martial art developed in Japan by Morihei Ueshiba (1883–1969). While some of its specific techniques date back centuries, Aikido's progressive philosophy and movements set it apart from other, more aggressive, martial arts. "Aikido" literally means the way of harmony with life's energy (Ki).

With a bow of respect, class ends.

The harder they come, the harder they fall.

Aikido movements are about efficiency and conservation of energy. Rather than meeting force with force, the goal is to blend with the attacker's energy to resolve the aggressive situation in a nondestructive manner. A good Aikidoka will not tire, but attackers will wear themselves out, futilely. Aikido is a martial art that works equally well for male and female, young and old, large and small. But what does this have to do with lightbulbs?

The Electricity Connection

Renewable energy (RE) and energy conservation use very much the same philosophical approach as Aikido. RE accepts the energy that the universe provides, and guides it to accomplish the desired effect. RE does not force energy from the planet, violently extracting resources to achieve its end. Rather, it accepts the energy that is offered, and manipulates it peacefully to achieve the desired goal.

Even more simply, energy conservation is the understanding that the goal can be achieved with a minimal consumption of energy. Wasted energy will tax the system unnecessarily without improving the outcome. Conservation achieves the same goals without the destructiveness that comes from wastefulness.

When one of the overhead lights burned out over the mat at Siskiyou Aikikai, the Aikido dojo (school) where I train in Ashland, Oregon, it looked like a great chance to merge two very similar philosophies. Since we'd have to climb up there anyway, why not replace all four lightbulbs with compact fluorescent (CF) bulbs? And if we're going to replace the hard to reach ones, why not replace all the lightbulbs in the dojo with energy efficient CFs? It would cost a few bucks, sure, but in the long run it would save money. And because energy conservation is an application of Aikido that can work for everyone, it would also help spread the Aikido philosophy beyond the walls of the dojo itself.

We took a quick inventory of the lightbulbs being used, and I ran to the hardware store for energy efficient replacements. Modern compact fluorescents lightbulbs are often marketed with the wattage of incandescent bulbs of equivalent brightness. This makes it easy to match your new bulb to the light requirements that you are used to. In fact, the actual wattage is often difficult to find on the package. Basically, a CF uses about one-fourth the electricity of an incandescent with equivalent illumination. And they last about eight times as long.

Prices for CFs vary, and they can often be found on sale. I purchased the thirteen bulbs for the dojo from my locally owned hardware store. This may have cost a bit more than shopping at a big discount store, but it helps support my community, and I was able to get there by bicycle.

Modern CFs have some new features, making them more consumer friendly than their predecessors. The new spiral bulb designs make it easier to fit CFs into decorative fixtures. Three-way bulbs that provide three levels of brightness in the appropriate lamps are available. Special bulbs for use with dimmer switches are also made. I'm not impressed with the performance of dimmer bulbs I've seen, but at least the sensitive electronics in the ballasts don't give out when exposed to the low voltage of a dimmer switch being adjusted. At the dojo, this meant we didn't have to go through the extra steps of throwing the breaker and replacing a switch—we could just upgrade the lightbulbs.

The Mission

All in all, we replaced 1,850 watts of incandescent bulbs with 348 watts of compact fluorescent bulbs. In some of the rooms, we were willing to have a little less light—the 20 watt bulbs in the dressing rooms, bathroom, kitchen, living room, and the teacher's room seemed bright enough to replace the 100 watt incandescent bulbs. The 28 watt bulbs provide great light, replacing the 175 watt floodlights on the front porch, though we might upgrade to weatherproof CF floods for those exposed bulbs.

Siskiyou Aikikai CF Bulb Replacement: Energy & Money Saved

Qty.	Location	Hrs. / Mo. Dark	Hrs. / Mo. Light	Hrs. / Yr.	Incand. Wattage	Incand. KWH / Yr.	CF Wattage	CF KWH / Yr.	Savings KWH / Yr.	Cost Ea. (US$)
4	Mat	96	32	768	150	460.8	26	79.9	380.9	$8.99
2	Dressing rooms	96	96	1,152	100	230.4	20	46.1	184.3	5.99
2	Kitchen	96	96	1,152	100	230.4	20	46.1	184.3	5.99
2	Front porch	80	16	576	175	201.6	28	32.3	169.3	10.49
1	Sensei's room	96	96	1,152	100	115.2	20	23.0	92.2	5.99
1	Hallway	96	96	1,152	100	115.2	20	23.0	92.2	5.99
1	Foyer	96	32	768	100	76.8	28	21.5	55.3	10.49
1	Living room	48	48	576	100	57.6	20	11.5	46.1	5.99
1	Bathroom	30	15	270	100	27.0	20	5.4	21.6	5.99
					Extended Totals	1,515.0		288.8	1,226.2	$115.35
					Cost per Year at US$0.041 per	$62.12		$11.84		
							US$ Saved per Year	$50.27		
							Payback Period (Years)	2.3		

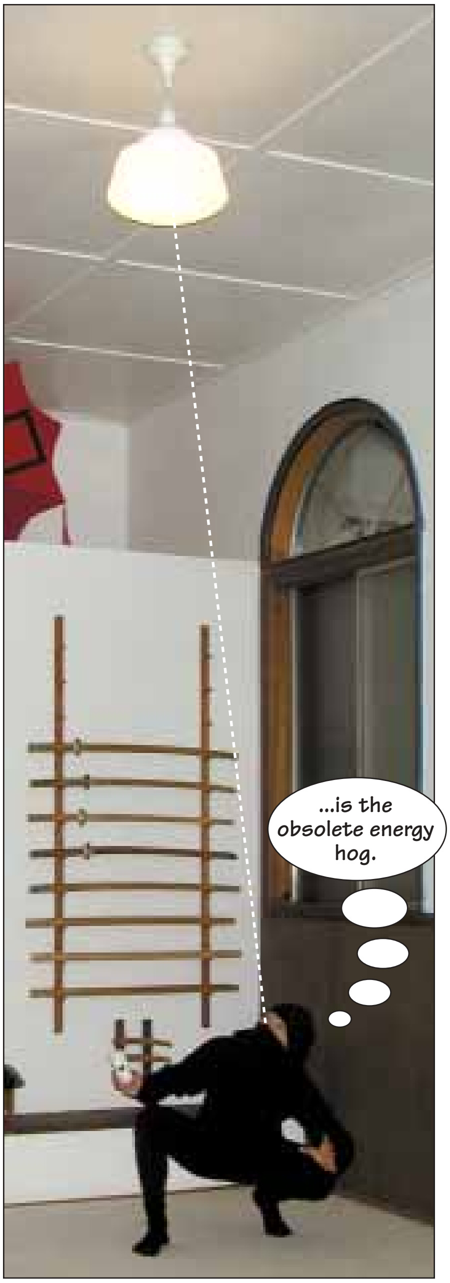
On the training mat though, the 26 watt dimmer-ready bulbs just don't quite put out as much light as the 150 watt bulbs we replaced. The truth is, the hardware store didn't have anything brighter. Sensei (literally, "teacher") is going to live with them for a while, and I'm going to keep my eyes open for higher wattage bulbs. We'll reevaluate the situation later on to see if we should upgrade to something brighter.

To figure out exactly how much energy and money the dojo will save took some estimating. We had to speculate on how much time each light is on. The dojo mat area and foyer are upstairs, with large windows for natural daylight. For these areas, and the porch lights, we estimated usage for the six darker months, when the lights need to be on during early morning and evening classes. The other six months, we estimated that the lights need only be on during the last class of the evening (see table). We added a half hour of "on" time before and after these classes for changing clothes and dojo cleanup.

All other areas of the dojo are in the basement of the building, so most of the lights are on when the dojo is occupied. For these areas, we added a half hour of lights-on time before the first class and after the last class of the day. The bathroom light is on a minimum amount of time. All in all, these hourly estimates are rough. The real numbers will come from the lower electricity bills each month.

The Data
We figure that the new compact fluorescent bulbs will save about US$50 per year based on the cheap US$0.041 per kilowatt-hour electricity here in southern Oregon (see table). In many places in the U.S., this number could be doubled. The payback period on the new lightbulbs is just over two years—not bad for a product that comes with a seven-year (8,000 hour) warranty.

Perhaps more important than money is the electricity saved. About 70 percent of the energy that goes into the generation and distribution system in the U.S. is lost to inefficiencies. So every kilowatt-hour that is saved prevents 3 kilowatt-hours from needing to be produced in the first place. Wow—that just tripled the positive impact we made by changing our dojo's lightbulbs!



Saving this electricity also offsets pollution that would otherwise go into our environment. Several "calculators" on the Internet can help you figure out how much pollution you can prevent by lowering your energy use. See Access for a good one at the Cleaner and Greener Web site.

Most of these calculators correct for your location. This means that they are figuring out the pollution created per kilowatt-hour based on the typical mix of energy at your location. For example, in the Northwest (southern Oregon included), it is assumed that a high percentage of the electricity is provided by hydroelectric dams. The pollution offset by the dojo's 1,226 KWH per year savings is different than if we were in Colorado where most of the electricity is assumed to be supplied by coal. See the table adapted from the U.S. Environmental Protection Agency (EPA) that shows carbon dioxide (CO_2), sulfur dioxide (SO_2), and nitrogen oxides (NO_X) released per KWH of electricity for various regions of the U.S.

The Effect
Personally, I don't like this pollution calculation method. The U.S. electrical grid is a national network that is operated at a certain level to maintain the energy demands of the whole nation. All those electrons go into one big mix that is the nation's electricity supply. When you use energy, there is no way to say where those electrons came from—electrons cannot be tracked. The energy supply is like a puree from different energy sources—when you take a helping, you might as well assume that your portion reflects the same mix that anyone, anywhere else in the country would receive.

Even if you are buying "green" power from your electric company, you are basically receiving the same electricity as your neighbor across the street, or across the country. The difference is that your money is

Recycle CFs

Compact fluorescent lightbulbs last roughly eight times longer than incandescent bulbs, but they do wear out. Because all fluorescent lighting, including the tube lights common in office buildings and shops everywhere, contain a small amount of mercury, they should be recycled or disposed of properly. Mercury is a poison that affects the neurological system, and is particularly dangerous for children and pregnant women.

The reason fluorescent bulbs are so efficient is largely due to the mercury vapor that's sealed in the light tube. How much mercury is in a fluorescent bulb? If you took the mercury from 100 fluorescent bulbs, it still wouldn't equal the amount of mercury contained in a single household thermometer. The mercury present in fluorescent bulbs isn't a health issue, but as their use becomes more common, it could become a disposal issue. That's why recycling fluorescent lighting is the responsible thing to do.

It's important to note that the mercury released into the environment by one, improperly disposed of fluorescent lightbulb is half that of the mercury released into the environment by a coal-fired power plant providing the additional energy needed to power a comparable incandescent bulb over the lifetime of the replacement CF. Don't forget the rest of the pollutants that power plants produce, depending on their type—carbon dioxide, carbon monoxide, sulfur dioxide, nuclear waste, etc.

For a list of U.S. fluorescent bulb recyclers, see: www.gelighting.com/na/specoem/lamp_recyclers.html

going to a company that is adding green power to the total mix. The current breakdown of sources for the national energy mix goes roughly like this: coal, 51 percent; nuclear, 20 percent; natural gas, 16 percent; hydro, 8 percent; oil, 3 percent; biomass and other (including solar and wind), 3 percent.

Because I want to pay attention to our national involvement with energy consumption (and why round down if the goal is to inspire others?), I made a rough average of 1.5 pounds (0.7 kg) of CO_2, 5 grams (0.2 oz.) of SO_2, and 2.5 grams (0.09 oz.) of NO_X per KWH as a medium estimate. Thus, the 1,226 KWH that the dojo is projected to save next year will result in 1,839 pounds (834 kg) of CO_2 (almost a ton), 13.5 pounds (6 kg) of SO_2, and 6.8 pounds (3 kg) of NO_X that won't go into our environment. For comparison purposes, the average car emits 15,000 pounds (6,800 kg) of CO_2 in a year, and planting an acre of trees consumes 7,333 pounds (3,326 kg) of CO_2 in a year.

The Point

The numbers are estimates, and their meanings esoteric. The point is, it is easy and cost effective to reduce our energy consumption. Every bit we cut back means three bits that don't need to be extracted from our environment. And it can happen without adversely affecting our much cherished American way of life. Heck, shutting off the light when we leave the room costs nothing.

We could say that choosing and using our energy resources carefully and purposefully is very "Aiki" (harmonious with life's energy). We can live the life we desire without forcing the universe to provide. Rather, we accept what it has to offer, we redirect it in a respectful and nonaggressive way to match our needs, and the outcome is positive for everyone and everything involved. Yes, very Aiki.

Special thanks to Darrell Bluhm Shihan, of Siskiyou Aikikai for immediately realizing the universal value of reducing our energy use, and for putting up with the corny photo shoot.

Pollution per KWH for U.S. Regions

States	*Lbs. / KWH* CO_2	*Grams / KWH* SO_2	*Grams / KWH* NO_X
CO, MT, ND, SD, UT, WY	2.2	3.3	3.2
IA, KS, MO, NE	2.0	8.5	3.9
IL, IN, MI, MN, OH, WI	1.8	10.4	3.5
AR, LA, NM, OK, TX	1.7	2.2	2.5
DC, DE, MD, PA, VA, WV	1.6	8.2	2.6
AL, FL, GA, KY, MS, NC, SC, TN	1.5	6.9	2.5
CT, MA, ME, NH, RI, VT	1.1	4.0	1.4
NJ, NY, VI	1.1	3.4	1.3
AZ, CA, HI, NV	1.0	1.1	1.5
AK, ID, OR, WA	0.1	0.5	0.3

Carbon dioxide (CO_2) is a greenhouse gas.
Sulfer dioxide (SO_2) is the key ingredient in acid rain.
Nitrogen oxides (NO_X) are key ingredients in smog.

Access

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Cleaner and Greener www.cleanerandgreener.org/pollution-from-electricity.htm • Pollution per KWH calculator

SafeClimate carbon footprint calculator www.safeclimate.net/calculator • Pollution calculator

SUN ELECTRONICS
www.sunelec.com
Solutions for all your power problems
Southwest Windpower: Wind generators. Air 403 $349
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Florida Batch Water Heater

Robert Owens

It was during the energy crisis of the 1970s that I first saw a batch solar water heater. It struck me that something so simple and so elegant just had to be a good idea! An active solar hot water system with its panels, pumps, and pipes just didn't work for me. After Barbara and I set up home in Tampa, Florida, I decided to make my solar dream a reality and install a batch solar water heater.

Bob's self-installed system makes good use of the Florida sun.

The solar batch heater supplies most of the family's needs many months of the year.

We live in a typical two-story home in the suburbs of sunny central Florida. When the house was built, the water heater was positioned in the laundry room on the north side of the house. Local restrictions require that no solar panels can be visible from the street in front of our house. In addition, our house has a gable end on the south side.

These restrictions required that we site any active solar panels on the second story of the house on the west side. This would have required a piping run of more than 100 feet (30 m) with a vertical lift of 25 feet (7.6 m). Any hot water produced would have cooled considerably by the time it got back to the hot water tank. That and the active controls needed, along with the pumping power required, made it an unusable option for us.

After consulting with AAA Solar, I decided that the best thing to do would be to install a batch solar water heater. The best site for it was 15 feet (4.6 m) to the north of the laundry room, near the property line. The house would end up shading the batch heater about three months of the year in the winter, reducing its usefulness slightly. It would still function as a tempering tank during the winter.

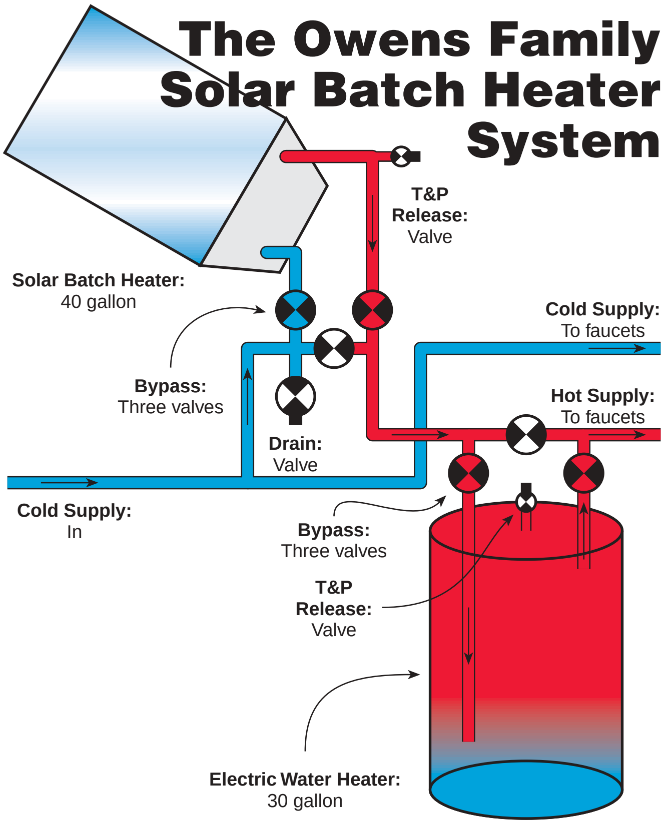
The piping would be routed underground to the laundry room. This would look neat and prevent the pipes from freezing during the winter. Since we're in Florida, we have no deep freezes to be concerned with. People in more northerly locations need to make sure that all pipes are well below the frost line.

Advantages & Disadvantages

Batch water heaters have several advantages that make them useful in the appropriate situations. They have no moving parts. Homeowners can install the units by themselves on the ground floor. They need no pumps, operating strictly on the water pressure to the house. Their large mass helps keep them from freezing. They are the most reliable solar water heaters available. No electricity is needed for their operation.

As with everything, there are drawbacks. First, batch heaters are heavy! Be sure to get an accurate estimate of the shipping charges. Ours weighed 450 pounds (204 kg) when crated, and cost US$400 to ship from New Mexico to Florida. Knowing the weight when full is also important if the heater is going to be located on a roof.

Bypass valves on the solar batch heater allow for draining the tank.



Second, you need to be able to make the lifestyle adjustments necessary to get the most from a batch heater. It is basically a large water tank sitting in the sun, gathering heat, with primary heating hours of 10 AM to 3 PM. You need to time the use of your appliances to get the hot water you need.

We make an initial draw of hot water early in the afternoon for the dishwasher or clothes washer. This does not affect the total amount of hot water available at the end of the day. Then we take our showers in the evening as soon as we get home. During the night, batch water heaters will lose much of the heat they have accumulated. A shower in the morning will be mostly cold water if the batch heater is the only source of hot water.

When ordering the unit, be sure to specify where you want the inlet/outlet tubes located; either on the east or west side of the unit. You don't want them on the wrong side!

Site Preparation & Plumbing

Towards the end of the summer of 1998, the unit arrived. I uncrated it and inspected it for damage, and there was none. I bolted the support brackets to two pieces of 4 foot (1.2 m) pressure-treated 2 by 4 for a base. The unit was tilted to my latitude (30 degrees) plus 15 degrees for a total of 45 degrees. I may try the angle at 35 to 40 degrees in the future since the collector is partially shaded in winter.

Tips from the Pros

All batch integrated collector storage (ICS) systems have a ratio of glass aperture area of from 1 to 1 1/2 square foot of glass to 2 gallons of water. This translates into using about 20 to 30 square feet of glass area for a 40 gallon (150 l) tank, which is pretty much the standard of the industry.

Three companies in the U.S. make a progressive tube-type batch heater. These use 4 inch tubes behind a 30 square foot piece of glass. The two manufacturers of batch water heaters with tanks use a 20 square foot piece of glass. All that I know of are double glazed, most with two pieces of low iron tempered glass, although one manufacturer in Florida uses plastic as the inner glazing.

A unit with a larger glass-to-storage-area ratio will pick up more heat during the day and lose it more quickly at night. This is because most of the heat loss of batch heaters is through the glass, the same place the gain is. The higher surface-to-volume ratio of the tube-type, which helps in gain, is also a cause of more heat loss at night.

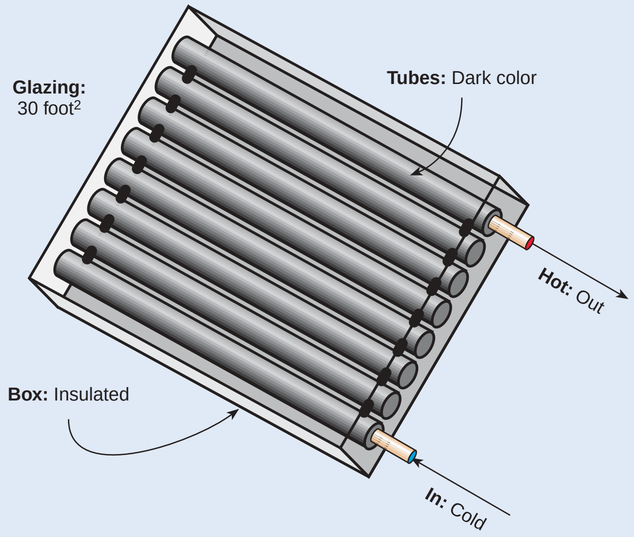
We have found that unless it gets really cold on any one winter night here in Albuquerque, a batch heater will typically have a temperature of 90 to 100°F (32–38°C) the morning after a good sunny day. In the summer, the heaters typically make at least 140°F (60°C) water, and have temperatures of 110 to 120°F (43–49°C) the next morning.

We do not recommend batch water heaters in any but the most southern states or coastal areas that rarely freeze, or for seasonal use. A tank-type batch heater will not freeze in even the coldest of climates in the lower 48 states, but the piping to and from the collectors will. Tube-type batch heaters are a little less freeze tolerant, since the mass inside each tube is much less than that of a 40 gallon tank. In addition, the connections (typically 3/4 inch) between each tube in a tube heater are also an Achilles heel when it comes to freezing.

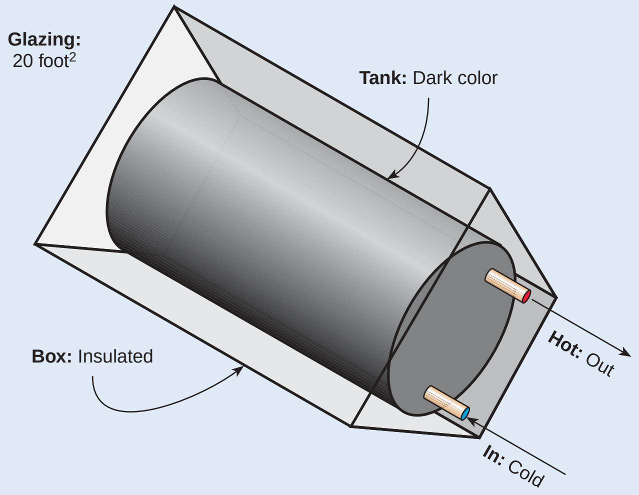
Tube heaters will outperform tank heaters because of the larger glass tubes, piped in series for better temperature stratification, and the higher surface-to-volume ratio of the tubes versus the tank. But they are not as freeze tolerant.

Chuck Marken, AAA Solar Supply Inc. • info@aaasolar.com

Solar Batch Heater: Progressive Tube



Solar Batch Heater: Tank



Next, I prepared the site I had chosen for the unit. All surrounding shrubbery and debris was removed, and the ground was leveled. A trench was dug from the house to the east side of the solar water tank for the piping, and the cold water line was located. Using a large wheeled dolly, Barbara and I moved the batch heater to its final position. Phase one was complete, and we were ready to proceed to the plumbing part of the project.

I wanted to be able to bypass either the solar water heater or the electric water heater at will. To accomplish this, I used three CPVC ball valves at each heater (see photos).

The batch heater has an additional tee and drain valve so it can be emptied when necessary. We added a timer switch to the conventional heater's electrical circuit so its elements could be easily shut off without going to the garage and throwing the circuit breaker. This made it easy for anyone to operate at any time.

Installation

I started our installation by shutting the municipal water supply off at the street. Then I opened a faucet in the house and cut into the cold water line outside the house, where I planned to tap into the line for the solar water heater. This drained out all the water in the house lines, which is necessary to glue and solder the joints.

The plumbing in my home is typical for suburbia. A cold water line from the street enters the house at the laundry room. A tee located in the wall feeds cold water to the conventional water heater. The hot water line from the electric heater feeds the hot water lines in the rest of the house. The cold water line to the electric water heater was cut and capped where it exits the wall. It was replaced with the hot water line from the solar heater.

The new hot water line runs from the solar water heater through the concrete block wall behind the washer and dryer and up to the cold inlet at the conventional water heater. It was necessary to use a 1 inch (25 mm) masonry drill bit, 12 inches (30 cm) long, to get the correct hole drilled through the block. The line was placed in the prepared trench over to the solar heater.

All piping for the hot water line was done in CPVC pipe, which is able to handle the hot water. Don't forget to use the correct glue for the CPVC pipe—it is orange. All cuts need to be made on a miter saw at a 90 degree angle, and deburred so that the joints will achieve their maximum strength. Cover all piping for the hot water line with insulation. This is sold in 6 foot (1.8 m) lengths and needs to be of outdoor quality. Insulate the lines on the inside of the house too; solar heat is precious, and you don't want to lose any of it!

If you have never used CPVC pipe before, this makes a great starter project. CPVC directly replaces copper in any hot water line, and no soldering is needed. Joints are glued just as with PVC pipe. CPVC pipe is sized to join with copper, galvanized steel, and PVC. Special fittings provide the correct interface. The CPVC fittings are more expensive than their copper counterparts, but unless you are good with plumbing and soldering, the ease of assembly of the CPVC is worth the difference.

The cold water line should be done in schedule 40 PVC. This weight of pipe is heavy enough to be able to take any traffic over the trench lines and not break. It is less expensive than the CPVC and uses standard PVC glue. I put a tee in where I had previously cut the cold water line, to allow it to drain. I ran the pipe from this tee in the trench over to the solar heater. Insulation on the cold water line is not needed. I had to transition from the PVC to the CPVC ball valves with the correct fittings.

Owens Batch Heater Costs

Item	*Cost (US$)*
AAA Solar heater, batch*	$900
Shipping	400
Valves, piping, etc	100
Total	$1,400

*Current price is US$1,605

On the electric water heater, the timer switch and bypass valves are arranged for easy access.

Finishing Up

Next came the big moment! I closed all faucets in the house and turned on the water at the street. Then I examined all lines for leaks. I opened the drain valve to the solar water heater so it would fill with water and have the air removed. I manually opened the temperature and pressure (T&P) valve on the electric water heater to remove any air in the line, and continued removing air by opening a faucet valve. No leaks—great! I was almost done. By opening the hot and cold water lines in the bathtub (or non-aerated faucet), and letting the water run for several minutes, I flushed any debris from the lines.

At this point, I just had wrap-up work to do. When I was satisfied that everything was working, I filled in the trench part way with dirt. I soaked this with water so the dirt would fill in around the pipes. This helps support the pipes and any weight on top of them. I then completed filling the trench with the remainder of the dirt.

To hide the water heater from the street, I installed a fence section even with the front of my house. This also serves as a trash can storage area. Because I live in a hurricane zone, I constructed a cover for the unit out of an appropriate-sized piece of siding and two pieces of angle iron. The cover is tied to the unit when needed. This protects the glass from breakage. The installation was complete!

Overcoming the Limitations

During the summer, Barbara and I are able to turn the electric water heater off totally, except for overcast days. As soon as the house shades the solar heater in early winter, we turn the electric heater on full time. Our electric bill is lower by about US$20 per month. This results in a simple payback period of seven years. If the shipping costs were lower or I had constructed my own unit, the payback period would be much less.

This is a good demonstration of what can be done with solar energy in a less than optimal location. If my house plan had been reversed and I could have located the heater on the south side, I would have been able to use the unit year-round. Also, I could have located it right next to the house, with no underground piping. Because three-quarters of the houses in the U.S. are not optimized for solar, solar retrofits need to be able to function within the limitations imposed.

Access

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AAASolar Supply, Inc., 2021 Zearing NW, Albuquerque, NM 87104 • 800-245-0311 or 505-243-490 www.AAASolar.com • SDHW components

Evergreen Solar
The Power of Pure Play

Richard Perez & Joe Schwartz

On November 6, 2002, *Home Power* toured Evergreen Solar's new photovoltaic (PV) manufacturing facility in Marlboro, Massachusetts. We'd toured PV manufacturing plants before, and we thought we knew what to expect. We were wrong. Evergreen Solar's process for manufacturing PV cells is radically different from any other company's. And they make just one thing—PVs. This is the essence of "pure play," a stock market term used to describe a company that focuses on a single product.

Solar Folks

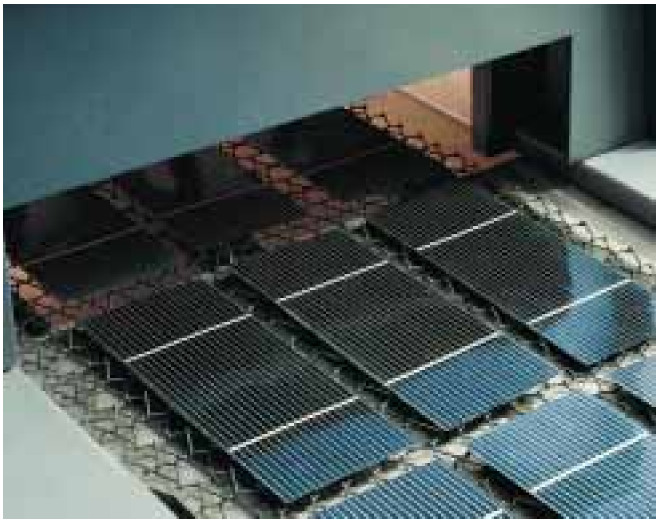
During the energy crisis of the 1970s, many conventional energy companies began looking for new ways to generate electricity. One such company was Mobil Oil. Mobil created a subsidiary, Mobil Solar, to research the manufacture of photovoltaics. It was at Mobil Solar that the founders of Evergreen Solar—Mark Farber, Jack Hanoka, and Richard Chleboski—first met. When Mobil decided to abandon its twenty years of photovoltaic research in 1993, the three colleagues remained dedicated to solar electricity, and set their sights on the independent manufacture of photovoltaics.

Mark Farber, Evergreen Solar's president and CEO, studied at the Massachusetts Institute of Technology's (MIT) Sloan School and the Industrial Engineering School at Cornell University. His professional background is with electric utilities—conventional electric generation through oil, coal, natural gas, and hydro. During our conversation, Mark pointed out, "Utilities are not progressive. They are old-tech driven." While Mark was once a "utility" person, he now sees the future of PV as privately owned, distributed generation.

Jack Hanoka has a Ph.D. in solid-state physics. Jack is Evergreen Solar's vice president and chief technical officer. He's responsible for the evolution of Evergreen's "String Ribbon" PV technology from a laboratory experiment to a working, mass-produced product. Jack is the quintessential "gray beard" inventor with a passion for solar electricity. "Creating better solar products is the fulfillment of my professional career, and something I love to do," he stated. And it's not just a technical passion for Jack. While giving us a tour of his R&D lab, he told us, "It's extremely satisfying to be producing a product that is beneficial to humanity. We're going to change the world."

Richard Chleboski is Evergreen Solar's chief financial officer (CFO). Rich has a BS in electrical engineering from MIT, as well as an MBA in finance. He states, "Our challenge now is to continually lower our manufacturing

Finished String Ribbon cells on their way to becoming PV modules.



costs to the most competitive level in the shortest time period possible." While one might expect a CFO to be solely focused on money matters, we found him to be dedicated to solar electricity. He asked us, "How many power generation technologies can you name that people want to put in their backyard?"

Clockwise from top left: Richard Chleboski, chief financial officer; Jack McCaffrey, VP of manufacturing and engineering; Jack Hanoka, VP and chief technical officer; Mark Farber, president and CEO; Rex D'Agostino, VP of marketing and sales.

Pure Play

Evergreen Solar began over dinner in the Hanoka family's kitchen. During the many years that the three founders had worked at Mobil Solar, they had learned a great deal about making PVs, and they had become convinced of the necessity and viability of solar electricity.

In 1994, they formed Evergreen Solar. It's difficult to imagine a business that is more capital intensive than making PV modules. Tens of millions of dollars must be spent on R&D and manufacturing hardware before the very first module rolls off the assembly line. Farber, Hanoka, and Chleboski were not fazed by the lack of money. They licensed the String Ribbon process from its inventor, MIT's Professor Emanuel Sachs, recovered Sachs' original experimental furnace from an MIT warehouse, and got started. They set out to develop the String Ribbon technology into a commercially viable product.

They rented an abandoned 2,500 square foot (230 m^2), plumber's warehouse in Waltham, Massachusetts, and set up shop with a handful of employees. Here their first String Ribbon wafers were produced in 1995. After outgrowing the plumber's warehouse, Evergreen moved to a larger facility in Waltham. At the new location, about twenty Evergreen people created the company's first production line and began actually producing PV modules for sale in 1997.

Custom-built robots perform most of the handling of the delicate silicon cells.

In 1999, in preparation for commercial scale-up, Evergreen Solar expanded the management team, hiring Jack McCaffrey as the new vice president of manufacturing and engineering. Jack was available, due to the downsizing of Polaroid Corporation. When he went to work for Evergreen, he brought other laid-off Polaroid engineers with him.

In 2000, Evergreen Solar issued their initial public offering (IPO), taking their company public. The stock offering enabled them to raise the capital they needed to build a full-scale manufacturing plant and corporate headquarters at their current site in Marlboro, Massachusetts. Evergreen Solar's stock is publicly traded on the NASDAQ exchange under the symbol ESLR.

In January 2001, with the new facility in hand, they also hired another business veteran, Dr. Rex D'Agostino, as the vice president of marketing and sales. Rex brought a fresh perspective to gearing up the business development efforts. "Rather than approach the marketplace by telling customers what Evergreen has to offer, I began by listening and learning from them."

A line of String Ribbon silicon furnaces produce tomorrow's photovoltaic cells.

Mark Farber says, "We've gone from startup to shipping commercial product using a new technology faster than any other solar company in history. Naturally, I'm very proud of that." All in all, about 140 people are employed at Evergreen Solar. As of November 2002, Evergreen Solar has produced and sold more than 25,000 photovoltaic modules made with String Ribbon PV cells. These modules have been distributed all over the world—from the U.S. to Japan to Germany, and from Bolivia to Tanzania to Indonesia, from rural homes in the Dominican Republic to the World Trade Center in Tokyo.

Evergreen has made their solar dream a reality, and in doing so, they have commercialized a brand new PV cell manufacturing process. And it's in this new String Ribbon process that the secret of their success lies, and where the promise of inexpensive, crystalline PVs may finally be realized.

How Crystalline PVs Are Usually Made

To appreciate the technology of Evergreen's new cell process, you must first understand how crystalline PV cells are normally made. Here is a vastly simplified description of conventional crystalline PV cell manufacturing.

The first step is to make a wafer of crystalline silicon. Perhaps the oldest way to make a solar wafer is to form a single crystal by using the Czochralski (Cz) method. In this method, hyperpure silicon is drawn, in a vacuum, forming cylindrical ingots between 4 and 8 inches (10 and 20 cm) in diameter. These ingots, called boules, are sawn into very thin, disk-shaped wafers of silicon about 500 microns thick. These wafers are then etched in hydrofluoric acid and washed with pure water.

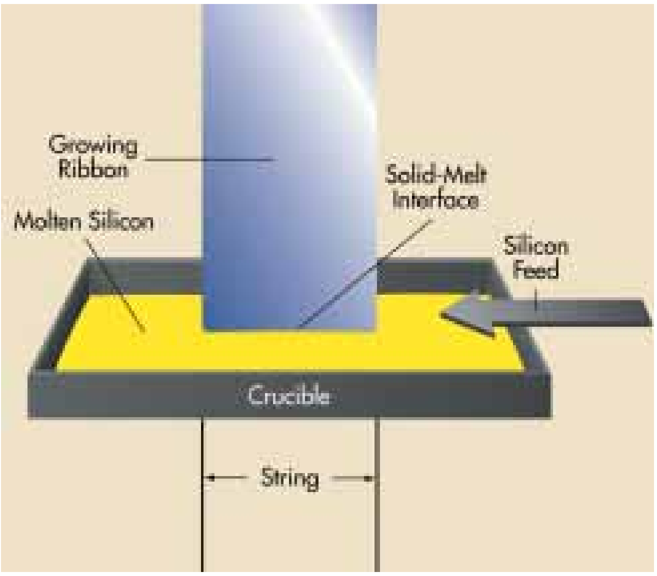
In a slightly newer alternative technique, the silicon can be poured into a mold and slowly cooled into a rectangular block. The cast block also must be sawn and acid etched. Either with single-crystal boules or polycrystal blocks, roughly half of the highly purified silicon is lost as unrecoverable sawdust or to breakage.

To turn the wafer into a solar cell, a semiconductor junction is formed between two or more semiconductor materials. Typically, phosphorous is vaporized and pumped into a chamber. High temperature causes the phosphorous to diffuse into the surface of the boron-doped silicon substrate. The boundary region between the phosphorous-doped silicon and the boron-doped silicon is the P-N junction.

The wafer is then etched again along its edges to remove the short circuits that bridge the junction. The wafer is washed once more with pure water. A metalization layer (typically an alloy of aluminum or silver) is then screen printed onto the back of the cell (the P side of the junction), and screen printed as thin traces to the front of the cell (the N side of the junction), which faces the sun.

Next the cell is thinly coated with an antireflective coating, which turns the shiny silver silicon a deep blue. At this point, the cell is ready to have strips of tinned copper soldered to it so that it may be electrically connected to other cells and eventually become a module. The series strings of cells are then encapsulated into a module, most typically using plastic backing materials, a glass front cover, and a rigid aluminum framework for physically mounting the module. The final steps are attaching a junction box or cables with plugs to the back of the module and flash testing the module to measure and verify its performance.

Whew—if you think this sounds like a lot of work, you're correct. And we've left out many of the more trivial or backroom steps involved, like cleaning and disposing of the cutting slurry used to saw the boule or block into



The String Ribbon crystallization process.

A ribbon of crystalized silicon 81 mm wide and 1/4 mm thick is pulled from the molten pool at 16 mm per minute.

slices. Consider that at each step, the cells are handled in batches, being loaded and unloaded, usually by hand, through the various machines. If you've ever wondered why PV modules are so expensive, this is a big part of the answer.

Evergreen Solar's PV Manufacturing Process

The folks at Evergreen are using a new and different process to make PV wafers. The technique is exclusively licensed to Evergreen Solar for commercial production. This String Ribbon process simplifies PV wafer manufacture, and it reduces the amount of silicon needed to make a crystalline cell by about half.

This is significant because pure silicon is the most expensive material in a PV cell. Jack Hanoka estimates their cell fabrication process also reduces the amount of hydrofluoric acid used in etching, and the amount of distilled water used for washing by more than a factor of ten. In short, Evergreen's process involves fewer steps in the cell manufacturing process and uses less energy and material, especially expensive hyperpure silicon. This means that Evergreen Solar's manufacturing process is among the most environmentally friendly in the industry today.

The String Ribbon process involves drawing two high-temperature filaments, called "strings," through a shallow pool of molten (2,574°F; 1,412°C), pure silicon. When the strings, one at each edge of the ribbon, are drawn through the molten silicon, the silicon spans the gap between the strings and crystallizes into a very thin ribbon about 250 microns thick.

The strings are drawn vertically through the silicon melt at a rate of about 16 millimeters per minute. The result is a 3.2 inch (8.1 cm) wide continuous, polycrystalline silicon ribbon. During the ribbon pulling process, a computer measures the thickness of the ribbon and feeds this data back to the furnace's microprocessor, which adjusts the process to maintain thickness uniformity. This assures a uniform ribbon with minimal waste. When the ribbon grows to the ceiling, Evergreen cuts the 6 foot (1.83 m) ribbon without terminating the process. It grows continuously—24 hours a day, 7 days a week—with only periodic maintenance shutdowns.

When we visited Evergreen's crystal growth room, about 60 String Ribbon furnaces were working at once. Each cylindrical furnace is about 2 feet in diameter and 2 feet tall (0.6 x 0.6 m). Hovering over each furnace is a 6 foot (1.8 m) tall, computer-controlled mechanism that pulls the strings and the ribbon out of the silicon melt. Housed below each furnace are two spools feeding the string into the bottom of the furnace. Each furnace has its own silicon reservoir to assure a continuous supply

Jack Hanoka shows off a freshly grown silicon ribbon.

of raw material. The setup is remarkably compact and only occupies a few square feet of floor space.

A single furnace is capable of producing about 100 KW of PV material per year. One person can operate twenty furnaces at once. Evergreen keeps their production line working around the clock, 360 days a year. We saw a second production line being assembled that will more than double production. Once this second production line is functioning, Evergreen should be able to produce close to 8 MW of PV modules annually in this 56,000 square foot (5,200 m^2) facility, which also contains R&D, marketing and sales, and administrative headquarters.

One of the advantages of the String Ribbon process over conventional wafer manufacturing is that there is no sawing of ingots into wafers. This means no loss of silicon to sawdust, or loss due to breakage of the wafer during sawing. And the technique results in a wafer as thin as any that can be obtained by sawing a boule into slices. The net result is that the String Ribbon technique reduces the amount of expensive hyperpure silicon necessary to make a PV cell by about 50 percent. It also significantly reduces the amount of energy input to the manufacturing process.

Evergreen Solar wasn't content to stop with the commercialization of the String Ribbon process. This process is just the very first step in making PV cells. Jack Hanoka and Jack McCaffrey examined all the subsequent, downstream processes necessary to turn a String Ribbon into a working PV module. Each step in the process was either simplified, or if possible, eliminated. And great attention was given to reducing the capital, energy, materials, and time it took to complete each step in PV cell fabrication. For example, Evergreen may be the only crystalline silicon manufacturer in the world that doesn't acid etch a wafer before the P-N junction formation.

Built from Scratch

Almost all of the production equipment used by Evergreen was designed by them and custom made for them. Jack McCaffrey, who oversaw the design and construction of the custom equipment, knows every detail of the production line like the back of his hand. He is an expert in handling thin and delicate objects (like PV cells and film), using robots that can "see" with sensors. He gave us a tour and pointed out the ways that Evergreen's process after the String Ribbon furnaces was new or different from the way that other PV makers accomplished these specific tasks.

We felt honored to view this production line, since we were the very first media people to be shown the entire line and have it explained to us in detail. In many cases, we were asked not to be too specific about what we saw and were told. The innovations here were radical, and solely due to the intelligence and hard work of the people at Evergreen. We agreed to respect their proprietary information and to not give away any industrial secrets.

After the silicon ribbon is pulled from the furnace, it enters a highly automated world where it is serviced by robots. We counted only two places on the cell fabrication line where the cells were actually touched by human hands. In contrast to normal PV cell fabrication where batch processing is much more common, Evergreen's process is largely continuous. The cells ride on a network of conveyor belts. Each process is performed on the cells as they continue their merry ride to become finished modules.

Just one hugely innovative example is the implantation of the phosphorous, which actually turns the raw silicon into a P-N solar diode junction. In conventional cell fabrication methods, this is done to batches of cells inside a gas-filled chamber. Evergreen does this with a specialized, continuous belt, diffusion process that requires no vacuum. This produces big savings in time and energy. Even the method of getting the metallic contacts on the cells was different, performed by robots, and far faster than conventional screen printing techniques. Jack McCaffrey and his crew of engineers and robots have produced a never-ceasing river of PV modules.

We were impressed at the levels of quality control (QC), happening all throughout the process, from String Ribbon to finished module. At each critical juncture of the process, the individual parts were tested and graded. The ribbon itself was tested as it was being pulled from the melt. The individual cells were tested for uniformity and performance at each critical stage, both electrically and visually by robots. And finally, the finished module was flash tested and an IV curve traced, printed, and attached to the module.

QC was very tight. Evergreen modules are made to a power rating tolerance of minus 4 to plus 10 percent, which is excellent when compared to much of the PV industry. In addition, every effort is made to make sure that modules average as close to the nameplate rating as possible. Evergreen uses the rated output as the target. From what we could see, Evergreen Solar comes very close to that target—they ship modules that average what they're rated at.

A Sunny Future

Evergreen is one of the first companies to approach PV manufacturing as a thing unto itself. Virtually their entire production line uses advanced technology. Most manufacturers are using many of the conventional fabrication techniques inherited from the semiconductor industry. Evergreen took a fresh look at PV manufacturing and designed their production techniques in light of just making PVs. This resulted in a more efficient, faster, and more environmentally friendly way to turn sunlight into electricity.

And the innovation continues. Not content to rest on their radically new way of making solar-electric panels, Evergreen is forging on. Jack Hanoka showed us prototypes of furnaces that can pull two ribbons at the same time. Plans for furnaces that can pull four ribbons simultaneously are in the works. They've also made R&D cells as thin as 100 microns. Still to be automated are the assembly of the strings of cells into encapsulated modules. Jack McCaffrey is further reducing human contact with the cells on the assembly line to increase cell uniformity and efficiency, and to further reduce cell breakage. We have the impression that the Evergreen folks are just getting started.

One of the beautiful things about PV is that it's a modular technology. Evergreen Solar's manufacturing process mirrors this. The String Ribbon process holds the distinct possibility of enabling the manufacture of solar-electric cells virtually anywhere in the world, and a company with this much technology, talent, and tenacity just might make it happen. We felt right at home at Evergreen Solar. We shared a common vision and a common goal: "We're going to change the world."

Access

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What the Heck?

Overcurrent Device

Used In: PV systems and other electrical wiring

AKA: Circuit breaker, breaker, fuse

What It Is: A device that protects wiring from too much electrical current

What It Ain't: A place to stick your finger

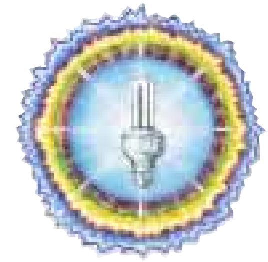
Overcurrent devices exist for a simple reason. Each size of wire can only carry a certain amount of electricity (electrical current). If you put too much electricity through a wire, it will start to overheat because of the resistance. A fuse will blow or a circuit breaker will trip if the current through the wire is too high. This prevents the wire from overheating and damaging the wire's insulation, which could possibly start a fire.

The *National Electrical Code (NEC)* specifies what size wire must be protected by what size overcurrent device in building wiring. In residential wiring, the smallest allowable overcurrent device for AC electricity is rated at 15 amps, and normally protects #14 (2.1 mm^2) wire. As the wire size goes up (as size goes up, wire gauge numbering goes down), the size of circuit breaker goes up accordingly. A #12 (3.3 mm^2) wire is normally protected by a 20 amp overcurrent device in residential wiring, a #10 (5.3 mm^2) wire by a 30 amp breaker, and so on. If you try to circumvent the protection of a fuse or circuit breaker, you are asking for trouble—this is truly the cause of many fires.

Chuck Marken, AAA Solar Supply Inc. • info@aaasolar.com

Circuit breakers are the most common overcurrent device used in homes and buildings.

Home Power's Business



"The man who on his trade relies, Must either bust or advertise."
Sir Thomas Lipton — 1870

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GUERRILLA SOLAR WANNABE

GUERRILLA SOLAR: The unauthorized placement of renewable energy on a utility grid.

PROFILE: 0024

DATE: October 1, 2002
LOCATION: 43°42.975′ N; 114°22.976′ W
INSTALLER NAME: Sun Valley Solar
OWNER NAME: Morgan Brown & Rebecca Bundy
INTERTIED UTILITY: Idaho Power
SYSTEM SIZE: 3,520 watts of PV
PERCENT OF ANNUAL LOAD: 110% (we hope)
TIME IN SERVICE: one billing cycle

Guerrilla solar partisan before armistice.

I've wanted to join the ranks of solar guerrillas ever since learning of the movement from the pages of *Home Power*: "Guerrilla solar is the unauthorized placement of solar electricity on the utility grid. It's safe, good for the environment, and bureaucracy-free."

Wonderful words. The stories of myopic utilities thwarting renewable energy pioneers made my blood boil. I've rejoiced at tales of persistent idealists doing their bit to protect the environment. I've even traveled widely to attend guerrilla-training sessions set up at special mobile camps in remote locations such as Custer, Wisconsin; John Day, Oregon; Hopland, California; and Carbondale, Colorado. I had the good fortune of hearing two live performances where Richard Perez—supreme commander of the movement—whipped the troops into a frenzy.

When it came time for my wife and me to plan our new house, I looked forward to joining the fray. Ours would be a solar house through and through. Clean electricity from the sun—a bounty we'd be proud to share with our neighbors. If the utility didn't like it… well, they just didn't have to know. I was prepared to take up arms (Sunny Boy 2500 grid-tie inverters in our case) and defend my right to produce and share green energy.

Sadly, life isn't always so simple. The first inkling that ours was not to be a guerrilla story came with the realization that our home would need to be fairly public. We could only justify the concentration of assets if the house served as a demonstration model for both my wife's architecture practice and my nascent solar business. The house would have to work hard to earn the money to pay for itself. Public display from a published address doesn't tend to be a trademark of guerrilla movements.

The second blow came with analysis of the local market for a solar business. My mountain valley is fairly remote—it's located in south central Idaho, and has a world famous name pretty close to "Solar Valley." Its residents have come from all parts of the globe to appreciate its beauty, recreation, and sun. Given the abundant resource, the available capital, and the green-minded nature of the locals, it seems an ideal place for a solar business. But alas, an essential percentage of potential clients are likely to balk at doing the right thing if it involves subterfuge.

Obstacles yes, but perhaps not insurmountable. Many an aspiring guerrilla has met and overcome greater adversity. Imagine my surprise when the clincher that pushed me toward undesired legitimacy came in the form of cooperation from my local utility. The bittersweet irony—foiled by collaboration with the enemy!

Arming ourselves with electrons—benevolent bullets that do good while packing tremendous potential to intensely annoy an intransigent foe.

As part of my initial reconnaissance, I had contacted the utility, careful not to reveal my location. I was directed to Scott Gates, an Idaho Power employee dedicated to supporting renewable energy issues. He was very helpful, even excited about someone in our area feeding solar electricity back into the grid. Apparently, we would be one of the first households in Idaho to do so. (That novelty refers, of course, to households with utility permission. I personally know of unpermitted sources of green electricity, but no amount of utility cooperation is going to make me talk.)

To qualify, we would just need to fill out a paperback-sized, 18-year-old form ("just ignore the 95 percent of questions that only apply to large commercial producers"), pay a US$100 administrative fee, and get a final electrical permit sign-off. Eventually, they even told me to forget about the form. That left only the US$100, but given that Scott was going to make the long drive from Boise for the inspection himself, it was pretty hard to complain. Heck, a good chunk of that money was going to go towards the fossil fuel needed to get him here. (Now if he were to drive a hybrid…)

The specifics of Idaho Power's net metering policy are pretty good. They don't pay a premium as they should for clean, distributed, peak power, but they do buy it back at retail, and they never zero out the accumulated savings in the account. Pretty seductive terms. I can build up a surplus in the summer and make use of it in the shorter days of winter.

The most tantalizing part concerned what else they'd do if I were in surplus. Scott told me that if I asked, they would cut me a check. That did it. Not only was I going to get to watch my meter spin backwards, but under the right conditions, the utility was going to send me hard cash for the pleasure. I didn't even have to bill them. My transition to the dark side was sealed.

The solar-electric system is installed now. Thirty-five, building integrated photovoltaic panels from Uni-Solar and two SMA inverters have been feeding on average about 20 KWH per day into Idaho Power's grid for nearly a month. We're a pretty slow-moving construction site right now, so they're getting almost everything we produce. Idaho Power wanted to do their inspection

Hazardous guerrilla activities. Working high without nets and wiring in the dark. (The latter was done more to avoid SMA's high voltage array configuration, than infrequent utility patrols.)

Positioning the not-so-light artillery. If electrons are the ordnance, then these inverters are the assault rifles of choice for the well-armed green guerrilla.

Solar architect and guerrilla partisans after negotiated amnesty.

after final electrical sign-off, but I couldn't get that without testing the PV and inverters. Once I'd proved that they worked, it seemed a waste of resources to disconnect them. The electricians are slammed right now and the final keeps getting delayed. That means we've had no utility inspection or approval yet.

So for the time being, I'm a solar guerrilla. The rebel in me gets some satisfaction after all. As I wrote this today, a utility truck pulled up, and a young man with an official note pad disappeared around the side of my house. I just kept typing. When he returned a few moments later, I did look up and check his demeanor. Nothing. He probably didn't notice which way the meter was spinning.

It's been fun, but I guess I better give Scott a call tomorrow and negotiate an end to my brief stint as a guerrilla, before somebody in accounting asks how they are supposed to bill a 450 KWH surplus. I'm pretty sure what my terms of surrender are going to be. At today's utility rates, I figure a check for about US$31.50 from Idaho Power made out to Sun Valley Solar ought to do it. I think I'll frame it.

Access

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Guerrilla Solar Defined

Energy is freely and democratically provided by Nature. This century's monopolization of energy by utilities both public and private threatens the health of our environment. Solar guerrillas believe that clean renewable energy should be welcomed by utilities. But utilities and governments continue to put up unreasonable barriers to interconnection, pushing common citizens to solar civil disobedience. Guerrilla systems do not endanger utility line workers (see *HP71*, page 58). They share clean, renewable energy with others on the utility grid, and reduce the need for polluting generation plants. When interconnection for small-scale renewables becomes fair, simple, and easily accessible to all, there will be no more need for guerrilla action.

Backyard Solar Electricity, Made Simple

Mickey Mestel

I wanted to install a utility-intertie system on the house that we rent, but that was the problem—renting. The desire for a system was born from the belief that we must make use of the vast resources of renewable energy before we waste the planet by using up the nonrenewable resources.

While relations are great with our landlord, you never know when a rental situation can change. So we really had no idea how long we would be here. It just didn't make sense to sink thousands of dollars into a permanent system if we might have to move out two months after it was finished. The rebate program in Palo Alto, California, where we live, also required that the installed system stay on the structure for a given number of years.

Starting Small

So it occurred to me to set up a small system and get some 12 volt DC lights. We could light up the back porch, where we spend a lot of time in the evenings when the weather is nice. That would allow me to do a couple of important things—get some experience in setting up a solar-electric system, and at least do something with a technology that I believe in so strongly.

I started out with the folks at Real Goods, and we quickly designed a small system that would do what I wanted. I purchased a Uni-Solar 32 watt panel; a UniRac top-of-pole mount; a Morningstar SunSaver 6 amp charge controller; a 32 amp-hour, sealed gel-cell battery; and two, 12 volt, 13 watt fluorescent bulbs in outdoor enclosures. The pieces started arriving, and I read the little bits of documentation that came with them. Between reading *Home Power* articles and talking with the guys at Real Goods, I got a fairly good idea of what I needed to do to set this all up.

System Installation

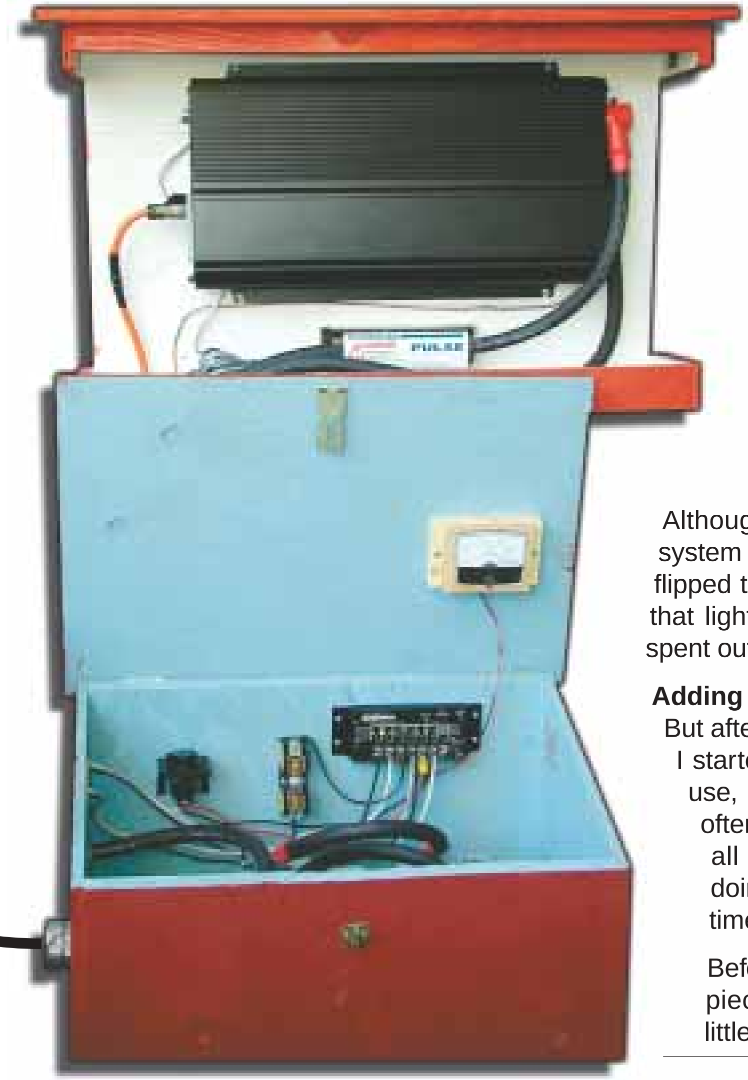
A week or so later (just days after the birth of our first son!), my father was out to visit, and we went at it. He has years of experience wiring and building, and is just finishing a small, solar powered cabin in the Colorado Rockies. So I had everything I needed—tools, experience, desire, and lots of little things to hook together!

The system is very straightforward. The Uni-Solar panel is attached to a UniRac top-of-pole mount, which is secured to a 1 1/2 inch (38 mm) steel pole. The pole is bolted to a 4 by 4 post that supports the trellis above the porch area. Although the techs at Real Goods told me to use #10 (5 mm^2) wire, Pop said that he was sure that #12 (3 mm^2) would be fine for the short distance (24 feet; 7.3 m) that we were covering, so UV and moisture resistant #12 copper USE wire it was. This was also easier to work with!

The panel output is fed to the Morningstar controller, which is the right size for my needs. It's rated for 6.5 amps at 12 VDC, and the PV's rated output is 1.9 amps. It has a low voltage disconnect (LVD), so I don't have to worry about draining the battery if I leave the lights on all night. It also has terminals for a small DC load circuit right on the controller, which makes for easy wiring.

The charge controller has three sets of connections, each with a positive and negative lead. The first is labeled "solar" for the connection from the solar-electric array, the second is "battery," and the third is "load." The main load consists of the two, 13 watt lights, with the circuit running from the "load" terminal, through a switch, and to the lights.

The 32 watt Uni-Solar PV is mounted on a Direct Power top-of-pole mount that is secured to the back porch's grape arbor. Two power boxes house the inverter, batteries, charge controller, overcurrent protection, and metering.



Mestel System Loads

AC System Loads	*Watts*	*Hrs./Day*	*WH/Day*
Champion juicer	672	0.17	114
Vacuum cleaner	1,440	0.05	72
Blender	375	0.05	19
DC System Loads			
Outdoor lights	13	2.00	26
		Total WH/Day	231

One of the interesting things was the light switch itself. We couldn't find one rated for DC at any of the local hardware or even electrical supply houses, and readily available AC switches aren't rated for the higher arcing potential inherent in DC circuits. So we ended up pulling a decades old switch from the garage and using it, and putting a modern switch in the garage. Some older AC switches from before the age of "silent" switches had a switching mechanism and contacts that stand up to DC arcs. Another DC load is our Accucell household battery charger, which plugs into a cigarette lighter receptacle and charges AAA, AA, C, and D cells.

We wanted to use as many recycled materials in the project as we could. So we rummaged through scrap piles at a local building site and came up with enough 1/2 inch (13 mm) plywood to build a box to house the system. I had a feeling that we'd want to add a second battery to the system, so we sized the box with this in mind.

The charge controller, battery/controller fuse, DC receptacle, and household battery charger all fit into the box. A slanted, hinged top protects the system components from the elements. The finishing touch was a coat of bright red paint.

Although Pop had to leave after one day, we had most of the system hooked up. I finished all the connections the next day, and flipped the switch. I must admit, it was a really nice feeling seeing that light come on and knowing that from now on, our evenings spent out on the porch would all be lit with the power of the sun!

Adding AC Loads

But after a few short weeks, and some chiding from some friends, I started to realize that while the system did indeed have some use, besides the instructional aspect, it was fairly limited. How often are we really going to use the lights? It made me think of all that energy being stored in the battery, and the panel doing nothing more than topping the battery off most of the time.

Before this, I had thought of inverters as multi-thousand-dollar pieces of equipment, something much too involved for my little application. But I started doing some checking around,

Left: Top-of-pole PV mount fastened to grape arbor.

Center: Battery box with gel-cells, fuse, and charge controller.

Right: Inverter, GFCI receptacle, and Class-T fuse.

Mestel System Costs

Item	*Cost (US$)*
StatPower ProWatt 1750 inverter	$354
Uni-Solar panel, 32 W	261
2 Floodlights, 12 VDC	151
UniRac U-22 top-of-pole mount	139
Wire, bolts, washers, hardware	93
Real Goods Solar Gel Battery 12 V, 32 AH	75
Real Goods Solar Gel Battery 12 V, 32 AH	71
Morningstar controller, 12 V, 6 A	57
Fuse & holder, class T, 200 A	52
Inverter cables, #2/0, 5 ft.	47
Battery interconnects, #2/0	35
Fuse & holder, 30 A	9
Outlet, DC lighter type	6
Total	$1,350

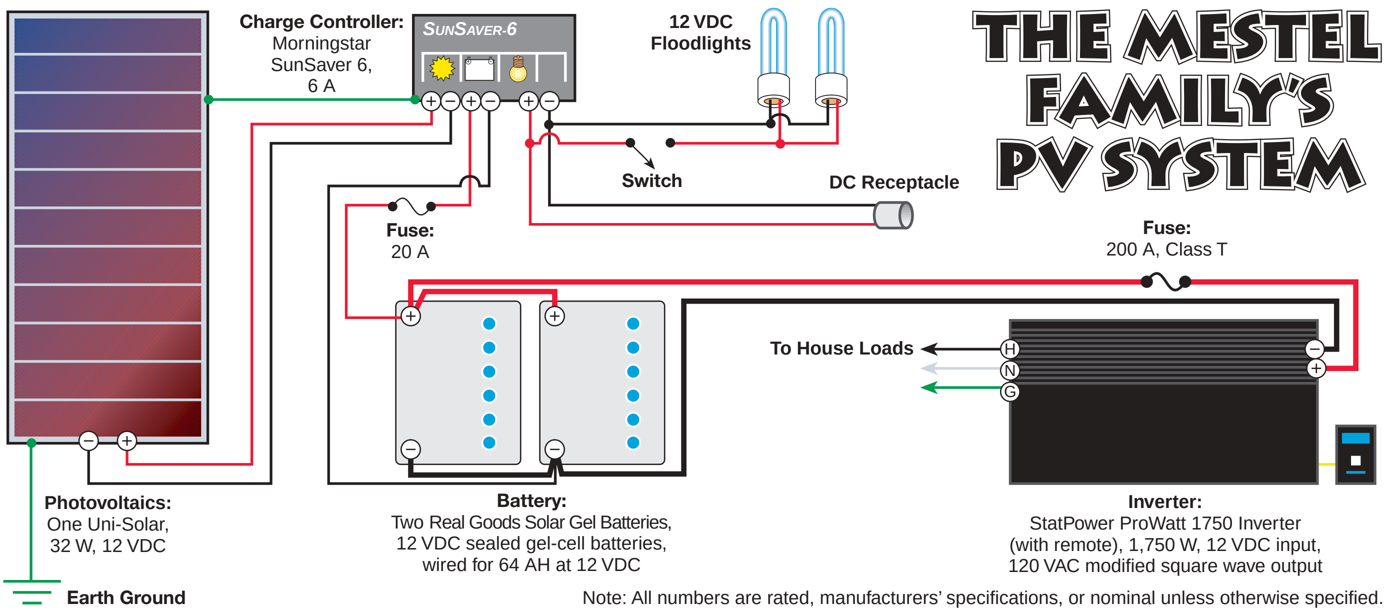
and sure enough, found that there are inverters from about 40 watts on up. My idea then was to add an inverter, run an extension cord in through the kitchen window, and power the blender and juicer from it.

I checked with the people who make the Champion juicer we own, the bigger of the two loads, and found out that there is no problem running the juicer on a modified square wave inverter. They recommended, since the juicer can pull up to 1,200 W or more at startup, that I have at least a 1,500 W inverter. After a little research in *Home Power,* and then some digging around on the Net, I found the perfect solution—the StatPower ProWatt 1750. The price was right, so I went for it.

Another trip to a local building site produced more $^1/_2$ inch (13 mm) plywood, and off I went. I ran into two small issues while putting the second phase of my project into action. I hadn't counted on the space needed for cables as large as the #2/0 (67 mm^2) that I decided to use for the 5 foot (1.5 m) run from the battery to the inverter, nor for the 200 A fuse and holder that are needed for the inverter. Although the fuse is supposed to be installed as close to the battery as possible, I ended up having to put it much closer to the inverter. Since there simply wasn't enough space in the battery box, I built the second box to hold the inverter and the fuse. The cables were a tight fit in the battery box, but after a little wrangling, I managed to get them in.

The inverter has a remote on/off switch, which connects to the inverter with standard telephone wire and an RJ-11 connector. So my plan was to run that wire and an extension cord though the window and into the kitchen. I was going to build the bottom of the window sill up with a piece of wood and some foam strip insulation on top with a slot for the wires. But the window ended up sitting higher up than I planned, and then wouldn't seal well with the stationary top part of the window. So it was looking like more trouble than it was worth. But hey, a little sheetrock, putty, and plaster will fix all sins. I drilled a hole through the wall and ran the wires through, sealing each side with a rubber grommet and some silicon.

I calculated the load I expected to draw, and sure enough, I needed one more 32 AH battery. One more battery, a couple more #2/0 (67 mm^2) cables, and yes,



the battery box is getting full! But the system is together now, and works quite well. It is also very modular. I can disassemble the whole thing in about two to three hours, so we can take it with us when we move. We plan to find a piece of land and build an off-grid, straw bale home. This little system could be set up in a few hours to provide us with on-site electricity for hand tools and such, as well as for lights.

Lights at night—the RE powered 12 VDC floodlight is plenty bright.

One last addition—I'm going to add another 32 W panel, since if I really draw the batteries down, the one panel won't recharge the battery in one day. But that's the last thing I'm going to do, really. Well, besides the voltmeter, and gee, I need an amp-hour meter too, and maybe a disconnect would be nice on the DC side, and well, probably the AC as well, and a real control center would be cool... This is getting to be a little intoxicating!

Using the Sun

Now that the system is up and running, we find ourselves making as much use of it as possible. Besides the blender and the juicer coming off of the three-way receptacle on the end of the extension cord, we also have a charger for our cell phones. The vacuum cleaner has become a favorite to run off the system as well, even though it is a huge draw. (Ours draws 12 amps, as is so proudly displayed on the front cover!) Anything the system is large enough to power is fair game—Carol's breast pump to extract milk for our newborn, the food processor, ice cream maker, etc.

In essence, now that we have it available, we try to make as much use of our free, stored electricity as possible. The only problem is that I try to run too much off of it, and only want more! I'm constantly looking for one more little thing to power without overextending the system. I tried to run the computer all day, but that drained the batteries below 11 volts (which I swear I won't do again!).

Mickey Mestel using his RE system's "juice" to power the family juicer.

The system has worked out very well. I wanted to do this to learn, and to put my energy where my mouth is. It has been a wonderful learning experience, and my juice is free and sustainable! I am just waiting for the day when our situation allows us to put up a full array, and get all of our electricity from the sun.

Access

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www.realgoods.com • PV system components

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Fax: 215-321-4458 • info@morningstarcorp.com
www.morningstarcorp.com • Charge controller

Northern Arizona Wind & Sun, 2725 E Lakin Dr., Flagstaff, AZ 86004 • 800-383-0195 or 928-526-8017
Fax: 928-527-0729 • windsun@windsun.com
www.solar-electric.com • Inverter cables & fuse

Palo Alto Hardware, 875 Alma St., Palo Alto, CA 94301
650-327-7222 • info@paloaltohardware.com
www.paloaltohardware.com • Wire and all hardware

UniRac, Inc., 2300 Buena Vista Dr. SE, Suite 134, Albuquerque, NM 87106 • 505-242-6411
Fax: 505-242-6412 • info@unirac.com
www.unirac.com • Top-of-pole PV mount

Xantrex Technology, Inc., Distributed Power Markets, 5916 195th St. NE, Arlington, WA 98223
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inverters@traceengineering.com • www.xantrex.com
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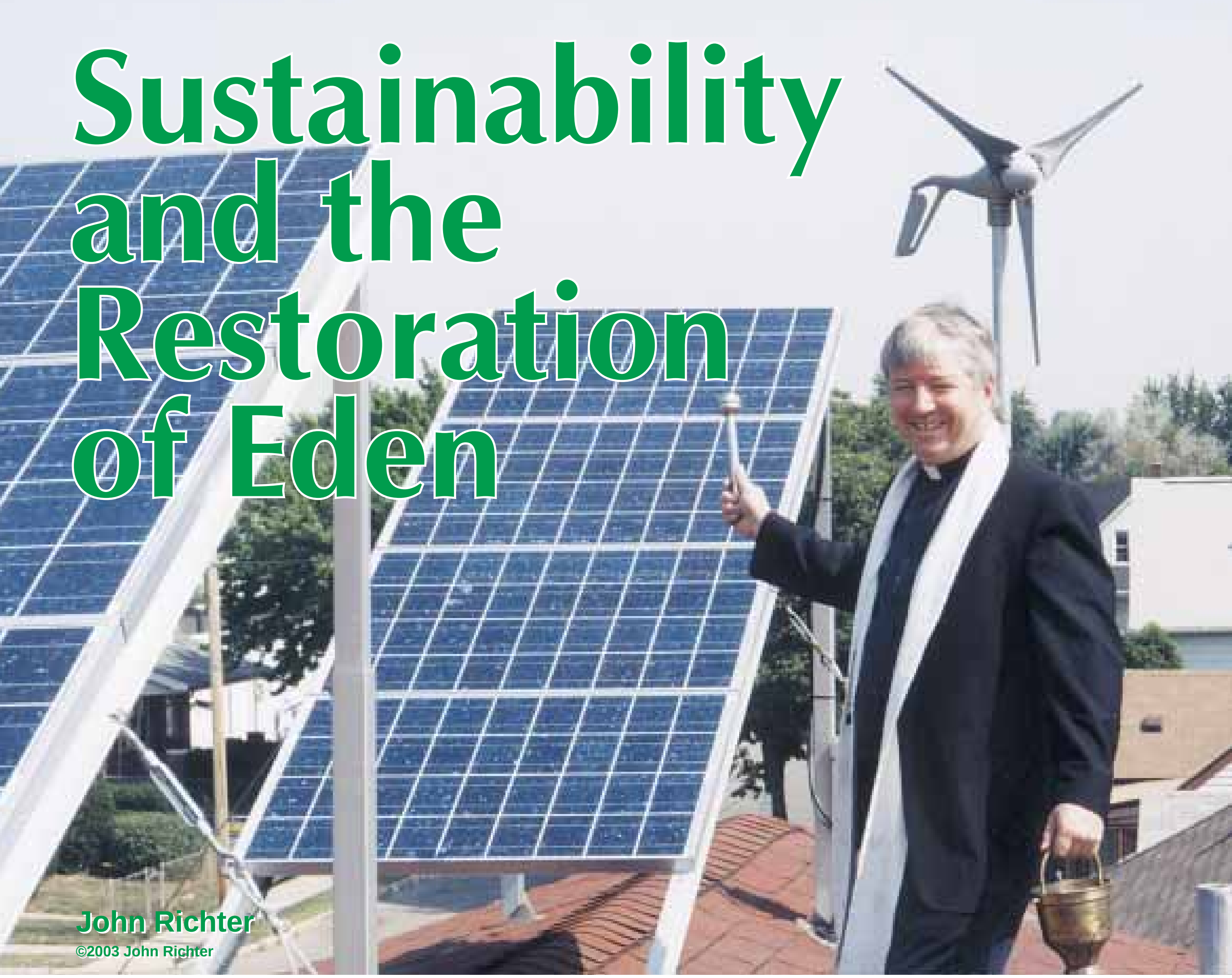
Sustainability and the Restoration of Eden



John Richter

Father Charles, on the roof of the rectory, blesses the PV panels with holy water.

Harnessing solar energy is not just functional, but deeply spiritual. By exploring the demands that our lifestyle puts on the rest of the world, we can rediscover our connection to everyone and everything that surrounds us. How can we worship a creator while destroying creation? Humanity is a part of, not apart from, creation. This adage has been well proven at St. Elizabeth's Catholic Church in Wyandotte, Michigan.

This working-class residential suburb of Detroit doesn't enjoy the intense solar insolation of the American Southwest, or the winds of the Great Plains. But it has a great resource in the dedication of St. Elizabeth's Father Morris to demonstrate sustainability and restore the Garden of Eden. With this parish achieving nationally recognized energy effiency, and installing a triple-hybrid system—PV, wind, and solar hot water—Eden is getting a bit closer.

A Mission

"It's a question of how to do justice and save money for other programs," says Father Morris, St. Elizabeth's priest and resident of the solar powered rectory. Father Morris is a member of the Michigan Interfaith Climate Change Campaign. This organization is working to unite people of all faiths to "take action together—on public policy, in our congregations, and in our homes and daily lives." True to this pledge, he continues to look for opportunities to cut energy usage and trim utility bills.

St. Elizabeth's Catholic Church RE System Loads

Item	*Qty.*	*Watts*	*Hrs./Day*	*WH/Day*	*Days/Wk.*	*Avg. WH/Day*
Office lights	16	32	2.5	1,280	6	1,097
Humidifier	1	28	12.0	336	7	336
TV	1	150	2.0	300	6	257
Living room lights	3	15	4.0	180	7	180
Bedroom lights	1	32	4.0	128	7	128
VCR	1	40	2.0	80	1	11
Uncorrected Avg. WH per Day						2,010
Total Avg. WH per Day (Corrected for 70% Efficiency)						2,871

First came cost-effective, energy efficiency measures—a must before relying on solar electricity. These measures resulted in the church receiving a Department of Energy (DOE) Energy Star congregation award in October 2001. Each year, the DOE recognizes a few churches in the country (five in 2001), based on energy savings, benefits to the congregation, local media coverage, and recommendations the church can make to other congregations considering energy efficiency.

The parish is considered a small business customer by the Wyandotte Municipal Utility. Business customers pay a "demand charge" each month, based on their highest power demand during the previous 12 months. This is a common practice in the Midwest. Each KW of peak demand costs the parish US$7.34 each month. This demand charge makes up 60 percent of the parish electricity bill.

Primarily through energy efficiency, the parish has cut its peak usage from 106 KW in 1996 to just 43 KW last year, a reduction of 60 percent. This frees up thousands of dollars every year for church programs. If they can drop peak usage below 25 KW, the demand charge will drop to zero. The need for summer air conditioning makes this quite a challenge.

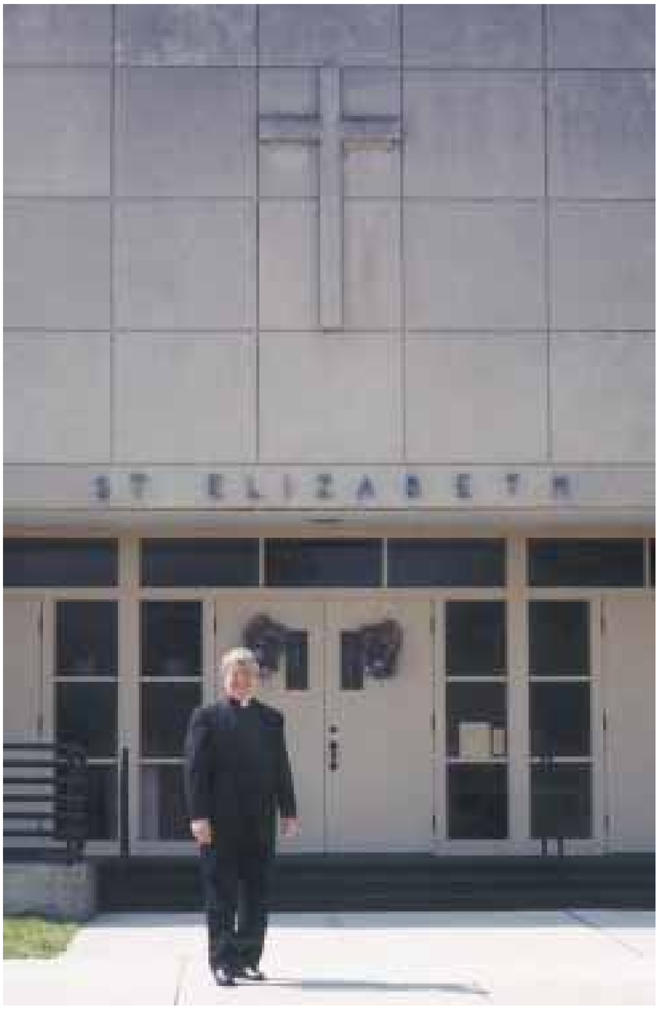
While these steps towards efficiency reduced the church's operating expenses and utility plant emissions, they were invisible to the surrounding community. This led Father Morris to inquire into a more visible example of the parish's commitment to preserving creation—a solar and wind powered electric system. "A visible symbol speaks louder than words," says Father Morris. "Since churches and schools are stable institutions in communities, they can take a long-term view on paybacks," he adds.

Through a series of contacts, Father Morris found Philip Holdom and his company, Alternative Power Solutions (APS). APS is based in Eastpointe, Michigan, on the other side of Detroit from St. Elizabeth's. Phil is a licensed contractor, and has been installing solar energy systems since 1991. APS caters to missionary organizations, installing and servicing systems worldwide. Their systems have been installed from Alaska to South America. Phil recently installed a PV powered ultraviolet water purification system in the Bolivian jungle. Ayore Indians can now drink clean, potable water for the first time, but that's another story.

The Project Begins

Phil and Father Morris had a few meetings in early April 2001 to define the scope and siting of the project. Father Morris had hoped to put the system on the garage roof when it needed new shingles, but the orientation was wrong. Both the rectory and the garage roof ridges run north-south, so there is no south-facing roof surface. As a result, both systems are mounted on a rack on the

St. Elizabeth's—solar on God's house.



Solar Array Sizing

Item	Amount
Loads, WH per day (from loads table)	2,871
Insolation, sun hours per day	4.5
PV needed, Wp	638
PV panel rating, Wp	80
Panels needed	8

Battery Sizing

Item	Amount
Loads, WH per day (from loads table)	2,871
Design autonomy, days	4
Storage needed, WH	11,484
Depth of discharge (50%), WH	22,968
Temperature derated (10% at 60°F), WH	25,520
L-16H battery capacity (395 AH), WH	2,370
Batteries needed	11
Sets of four for 24 V	3

roof ridge, making them quite conspicuous. Father Morris likes the fact that they are prominent and visible.

They agreed to a hybrid system combining PVs and a small wind turbine. Later, a solar hot water system was added. The whole system has been publicized to 34 catholic high schools in Michigan. Students come by the busload to tour the church installation!

Michigan doesn't have a net metering law, and feeding electricity back into the grid requires dual meters and pays a very low "avoided cost" rate. So four of the rectory's circuits were isolated to an AC subpanel to run off the hybrid PV/wind system. These four circuits power the parish offices and part of the priest's living space. The office's efficient T-5 fluorescent lighting, computer, and printer are all on the off-grid system, providing an excellent example for visitors. It's a stand-alone system within a grid-connected building.

The church's rectory houses Father Morris, and a couple who live upstairs. Pam, the parish secretary, works there during the day. The renewable electrical system powers most of the first floor of the rectory, including the church offices. Church business, conducted on renewable energy, continued right through a three-day city power outage last winter. "What's different now, living with solar energy systems?" I asked the reverend. "Nothing," he answered without hesitation, "the computer and stereo work just fine." This is a marvelous case of the dog that didn't bark.

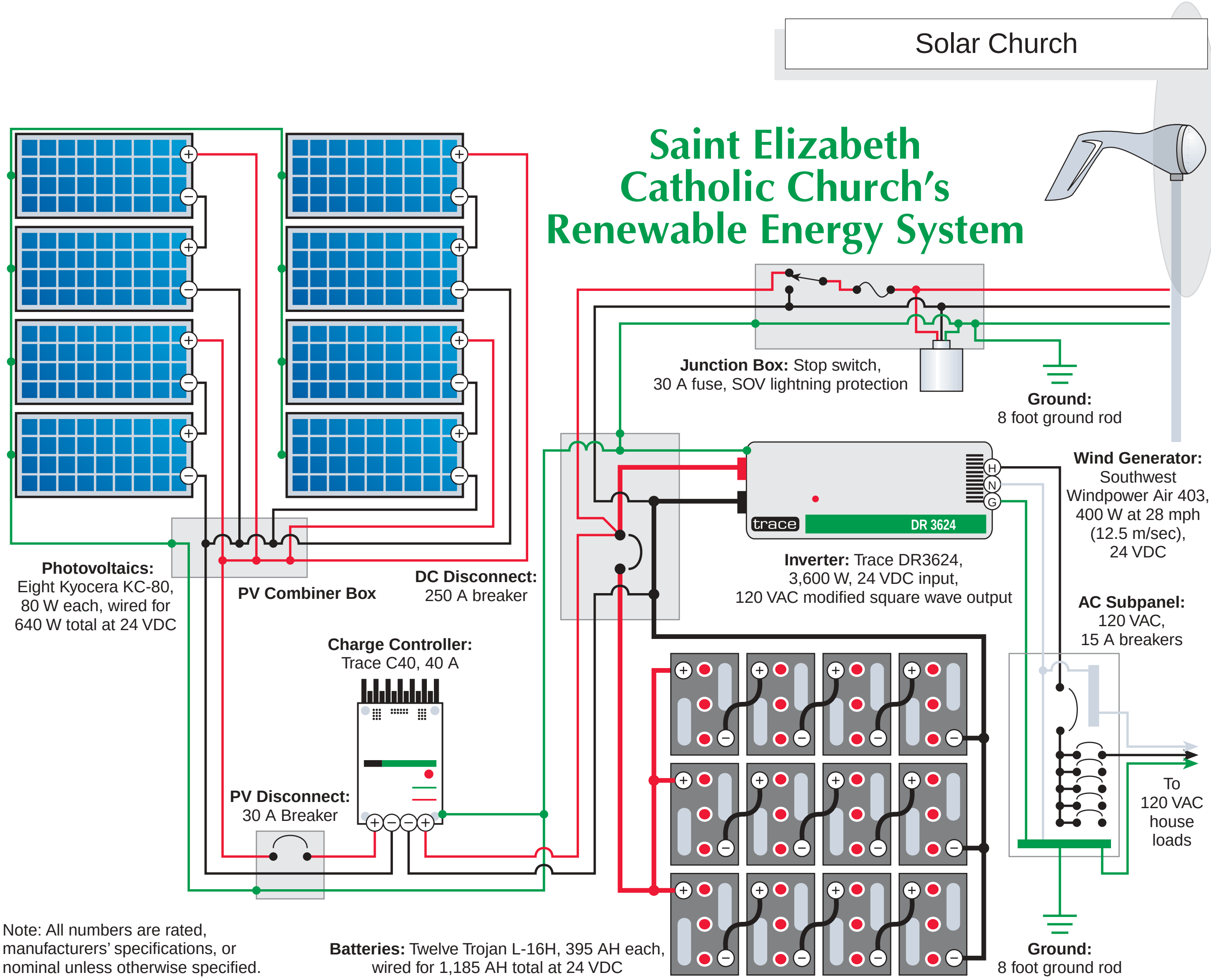
Mark Grybel lives across the street and thinks the whole project is "a great idea." He really saw the light during last winter's power outage. With no electricity, his gas furnace had no blower to heat his home, and it got "mighty cold." He says he occasionally hears the noise from the wind turbine when the wind is strong, but "it's not as loud as the trains," which they're used to in this urban area.

Electrical System Details

This hybrid system combines 640 watts of Kyocera PVs and a small Southwest Windpower Air 403 wind turbine. The Air 403 is rated at 400 W in a 28 mph (12.5 m/s) wind. The eight PV panels are mounted on two seasonally adjustable racks on the rectory roof, facing south. Their 24 V output runs through a Trace C40 charge controller and a 30 A fused disconnect to the battery bank.

The battery bank consists of twelve, Trojan L-16H, deep-cycle batteries (395 AH each). Three series strings of four L-16s are wired in parallel for a total capacity of 1,185 AH at 24 VDC. The battery bank is sized to last four days without charging. The batteries

The power room is set up for demonstrations, and has been visited by bus loads of high school students.



are housed in a vented battery box because flooded batteries produce explosive hydrogen when charging.

The Air 403 wind turbine is mounted directly to the north rectory wall. Southwest Windpower offers a special mounting kit for this kind of installation. It includes rubber isolators to reduce tower vibrations passing into the building walls. The turbine is sleek and surprisingly light at only 13 pounds (6 kg). The Air 403 is wired through a junction box that houses a lightning arrestor, overcurrent protection, and a stop switch for the turbine. The 24 VDC wind turbine is internally regulated, and is wired directly to the batteries.

Battery output is connected through a DC disconnect to a Trace DR3624 modified square wave inverter. That's 3,600 watts of AC output from the 24 VDC battery bank. A temperature sensor located in the battery box enables the charge controller to adjust the regulation voltage, based on the temperature of the batteries. The inverter is connected to the AC loads via an AC subpanel. Phil says that the electrical inspector largely ignored the DC part of the system and focused on the AC connections.

Unfortunately, there is no metering on this system. So there's no way to tell just how much of the load the two generating sources are covering. Considering the marginal wind resource in southeast Michigan at the rooftop level, I'd guess that the PVs carry the lion's share.

The charge controller, DC disconnect, inverter, and AC subpanel are all wall mounted in the basement of the rectory, to the right of the battery box. Since education and outreach are important goals of this system, it's set up to accommodate student tours. The area is roped off for safety, and a counter in front of the power systems is covered with free handouts of various RE and efficiency articles for visitors to take home.

This system was installed in stages. It was fully operational in early June 2001, and was christened on June 10th. The system is modular, so the church can add additional panels and batteries as their budget allows.

The Sun Heats Their Water

Like most buildings in southeast Michigan, the church

St. Elizabeth's Catholic Church System Costs

Wind Generator	*Cost (US$)*
Air 403 24 V	$670
Wind junction box, WJB-24	275
Roof Mount Kit, TOW-RA	155
Solar-Electric Array	
8 Kyocera KC-80 W	3,912
2 Kyocera KCS-5-20/40 adjustable rack	584
Fused array disconnect TG3221R, 30 A	119
6 Module interconnects, #10-2, 30 inches	87
2 Module interconnects, #10-3, 30 inches	37
2 Module output cables, #10-2, 10 feet	32
Breaker, FRN-R30, 30 A	4
Inverter	
Trace Power Panel, PPC1-DR3624/S with controller	2,886
2 Inverter cables, #2/0, 5 feet	79
Load Center	
Subpanel, LC-6-100	53
2 Breakers, Q0-115 15 A	28
Batteries	
12 Trojan L-16H batteries, 6 V, 395 AH	2,580
11 Battery cables, #2/0 x 12 inches, black	121
Battery temperature sensor, BTS15	29
2 Battery cables, #2/0 x 12 inches, red	22
Subtotal	$11,673
Shipping	584
Installation & Permits	2,250
Total System Price	$14,507

gets its heat and hot water from natural gas. And like most areas of the country, gas prices here jumped recently—40 percent in 2000. The rectory's gas consumption was reduced sharply by installing a closed loop solar hot water system.

The rectory had a standard, 40 gallon (150 l), gas-fired water heater. To reduce gas use, two solar hot water panels from Thermo Dynamics Ltd. are mounted on the roof of the rectory garage. They have a small PV panel to provide electrical power for the pump. A water/antifreeze mix circulates in a closed loop system, heating water in a storage tank via a heat exchanger. Cold water flows through this 50 gallon (190 l) tank first, then to the gas hot water tank, and finally out to the faucets.

The two panels have 64 square feet (6 m^2) of collector area, and provide 100 percent of the rectory's hot water during the summer. Other than the office, the rectory is a small home, with the usual requirements for hot water for bathing, washing, and cooking. A grant from the state of Michigan to support solar education covered US$4,200 of the US$5,000 cost.

The Future of the Mission

This system has generated considerable media interest. It was covered on the Great Lakes Radio Consortium and in the *Detroit Free Press.* U.S. Congressman David Bonier came to the christening, and the story was covered on the evening news. Father Morris blessed the panels and the turbine with holy water on a sunny, still day. As he issued the blessing, the wind came up and the turbine started spinning!

Hundreds of high school students have toured the facility, and have seen the church in action. "Global warming is the greatest moral challenge in our century," Father Morris proclaims. But he's not just lecturing; he's practicing what he preaches. Leadership speaks so much louder than just words.

Father Morris explained that 27 churches in the Sacramento, California area have PV panels, and many have ground source heat pumps. There are five with 2001 Energy Star Congregation awards. But St. Elizabeth's is the only U.S. church with a triple-hybrid system—PV, wind, and solar hot water. Father Morris has higher goals yet. He'd like to be completely off the grid, and inspire all those around him. "If it can work here, it can work anywhere," he says. "The potential is endless." Amen to that!

Access

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www.stelizabethch.org

Alternative Power Solutions, Philip Holdom, 19131 Veronica St., East Pointe, MI 48021 • 248-765-8786
Fax: 586-777-5416 • aps@qcinet.net
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Interfaith Climate & Energy Campaign, 110 Maryland Ave NE, Suite 108, Washington, DC 20002
202-544-5530 • dgrace@nrpe.org
www.protectingcreation.org • MI Campaign Coordinator, Kim Winchell • kwinch5940@aol.com

Southwest Windpower (SWWP), 2131 N. First St., Flagstaff, AZ 86004 • 866-807-9463 or 928-779-9463
Fax: 928-779-1485 • info@windenergy.com
www.windenergy.com • Wind turbine

Trojan Battery Co., 12380 Clark St., Santa Fe Springs, CA 90670 • 800-423-6569 or 562-946-8381
Fax: 562-906-4033 • marketing@trojanbattery.com
www.trojanbattery.com • Batteries

Kyocera Solar, Inc., 7812 East Acoma Dr., Scottsdale, AZ 85260 • 800-544-6466 or 480-948-8003
Fax: 480-483-6431 • info@kyocerasolar.com
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The Strong, Silent Type: The Gorilla

Shari Prange

If you want a decent little electric car for basic local commuting and errands, a converted Rabbit or something similar fills the bill nicely for a lot of folks. But if you want to keep going after the pavement ends, to get down and dirty for some serious work, you want a different kind of critter. You want something maybe not as quick as a bunny, but more muscular—something like a 550 pound Gorilla.

Son of a Burden Carrier

The Gorilla is the brainchild of Rick Doran. His business card lists him as the "Head Gorilla" of Gorilla Vehicles. However, for several years, Rick worked for various manufacturers of industrial burden carriers (utility vehicles). After working with these heavy duty steel carts, Rick felt that there had to be a better way.

He recalls one incident in particular that shaped the Gorilla. He and two of his bosses were calling on a resort hotel client who had several of their carts. The client related how a driver had accidentally backed a cart into a new Honda in the parking lot, and it "opened that Honda like a tin can." Rick's bosses were pleased to note that there wasn't any significant damage on the cart, but Rick kept thinking, "What about the poor Honda owner?"

He began to think about how he would design an industrial cart. It would be powerful and sturdy, yet nimble. It would be kind to the environment, and to any pedestrians or other vehicles it might accidentally contact. From this beginning, the Gorilla was born, and entered the marketplace in early 2000.

What Is It?

The Gorilla is a four-wheeled, two-wheel-drive electric utility vehicle. Rick explains that it is not technically an ATV (all terrain vehicle) because, by legal definition, an ATV cannot carry more than one person, and the Gorilla carries two. However, it can do a lot of the same tricks as an ATV, and more, but it does them without the noise and fumes.

The Gorilla is configured so that the driver and passenger straddle it. It has handlebars much like a motorcycle. It stands 37.5 to 39 inches (95–99 cm) tall to the top of the handlebars, depending on tires, and 70 inches (178 cm) long, or 81 inches (206 cm) with the long bed or enclosed box options. At less than 3 feet (0.9 m) wide, it will fit on a sidewalk, and can squeeze into places a golf cart can't go.

The body is made from high-impact polyethylene, the same kind of plastic that is used to make portable ice chests and kayaks, so paint and rust are not an issue. This durable material can take severe abuse without denting. Rick tells of one customer who drove a Gorilla into a pole, putting a 3 inch (7.6 cm) deep crease in the nose. The crease popped out by itself, leaving no dent, just a surface scar.

The Gorilla performing at the Reno Air Races.

The Gorilla's smooth, rounded, and tough but flexible shape has no hard, sharp edges like a steel cart, so it is less likely to damage anything it might bump into. The body sits on a welded frame made of powder-coated steel tubing. Powder coating provides a much more durable finish than conventional paint, and is a much more environmentally friendly process. The Gorilla also includes the little things that make driving easier, safer, and more pleasant, such as rearview mirrors, a horn, parking brake, and even cup holders.

Drive System

The Gorilla is powered by a series-wound motor from Advanced DC Motors, rated for 6.5 hp continuous duty and 9.5 hp peak. This is the little brother of the motors found in most homebuilt EV conversions. It's directly coupled to the rear axle. A forward/reverse switch reverses the motor for backing up.

This is essentially the same drive system found in most golf carts. However, Rick chose a higher speed, higher torque version of the motor, and coupled it to the axle with a 14.86:1 gear ratio as compared to the typical 12.5:1 for a golf cart, giving it even more torque. The Gorilla boldly goes where golf carts fear to tread.

The speed controller is built by Curtis Instruments, which also builds larger controllers for street conversions. Safety features include a circuit breaker and an emergency kill button, as well as a charger interlock to prevent driving away while still plugged in. This is a relay that disables the "ignition" of the vehicle whenever the charger is plugged in.

Under the hood—the gorilla's battery bank.

The charging is done by an onboard charger. While the U.S. version uses standard 60 hertz, 120 VAC, the export model can accept 90 to 125 or 180 to 250 VAC and 50 or 60 hertz. The charger is compatible with both flooded and sealed, lead-acid batteries in several sizes. Charging time can be up to ten hours for a depleted pack, or less for a partially discharged pack.

The neighborhood electric vehicle (NEV) version has three, 12 V batteries for a 36 V system. It uses the Trojan SCS 200 model batteries, rated for 115 AH at the 20 hour rate. The Worker Gorilla has three, 8 V Trojan T875 model batteries, for a 24 V system. These are rated for 150 AH at the 20 hour rate. The different battery packs offer different levels of performance, which we'll look at a little later.

The Gorilla is a hard worker—but it doesn't eat much. It can use solar electricity for supplemental charging.

Let Me Count the Ways

Numerous options are available. The body is available as a short bed, long bed, a folding long bed (which can become a jump seat with handrails), or with a lockable storage box. A windshield with wiper and roof canopy are also available, and the Gorilla comes in red, yellow, or green.

The tire choices include road tires, turf tires, and knobbies. Each has been designed for optimum performance on a particular type of surface—pavement, grass, or off-road conditions. The differences are in tire width, diameter, and tread.

For serious work, there's a tow hitch and pin hitch option. On the other hand, for street legal use as an NEV, the full lighting package includes headlights with high and low beams, tail and brake lights, turn signals, and emergency flashers. The standard versions of the Gorilla range in price from US$5,750 to US$6,490, depending on configuration, with the various options available at additional cost. This is on a par with mid-priced ATVs and low-priced industrial carts.

Riding the Gorilla

So how does the Gorilla perform? As noted at the beginning, it's not as quick as a bunny, but it was never intended to be. The 24 V Worker has a top speed of 12 to 15 mph (19–24 kph), depending on tires. The 36 V NEV version can reach 20 to 25 mph (32–40 kph), well above the speed of a standard golf cart. Depending on the battery pack used, the Gorilla draws 40 to 50 amps at top speed on level ground.

For comparison, a conventional ATV has a top speed of 40 mph (64 kph) or more, so the Gorilla is not for the go-faster crowd. However, it is much faster than the typical industrial cart, which tops out at about 10 to 12 mph (16–19 kph).

When you depress the thumb throttle, the Gorilla leaps forward eagerly. In fact, new drivers should exercise caution until they get used to the quick response. Drum brakes are controlled by motorcycle-style squeeze levers on the handlebars. The range of the Gorilla, in general terms, is between 20 and 35 miles (32 and 56 km) on a charge. The exact range will depend on which battery pack the Gorilla has, what kind of terrain it is driven on, and what type of load it is carrying, or other work it is doing.

Depending on tires, the Gorilla can turn in a 15 to 17 foot (4.6–5.2 m) circle, making it very maneuverable. And unless it's carrying a load, it can climb grades of 30 percent or steeper, which would leave the ordinary golf cart panting and straining at the bottom.

The really amazing thing about the Gorilla is its brute strength for such a little guy. It can carry 650 pounds (295 kg) including the driver, and has a tow rating of 4,000 pounds (1,800 kg), almost eight times its own weight! This is much higher than the ratings for ATVs, and comparable to many industrial carts.

Uses for a Gorilla

Because of its versatile configurations, the Gorilla has many potential uses. Rick originally intended it for use in industrial settings, much like the industrial carts with which he was familiar. It is very well suited to transporting loads around a warehouse, or traveling to different areas of a work site.

The Gorilla has not had the industrial sales that Rick had hoped for, for reasons unrelated to its abilities. As with many electric vehicles, it's a matter of mistaken impressions. At trade shows, Rick has found that industrial customers almost avoid the Gorilla. They take one look at its small size and bright plastic body and think "toy." They don't get close enough to compare its actual power and durability to the steel carts they are familiar with. However, when Rick can get one into their hands, they love it.

The Reno Air Races found a Gorilla to be useful for towing small planes around the parking area. The Army Corps of Engineers has also found the Gorilla useful for towing and for laying cable, for which they previously used a Cushman cart.

One used car dealer bought one as a mobile service unit, outfitted with jumper cables, air compressor, and tools. When Rick checked back with the dealer to see how the Gorilla was doing, the dealer said it was just fine, except that the nose was getting a little scuffed. Puzzled, Rick asked how that was happening, as the plastic nose is pretty tough material. "Oh, you know," the dealer replied, "from pushing cars around the lot."

"You're *pushing* them?" Rick asked in amazement "You're supposed to *tow* them." The dealer had been using the little Gorilla to push full-size cars weighing

2,000 to 3,000 pounds (900–1,400 kg) with only the unprotected plastic nose of the machine, and all it had suffered was “scuffs.”

In the NEV configuration, the Gorilla is street legal in residential areas or planned communities as a local errand runner. Its legal qualification as an NEV also makes it eligible for some financial incentives.

Other uses for the Gorilla include security patrols, resort rentals, and golf carts. But probably its biggest market is proving to be small farms of up to 20 acres. It functions as a small utility tractor, able to carry bales of hay or sacks of feed, and go cross country where it’s needed. The Gorilla will accept most common garden tractor attachments.

The Gorilla is especially suited to off-grid folks, who often have some acreage to tend. Unlike a full-size electric vehicle, the Gorilla’s small battery pack won’t need to suck much juice from the RE system. The Gorilla can be charged from solar, wind, or hydro plants with an optional 50 amp Anderson connector mounted on the vehicle, ready to plug into the other half of the connector on the RE system.

How *Not* to Use a Gorilla

Even more than most EVs, the Gorilla is designed for a specific purpose. Most unsatisfactory experiences occur when a driver tries to use a vehicle for something other than its intended purpose.

If you are looking for a neighborhood runabout, you need to be comfortable with the straddle seating and motorcycle type controls on the Gorilla. Some people prefer a more car-like arrangement. You must also acknowledge that its top speed is 25 mph (40 kph), and it does not offer the weatherproofing of a fully enclosed vehicle. You will need to check laws for your area to determine whether the Gorilla is street legal for you, and what licensing requirements might be involved.

As a work vehicle, even the sturdiest example can be pushed beyond its design limits, and will fail. For example, even though the Gorilla can climb a steep grade, care should be exercised when carrying a load, since this raises the center of gravity. Travelling straight up or down slopes, rather than diagonally, will help prevent rollover.

Big Things Can Come in Small Packages

Electric utility carts have been around for a long time, but they have been built primarily for industrial users. As a result, their design has tended to be somewhat, well, industrial—boxy and made from steel. The Gorilla breaks new ground here with a design that is useful for both industrial users and just plain folks. It combines strength and durability with small size, agility, and a user-friendly body. The Gorilla could be just the thing to provide a little clean, quiet muscle around the homestead.

Access

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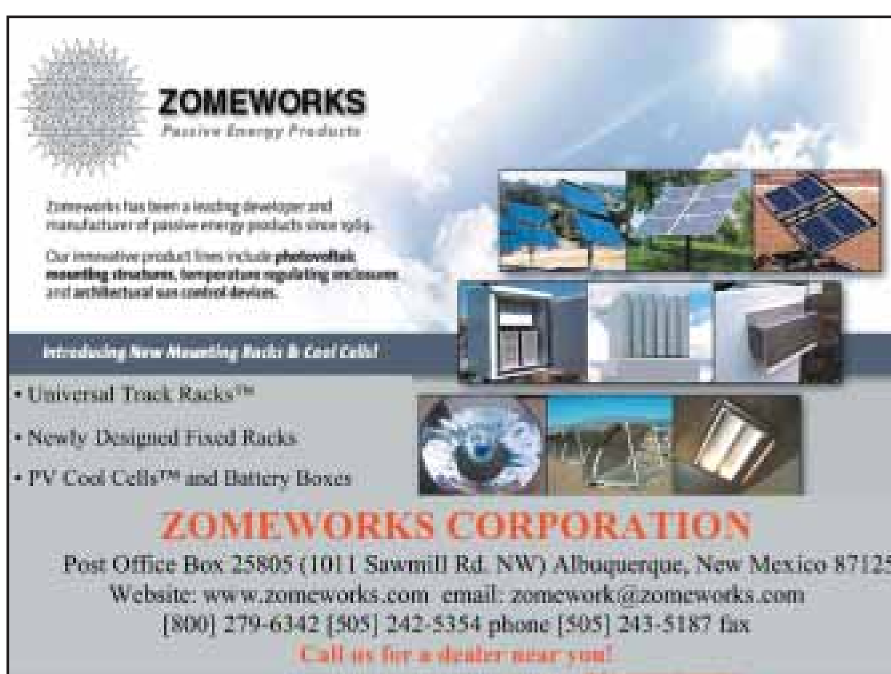

Owner's Guide to a Used EV—Part 1

Mike Brown

"I just bought a used VW Rabbit that was converted to electric with one of your Voltsrabbit kits," said the voice on the phone. "I put in a set of new batteries and it runs fine. The problem is that I lost the instructions to the battery charger. I don't know how to set it correctly to fully charge the batteries. I don't want to damage my new battery pack by over or undercharging it. Can you tell me what the right settings are?"

I get a lot of similar questions from new owners of used EVs. Since I wrote three columns telling you how to go about buying a used conversion EV, maybe a couple of columns on what to do after you have bought one are in order.

Getting to Know Your EV

The first thing to do is start a new logbook for your conversion. I'll get into more detail about what to put into the logbook later. For now, use it to record the make, model number, and manufacturer's contact information for each of the major components, such as the motor, controller, and battery charger.

You should already have most of this information from your pre-purchase inspection. Writing it down in one place will make it easier to find if you should need it. Having the correct model number of the component in question will eliminate wasted effort if you are troubleshooting a problem over the phone or by e-mail, and it will keep you from buying the wrong replacement parts.

Some of the documentation that should have come with the EV are the manuals or instruction sheets for the controller and battery charger. Study these documents and learn the features and operating limits for your components. Learn how to make any settings or adjustments you might have to make to tailor the component to your particular conversion.

If you didn't get these instructions and fact sheets, use the model numbers and manufacturers' contact information you gathered above and order documentation from the component manufacturers or one of their distributors.

If the person who did the conversion kept a project notebook, study it to find out if any special features are built into the car or truck. If this information was passed on verbally at the time of sale, record it in your logbook before it fades from your memory. If the conversion was done with a kit that included an assembly manual, study that in addition to, or in place of, the project notebook.

Do this reading *after* your first trip as an owner, so that the eagerness to get on the road under electric power doesn't make you only skim the documentation, and cause you to overlook something that might be important later.

Record Keeping—What & Why

I have mentioned keeping a logbook for the EV a few times already. Now let's look at what goes in it and why. An entry should be made in the logbook each time the converted car or truck is driven. This entry should include:

- Date
- Starting mileage
- Starting battery pack voltage (from your dashboard gauge)
- Destination (tells you the terrain and traffic conditions)
- Ending mileage
- Ending battery pack voltage

Why all the detail for each trip? Because a detailed logbook is the most important diagnostic tool you can have. Once you get into the habit, it only takes a couple of seconds to do.

If your dash gauge reads actual voltage rather than a percentage, you can subtract ending voltage from starting voltage, and then divide by miles driven. This will give you a very rough gauge of energy used from the battery pack. A higher than previous ending voltage reading for the same trip (which is why you record the destination) will show you how much a new battery pack's capacity grows as the batteries break in. It will also show how much your EV driving skills are improving.

The logbook can alert you to a potential problem as well. Since EVs usually make the same few trips each time they are driven, any change in the logbook entries will stand out. A lower voltage reading at the end of your usual trip could indicate a failing battery or some other problem.

A battery failure problem is most likely if the beginning battery pack voltage is also low, since a bad battery won't take a full charge. If the beginning pack voltage is the same as usual and a check of each individual battery's voltage at the end of the trip shows that all of the batteries in the pack are at nearly the same voltage, maybe you should look elsewhere for your problem. Some places to look are a low tire or a dragging brake.

If the previous owner kept a detailed logbook, a brief look at it might be useful. For instance, the changes in air temperature that accompany the changing seasons have an effect on battery capacity. Reading the old logbook will give you an idea of what to expect throughout the year.

Care & Feeding—Keep It Hydrated

The only part of a conversion EV that requires regular maintenance is the battery pack. How the batteries are cared for will influence their capacity and overall life. Most conversion EVs are powered with deep discharge, flooded lead-acid batteries, so I will limit maintenance instructions to this type.

The most important maintenance item is checking the fluid level. Gassing and fluid loss during the charging cycle are normal, and the batteries will need to be watered from time to time. If you are starting out with a new battery pack, you should check the fluid level once a month. Once you get an idea of what the fluid consumption actually is, you can lengthen the interval between checks to every two months. The batteries should be checked at least every three months, especially in the summer when higher temperatures might increase water consumption.

How much water to add and when to add it is as important as how often you check it. The battery is properly filled when the electrolyte level is $^1/_4$ inch (6 mm) below the bottom of the fill tube in the battery's top.

The fluid level should never be allowed to fall below the top of the plates. If the plates are exposed to the air, the battery's capacity is reduced and sulfation could start to damage the battery permanently. The sudden loss of range is the only warning of low water levels you will get from the batteries, and by then it will be too late. Check those batteries!

The batteries should only be watered when they are fully charged. This is because the volume of the fluid in the battery expands during charging due to the chemical reaction taking place and the gas bubbles that form on the plates at the same time. Topping off the batteries when they are discharged leaves no room for the additional volume of fluid to expand. The only place for the extra electrolyte to go is out the vent cap and onto the tops of the batteries.

Be Clean & Green

This talk of electrolyte on the top of the batteries leads into the next part of battery maintenance—cleaning. As mentioned above, a little gassing and fluid loss is part of the normal charging cycle. Over time, this leads to a thin coating of acidic electrolyte on the tops of the batteries.

If allowed to accumulate, this film becomes thick enough to start corroding battery terminals, interconnect cables, battery holddowns, and even battery racks. This corrosion, in addition to being an unsightly mess, can lead to short circuits, structural damage, and ground faults. (See *HP92* for the full story on ground faults).

Fortunately, battery top cleaning is just a matter of some rubber gloves, paper towels, a cleaning solution, and some elbow grease. The only one of the items above that needs any explanation is the cleaning solution. Some EV owners use a mild baking soda and water solution. That's a little too messy for my tastes. I have had good luck with both Simple Green general purpose cleaner and Windex window cleaner.

During the cleaning process, be generous with the paper towels and elbow grease, but stingy with the cleaner. The object of the cleaning exercise is to remove liquid from the battery tops, not add more. I usually do my battery top cleaning after I have checked and watered the batteries so I can mop up any water spilled during the refilling process.

Connections—Clean & Tight Is Right

While you are in there being up close and personal with your battery pack, you can tend to the remaining battery maintenance task. Checking the cleanliness, tightness, and condition of the battery terminals, interconnects, and the cables that lead from the battery pack to the other components is very important.

Neglecting the water level of the batteries can lead to reduced performance and shorter overall battery life. Not cleaning the tops of the batteries will give you an unsightly mess and a battery charger that won't work because of a ground fault. Not paying attention to the condition of the parts that make your batteries into a series battery pack and then carry that energy to the controller and motor may lead to being towed home, or at worst needing the services of the local fire department.

Corrosion or a loose connection between a battery terminal and an interconnect causes resistance. Enough resistance in a circuit that is carrying a 400 amp current can generate sufficient heat to melt a lead battery terminal, open the series circuit, and bring the tow truck, if you are lucky. However, if the molten lead or a newly free, swinging cable starts a fire, you have a bigger problem than just needing a tow truck.

When servicing your batteries, do not just grab a pair of ordinary wrenches and start tightening the battery terminal-to-interconnect nuts and bolts. Stop and make yourself some special battery wrenches. This is done by buying two combination open and box end wrenches that fit the nuts and bolts your EV uses. (Most battery hardware is 1/2 inch (13 mm) hex head, but you should check this before you buy the wrenches.)

Next, cover one of the wrenches with electrical tape almost all over, leaving only the open end of the wrench uncovered. Repeat the operation with the other wrench, but this time leave the box end exposed. You now have a pair of dedicated battery wrenches that you can use on the battery pack without fear of causing a short by accidentally connecting the wrong two battery terminals via the wrench.

Now you can start checking your terminal connections for tightness. Work methodically, either following the series string of batteries, battery by battery, or by going down the rows of batteries in the battery box, one row at a time. Whatever system you use, make sure to check every terminal. The one you miss could be the one that gets you.

If during the battery top cleaning or the terminal tightness check, you come across one or more terminal/interconnect assemblies that have some corrosion, it's time do some serious cleaning. Clean one terminal at a time if you have more than one needing work.

If the corroded terminal is on one of the battery interconnects, remove the cable or strap from the pack for cleaning. Remove the clean end of the interconnect first, if there is one. If it's a cable interconnect, cover the lug at the end of the cable with a piece of rubber or plastic hose that fits firmly over the lug, and then remove the corroded end from its terminal. A floppy cable with one end still connected can cause fireworks if it gets to the wrong terminal.

Clean the end of the interconnect first by removing the corrosion with a wire brush or other abrasive cleaning tool. Brush the connection area until all the corrosion is removed, and only clean, shiny metal is showing.

If the interconnect is the cable/lug type and the corrosion is bad, make sure it has not spread into the area where the cable is crimped into the lug. Corrosion there can only be removed by cutting off the lug and replacing it with a new lug crimped onto clean cable. If the corrosion has spread up the cable under the insulation far enough that cutting it to find clean cable makes it too short to reach its intended terminal, you will have to replace it.

The battery terminal involved should be cleaned with the same cleaner used on the battery tops and a wire brush. The contact area of the terminal should also be cleaned down to shiny bare metal.

Finally, once the battery tops and battery interconnects are clean and checked for tightness, check the cables that lead from the battery pack to the other components. Look for corrosion at the lugs and check the insulation for wear anywhere it makes contact with the EV's body. If you see some slight wear, try to reroute the cable to reduce contact with the body or secure it to the body more tightly to prevent the movement that causes the wear.

I have covered the importance of keeping a logbook, how to water the batteries, clean their tops, safely inspect the battery interconnects for tightness, and clean any corroded terminals. Next issue, I'll discuss battery charging specifics, and look at the small amount of mechanical maintenance required on a conversion EV. Then I will finish up with the fun stuff—how to drive an EV.

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IPP:

A Week in Japan

Don Loweburg

Mt Fuji from the bullet train window.

During early October, my partner Cynthia and I, along with about fifty other PV dealers from around the United States, spent a week touring Kyocera PV plants in Japan. Thanks to Kyocera for hosting the tour.

Participants from around the U.S. gathered in Los Angeles for a Friday evening social get-together before our Saturday morning departure. Two-thirds of the participants were from California, including IPP members Joel Davidson, Jon Hill, Bill and Melody Rocket, Greg Johanson, Scott Carlson, and Barry Cinnamon. Following a Saturday morning breakfast and tour orientation, the group bussed the short distance to the airport. Flying west, racing the sun, we arrived at Japan's Narita airport (near Tokyo) twelve hours later. The group checked into a nearby hotel and most of us went to bed, having been up for more than 24 hours.

Monday morning, we left by bus for Kyocera's Sakura plant, a short distance from Tokyo. Kyocera has established a solar R&D center there, where products and systems are developed and tested. Numerous operating systems are tested, including on grid, off grid, water pumping, and telecommunications. All systems are centrally monitored in the main building, providing a long-term database of system performance information. Additionally, a 100 KW PV array provides a significant portion of the plant's electricity. Opened in 1983, the Sakura plant hosts many international visitors every year.

We met with the plant's staff, who outlined the ongoing activities at the center. New work is taking place on roofing systems, building integrated PV, and inverter testing and development. We were given a tour of the plant and outlying test systems. Many of the off-grid systems were somewhat dated, some almost 20 years old. Many of us reminisced about our own off-grid systems done in the past.

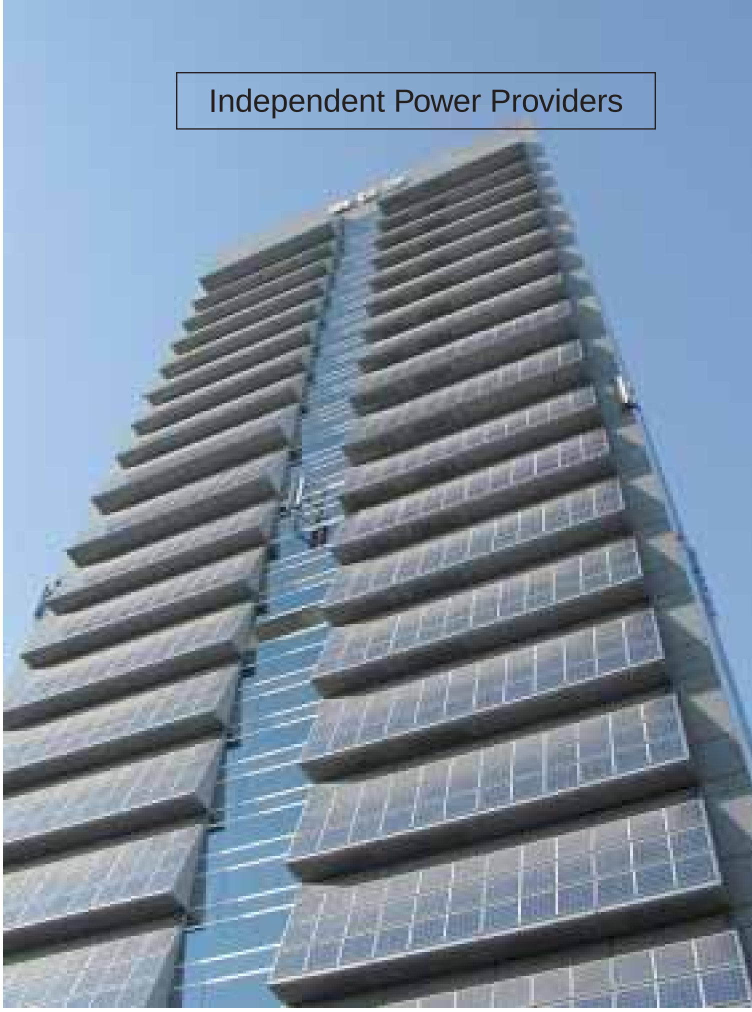
Though every part of this tour was very interesting, I was most intrigued by the ongoing work with inverters. It was quite evident by the number and variety of inverters on display and being tested that this is an area of interest at Kyocera. It was also interesting that the Kyocera staff was a bit noncommittal on exactly what they were planning in the way of Kyocera branded inverters for export. My opinion is that we need some heavy hitters to enter the inverter field. Even the best of today's inverters are not good enough. Reliability still needs to be improved. Inverters need to be at least as reliable as microwave ovens. In the 21st century, this should be doable!

As we left the plant, headed for an afternoon of sight-seeing in Tokyo, we were treated to a moving farewell as the plant's staff lined up outside and waved good-bye to us. This royal treatment would be repeated at the beginning and end of each tour in the coming days.

On Tuesday, we took the famed bullet train south from Tokyo for about two hours to the city of Nagoya. There we got on busses to Kyocera's module fabrication plant at Ise. At this factory, individual silicon cells are laid out, interconnected, laminated, and framed into solar-electric modules. The Ise plant is highly automated. Stacks of silicon cells are loaded at the beginning of the assembly line. Fully framed and tested PV modules come out the other end. These lines operate without operator intervention, though an attendant monitors each station. It was awesome to watch these operations done with extreme precision and high speed. Unfortunately, for security reasons, photographs were not allowed. Leaving Ise in the late afternoon, we bussed to Kyoto, arriving in time for dinner.

On Wednesday morning, our group visited the Yohkaichi plant, about an hour by bus from our Kyoto hotel. At this plant, raw silicon is transformed into PV cells. Once again for security reasons, photos were not allowed. Like the Ise plant, the processes at the Yohkaichi plant are highly automated, using proprietary equipment developed by Kyocera.

The cell material used in Kyocera modules is called polysilicon. Polycrystalline silicon contains many individual crystals, imparting the distinctive "sparkling" appearance to this material. The first step in the production of silicon cells is the melting of granular silicon feedstock and casting it into large (1 cubic foot; 0.028 m^3) blocks. The molten silicon is cooled in a controlled environment, resulting in the required crystalline structure. The solid block of polysilicon is sliced into four "loaves" or rectangular prisms each measuring 6 inches square by 12 inches long (15 x 30 cm). Finally, these loaves are sliced, creating thin 6 by 6 inch (15 x 15 cm) silicon wafers.



Kyoto headquarters building with 157 KW of PV on the south face.

The next steps transform the silicon wafer into a solar cell. For the wafer to become a cell, a positive to negative polarity must be established. This is achieved by using high temperature ovens to drive small amounts of dopant (phosphorus or boron in minute but controlled quantities) into the silicon crystal. It is the presence of

U.S. Kyocera dealers on a PV holiday.

Sakura research and development center.

the small number of dopant atoms that alters the electrical conductivity of silicon, making the silicon electrically either positive or negative. The process of using heat to drive the dopant atoms into the silicon crystal is called diffusion. The first layer diffused is made positive, while the second diffusion step, creating the top layer, becomes negative.

Once the positive and negative layers are established (P-N junction), the silicon wafer becomes a silicon solar cell capable of making electricity when light hits the top layer. The P-N junction allows electrons to flow across it in only one direction—it works like a common rectifier or diode used in electronics. When light hits the top layer (negative), free electrons absorb the energy of the light and become energized. The energized electrons cannot cross the junction from their side, and are forced to flow through an external circuit. The electric current can be used directly or its energy can be stored in a battery.

Using a photographic process, the front surface of the cell is etched, placing a very fine grid pattern to collect the electric current. Finally, flat foil conductors are applied to the front and back side (tabbing) of the cells and they are coated with solder. The cells are then individually tested and sorted for output. Cells from the Yohkaichi plant are shipped to the Ise plant for assembly into modules.

Leaving the cell plant at Yohkaichi, we returned to Kyoto for lunch and a tour of the Kyocera world headquarters building. Approaching from the south, we were presented with a grand view of the 157 KW PV array that clads the entire south face of the 21 story building. Another 57 KW PV array is mounted on the roof, making a total of 214 KW on the building. At the entrance is a clock tower with a bright digital display, showing the output of the arrays. (See *HP75* for an article on this building.)

The administrative offices of Kyocera Corporation are located in this building. The building also houses a gallery of contemporary Japanese artists, and a large number of late Picasso drawings. On the second floor is a technology museum and display of Kyocera products. The company manufactures a wide range of high-tech products, including specialty ceramics, synthetic gem stones, copiers, cameras, biomedical products, and PV modules.

After lunch on Wednesday, our group met with Kyocera management. They outlined the company's history and its fundamental philosophy, best exemplified by the Kyocera Environmental Charter. It states, "Kyocera takes environmental issues seriously. Our environmental charter calls for ever-greater efforts to resolve ecological problems. This spirit has led to diverse initiatives throughout our operations to facilitate sustained, harmonious coexistence with our planet." Complementing this overarching philosophical position, Kyocera promotes a no-nonsense work culture best exemplified by their first motto for success, "Work harder than anyone else."

Kyocera had several purposes for hosting this trip. They wanted to increase dealer knowledge of how

Cynthia Loweburg checks the PV readout at the Kyocera headquarters building in Kyoto.

PV modules are manufactured, and thank the U.S. crew selling their products. The company wants to strengthen and increase U.S. sales of their PV modules by establishing a stronger connection, a “partnership,” between Kyocera Japan and their independent U.S. dealers. Strengthening Kyocera’s commitment and relationship with the U.S. sales team is designed to build loyalty and future sales.

Another purpose of the meeting was for Kyocera to get direct feedback from installers and those selling PV in the United States. The meeting with Kyocera management resulted in some good exchanges. We dealers wanted to know what new modules and related products were coming, while Kyocera was interested in our experiences installing their modules and our customers’ feedback.

We explained to Kyocera’s management why they should be lobbying state governments in support of PV incentive programs in the United States. The Japanese management at Kyocera did not fully understand the reason for this. In Japan, the grid is a national enterprise and Kyocera focuses its lobbying activities at the national level. We explained that in the United States, our national government is currently held hostage by the petro-cartels, and that the only significant efforts for PV are happening at the state level. Kyocera management was encouraged to identify key states and work with lobbying efforts in those states to develop incentives for PV.

After the meeting with management, our group toured the building. On the roof, we got to examine in detail the 57 KW PV array and the racks of inverters delivering electricity to the building. The view of Kyoto was outstanding. We also had time to visit the technology museum and art gallery. The climax of our day was a buffet dinner and party hosted by Kyocera.

Thursday, our last day in Kyoto, was spent sightseeing. Because Kyoto was not bombed during World War 2, many ancient temples, shrines, and historic buildings still stand. Like all major Japanese cities, Kyoto is densely populated. However, throughout the city are numerous islands of green. These areas usually are the sites of temples and shrines. There are more of them in Kyoto than any other Japanese city.

PV & Japan

In terms of the number of installed KW of PV, Japan far exceeds the United States. Though this was not a tour of residential systems, I found myself constantly looking for houses with PV. Looking from the bus or train window did indeed result in a few sightings. However my naive expectation that I would see lots of rooftop PV was not realized. Upon reflection, this makes sense. Though the number of KW installed in Japan is significantly greater than the United States, the percentage of households with PV is still very small.

Friday, our last day in Japan, was spent checking out of the hotel and traveling to the Kansai airport near Osaka. We departed about 5 PM, just at sunset. Flying east, now against the apparent direction of the sun’s travel, we arrived ten hours later in Los Angeles after a fascinating and fulfilling week.

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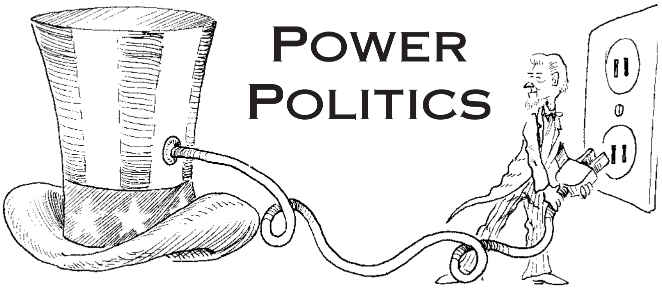

Organize Now!

A Second Chance for U.S. Energy Policy

Michael Welch

In my last column, I wrote about the House and the Senate trying to reconcile their two different versions of the energy bill. The ink was barely dry on *HP92* when the joint conference committee announced that they were abandoning their efforts.

More on that later, but first let's deal with the important stuff. We have a golden opportunity to obtain a better energy bill than the last version. But if we do not organize around this possibility, we will likely end up with an even worse bill than we almost got last year. For RE supporters, environmentalists, and political reformers, that may be hard to imagine.

The first step in the process is to identify the issues that need to be supported and those that need to be fought. The second step includes identifying and implementing the methods we as individuals and organizations can use to help mold the new bill into something we want. No major public campaigns have been started to address the next version of the energy bill, but future columns will include info on them as they get going. Don't wait to take action, though. The more publicity we can get now, the easier it will be later.

What We Want

Many parts of the energy bill need work. The specific items listed below seem to have the farthest-reaching effects toward a safe, clean, and peace-supporting energy policy. Politically, the ideal bill would be one that President Bush would want to veto, but would not, due to popular support. If we go too far—boom, the bill is gone and we'll have to start over. Concession is the reality of politics in modern times. "No compromise in support of Mother Earth," the Earth First! slogan, is a mighty fine sentiment, but it doesn't work in our corporate-influenced world.

What you do with this list is up to you, since each of us will support each point differently. Figure it out, and turn your own agenda into action.

1. Increase R&D money and consumer incentives for energy efficiency and conservation in homes, industry, and automobiles. The best way we can reduce reliance on foreign oil and decrease pressure to drill and mine for fossil fuel in domestic, environmentally sensitive areas is to cut down on energy use.

2. Increase R&D money and consumer incentives for renewable energy, both decentralized and on the utility scale. Homegrown RE is the big goal, but working within the utility industry is just as important as a shorter term goal. Our fossil fuels *will* run out. If we do not start gearing up for an RE future now, our economy will be in big trouble during the inevitable switchover. And if we do not build up the U.S. RE industry before we desperately need it, non-U.S. companies will control the field.

   You may believe that no subsidy is good, but make the point that until subsidies are eliminated for the unsafe and dirty technologies, it is important to create an even playing field among all potential energy sources. If RE and demand-side management (conservation and efficiency) are given the chances they deserve, they will prevail and become the norm. Deep down inside, people want renewable energy. They know at the most basic level that the future of the world relies on making the changes we are calling for.

3. No more R&D subsidies for the nuclear industry. Pushing this point will help make our politicians realize that what we really want is safe, clean, and decentralized energy sources. It is unlikely that we will reach this place in the near future, but with our current administration, it is a more achievable goal than ending subsidies to the fossil fuel industries.

4. No renewal of the Price-Anderson Act, the law that limits nuclear power plant liability for accidents. This is probably the largest nuclear subsidy of all. Without it, no utility would be able to operate nuke plants. At a minimum, push for having a separate bill to deal with P-A, so that full debate outside the bounds of general energy policy can take place in Congress.

5. Do not repeal or weaken the Public Utility Holding Company Act (PUHCA). In fact, the government should have more power to keep corporations from gouging the public.
6. Make the important point that world peace and homeland security will be much easier to attain if countries don't feel the need to go to war over resources like oil. Decreased dependence on fossil fuel through renewable energy, conservation, and energy efficiency will help markedly.

Making A Difference

Once you have decided what points you want to push for in a new energy policy, the next step is communicating them to the decision makers. The crucial effort now should be focused on your representatives in Congress. Sure, let the Bush administration know how you feel. It may have an effect if the president ever realizes that he is supposed to be there for the people and not the corporations.

1. Write letters to your Congressional representatives. This is the easiest thing to do. It also can be very effective if a lot of folks are doing the same thing. That is where organizing comes in. The more you can organize others willing to help out, the more letters and contacts your legislators will have with opinions similar to yours.
2. Write letters to the editors of local papers. These letters should not only express your own opinion, but should encourage other folks to get involved.
3. Organize small gatherings and block parties for discussion of the issue, and to write letters and increase organizing efforts. Take this opportunity to inform and prepare your friends, relatives, and neighbors to also be effective citizens and organizers. Teach others, so that they can teach others in turn.
4. Start a renewable energy activist organization. Convince other organizations about the importance of your cause so they will become involved. Remember, the point is to multiply the effect of what you can do on your own.
5. Publicize and give a tour of your RE home, and explain why it is such an important part of the formula for change.
6. Issue press releases and public service announcements. Any time you hold an event, the more folks that find out about it, the more will show up.
7. Arrange to visit your representatives. This is the ultimate way of contacting them. A citizen lobbyist can be more effective than a corporate lobbyist. Call your representatives' local offices to find out when they will next be in town. If their visit timing is not right, arrange a meeting with a staff person with clout. Most effective of all, arrange to take your vacation on the East Coast, and visit your representatives in Washington, D.C.—that will impress them.

   Of course, any time you meet in person with someone, you must be well prepared. It is not just a matter of passing your opinion on to them in a note. You will likely be faced with questions about the "why and how" of what you are asking them to do. This is an opportunity for discussion. You may learn why the representative feels differently than you on an issue. Then you can use that information to your advantage by doing further research to become more convincing. Or you might modify your position somewhat to become more effective, or even use that information to strengthen your other points.
8. If you own a business, take some company time to have a discussion with your employees about how U.S. energy policy affects your bottom line and their jobs. I'm not saying to scare them with economics, but just let them know what the long-term effects of bad energy policy can be. They may be interested in helping with your campaign, either as a group or as individuals.

Participation is the key to making the U.S. political system work for us. Oil, nuclear, and other corporations are excellent participants because it is easy for them to justify—throwing money at a problem pays off with increased profits. It is much more difficult for citizens to participate because our time is limited by all we have to do in the normal course of our lives. But if we are to turn things around, we must figure out ways to participate in our government. Corporate methods of gaining influence have been successful, so we should try to emulate them. That involves both:

- Educational campaigns—the citizen equivalent of corporate advertising, and
- Direct contact—the citizen equivalent of corporate lobbying.

The 2002 Energy Bill

On November 8, 2002, a letter from more than 100 energy groups was sent to members of the 107th Congress asking them to oppose the energy bill:

> As environmental, public interest, and consumer organizations, we strongly urge you not to pass a harmful, regressive energy bill out of conference committee this Congress. While H.R. 4 is packed with numerous incentives for destructive polluters, it

does virtually nothing to advance conservation and efficiency in this country, or meaningfully promote safe, clean, and affordable renewable energies.

If passed, this bill would include handouts and subsidies to some of the wealthiest corporations in this country. Do not give billions of dollars to the oil, nuclear, and coal industries at the expense of your constituents' health, safety, and tax dollars. We urge you to defeat the energy bill.

On November 13th, Congress wisely took that advice, though not strictly because of the letter. The H.R. 4 reference is to an "Energy Bill lite" version that the House passed as it began to look like the bills were dying in the House and Senate conference committee.

But the dynamics of what really happened are interesting. After the California deregulation fiasco and the Enron blow-up, states in the West and South were very afraid of the bill. The original House bill was pretty much written by Enron, and the Senate version was too close to it for comfort. Western states were nervous.

The main problem was with the provisions that would have axed PUHCA. Without PUHCA, it would make it much easier for the Bonneville Power Administration and the Tennessee Valley Authority (quasi-governmental entities) to be sold off to the private sector, which would mean much higher rates and less reliable electricity for the folks in those areas. Washington State's Senator Maria Cantwell promised to filibuster the bill, and it is unlikely that bill supporters could have developed enough votes to end it, so that would have delayed it until the next session of Congress.

So the lines of power drawn against the bill came from unexpected directions. They were drawn, not based on party politics, but mostly on regional politics. The potential for oil drilling in the Arctic National Wildlife Refuge also played a part. Massachusetts Senator John Kerry promised to filibuster any effort to include ANWR in the bill. He's pretty powerful—enough to be a serious contender for the 2004 Democratic Party presidential nomination.

Our Opportunity

In a brief postmortem on the 2002 Energy Bill, the November 20 issue of *Congress Daily* included,

> Another problem this past year, according to Bob Simon, Democratic staff director for the Energy and Natural Resources panel, was that "the general attention of the public to energy issues was not at an intense level."

That is what we as citizens need to change. Our involvement will make the difference. Comprehensive energy bills are tough to pass, sometimes taking ten years for the next one. Let's grab this opportunity while we have the chance.

Access

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

Wŏrd Pow´ ẽr

Renewable Energy Terms

Conductor—Material with Moveable Charges

Ian Woofenden

Derivation: From Middle English conducten*, from Latin* conducere, *to bring or lead together, to induce, to employ.*

In my last column, I mentioned that an electric current is the flow of charges, and that charges are part of matter. When there is an energy input on one end of an electrical circuit, charges flow and carry energy to other parts of the circuit.

But why do the charges, and therefore the energy, flow *in* the circuit? Why don't they flow from the wiring in your house into the framing, plumbing, and insulation? These things are full of charges too, but we don't use fiberglass or lumber to transmit electricity around our homes.

The answers lie in understanding what "conductors" are. All matter is made up of charges—charged particles. But some types of matter have charges that are more moveable than others. And I mean moveable within the matter, not across the room.

Basic chemistry theory says that electrons (charged particles) orbit around an atom's nucleus. There are a number of orbits or "shells," and each can hold a specific number of electrons. The outer shell (called the valence shell) holds the key to how moveable the electrons are. It can hold no more than eight electrons. If the outer shell is fully populated, the material will tend towards stability—that is, not to gain or lose electrons. But if the outer shell has only a few electrons, they are easily bumped out, forming an "electron sea" of very moveable charges.

So good conductors have only a few valence electrons, and the charge within them is very moveable. Metals are the best conductors, with silver, copper, and gold high on the list. Silver is actually a somewhat better conductor than copper, and you see it used on circuit boards, in solders, and in special wiring applications. Copper is significantly cheaper, so it is widely used for house wiring. Aluminum is another step down, but still a good conductor.

The conductivity of metals is rated on a scale that puts copper at 1.0. On that scale, silver is 1.08, gold is 0.725, and aluminum is 0.625. So aluminum is almost 40 percent less conductive than copper. But economics come into play again, and aluminum is often used for long or large wire runs because it is much cheaper and lighter. Thicker wire must be used because of the lower conductivity.

Other metals have much lower conductivities, and some are used specifically for this reason. Nichrome is a metal alloy used in heating elements. Its conductivity rating is 0.016, so it is 60 times less conductive than copper, size for size. It resists the flow of charges, and much of the electrical energy is converted to heat.

So why is conductivity important? The point of electrical wiring is to distribute electrical energy around your home, to power your appliances. And unlike in a heating element, we are trying to avoid losing energy as heat in our house wiring. As an analogy, consider a highway system. Its purpose is to distribute people from their homes to their jobs to their shopping malls and back.

If the roads are built with rough materials that slow down the vehicles, you get traffic jams, and hot tempers. Similarly, if a conductor isn't made of a conductive material, the resistance will be too high, and it will be harder for the charges to flow. Things heat up there too.

Fortunately, we don't really have to think too much about the technical details of conductors, conductivity, and conductivity ratings. Charts and spreadsheets are readily available to size wires appropriately for the job. See the "Solar Power" section on the downloads page of *Home Power's* Web site for charts and a spreadsheet. If you know the voltage of the system, the maximum amperage (charge flow rate) that the wire will see, and the distance, the chart or spreadsheet will give you the proper size wire to use.

Once you size the conductor properly, you're all set. The moveable charges in the wire will carry the energy where you need it. The wire's insulation keeps the charges from flowing where you don't want them. I'll talk about this and other materials in my column on insulators in our next issue.

Access

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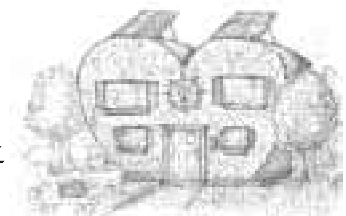
Home & Heart



Kathleen Jarschke-Schultze

It had been about three days since the lightning started wildfires in the mountains all along the Salmon River in California. Forest Service fire crews and management teams with their support equipment were arriving daily, almost hourly. I had never experienced anything like this before. My world was on fire.

I was spending all my daytime hours in our radio room. The scanner gave me an ear for listening to the Forest Service radio traffic. I used the CB for community news—both transmitting and receiving. I also relayed messages and made calls with our telephone/radio system on the two meter ham radio. At night, I was able to use the 75 meter ham radio for emergency relays through Western Public Service System, a ham net.

After the “Pork Chop Incident” (see *HP92*), Bob-O and his crew of locals went to work falling dead snags, clearing brush, and digging fire lines around the homes of people whose cabins were threatened by the fires.

Home Alone

Philbo had not been able to return to the Godfrey drainage yet to see if he had a cabin left. He kept trying to get up the road on his motorcycle, with a chain saw strapped to his back. Burning trees and debris fallen across the road stopped him. For a day and a half, he kept trying to get up the road every couple of hours. Finally he was able to cut through the still burning debris and get to the old Godfrey Ranch site.

He could tell as he rode up that Cedar and Mahaj’s house had survived the fire storm. Next he saw that his own cabin was still standing. He rounded the corner and climbed the hill to his charred front yard.

As he went into the cabin to get some changes of clothes, he noticed wisps of smoke rising from his porch steps. He bent down and took a closer look. His wooden steps were smoldering and glowing with embers! Because there was no other liquid available, he used what he had on hand, or should I say “in hand.” Persistence and practicality saved his home.

Other families in the Godfrey were not so lucky. Cedar’s and Philbo’s were the only homes left there. He had to deliver the sad news to his neighbors when he came down the mountain.

Matthews Creek Fire

The afternoon of the lightning, a down strike had hit about a mile down river, on our side. It was right across the river from Matthews Creek Campground. Some poor man was camping there at the time. He had a CB radio, so he kept coming on the road channel and giving everyone updates on “his” fire. “This is Bill at Mathers Campground. The flames are about 30 feet high,” he’d say, “and now it’s spread to five trees.” He never did get the name of the campground straight.

By the next morning, he had had enough. “This is Bill at Mathers Campground. That fire is getting bigger and I’m leaving. Good luck.” “Bill’s” fire was hard to get to and wasn’t an immediate threat, so it was left on its own. Slowly it crept towards us.

A couple of days later, Bob-O was home, and up on the mountain behind our cabin. Philbo was with him. All day long, I could hear the roar and lull of their chain saws. Falling the dead snags on the mountainside above us was what we could do to help our situation.

As the fire loomed closer, Donkey Puncher and Spider came up from the Little More mine up Matthews Creek. They helped me move a lot of our possessions out onto the bare rocks of the old Starveout mine’s tailing piles. I put my most valuable possessions in my car, ready to drive away if I needed to.

Salmon River Irregulars

Bob-O was gone during the day, working with his crew up and down the river. One evening, we got a call on the CB. “Bob-O, this is Hap. Can I come across your bridge?” Bob-O picked up the mic and said, “Sure, Hap, come on over.”

Hap was a local Scott Valley man who had made the Forest Service his profession. He had come to tell Bob-O that the Forest Service was going to hire his whole crew. Bob-O would still be in charge, and they would continue to do just what they had been doing on their own. Only now they would be paid and could eat in the fire camp whenever they wanted to.

The local residents who were already fighting fire quickly organized into the Salmon River Irregulars.

Three of us became the communications network—Awful Otto at the Prospect mine outside of Cecilville, Betty Ann at Knownothing Creek, and me at Starveout mine, halfway between Cecilville and Forks. All others were under Bob-O, with subcrews under Creek, Philbo, and Bob Beaver. The subcrews worked at structure protection mostly. This went a long way to heal the rift between the Forest Service and the locals. I've always suspected Hap pushed for it. No fool was he.

Forks Hose & Ladder

Larry, John, and Rex were hired separately as a water truck and crew. They put two large tanks on Larry's flatbed and became the "Forks Hose and Ladder." They didn't get any sleep the first three days, but they helped secure several structures. When the Forest Service's Texas Tanker guys arrived, they didn't have the right equipment to fill their tankers out of the river. So the Forks boys would fill their truck from the river and then go fill the official tankers.

At one point, Larry and John were headed up to Lloyd's on Knownothing Creek when they relayed their position on channel 18. Larry's wife, Nixie, came right back sternly, as if talking to one of her children, "Larry, you promise me you won't go over that bridge!" Larry mumbled something back in reply.

Two days later, I was a guide for a pump delivery at Lloyd's and I had occasion to cross that very bridge. Lodgepole pine logs spanned the creek, with 2 by 4s kind of nailed to the edges so you wouldn't slide off into the creek. It was only about eight feet wide and had a distinct lean to it. I was nervous going over it in a pickup.

Bob-O was up early and gone till late every day. We heard and talked to each other a lot on the radios, but it was all fire business then. So, when the Forest Service sent a fire crew across our bridge and up the mountain behind us, Bob-O was gone. They spent two days digging fire line to protect us from the fire that had started across the river from Matthews Creek Campground. It worked.

On the Road

After the first few weeks, I was able to get out of the radio shack occasionally—mostly to guide equipment here and there. I was returning from one of these forays when, there between the 24 mile marker and the 25 (we lived at the 25), a smoke jumper stopped me to ask where he was. He was supposed to be at "Drop Point 20" at Indian Creek (that was at the $23\frac{1}{2}$ mile marker). I was glad he was supposed to be farther away.

A weather phenomenon, called an inversion layer, began keeping all the smoke down close to the ground, so we lived in what was tantamount to a pea soup fog. Because of it, a National Guardsman drove an empty deuce and a half ($2\frac{1}{2}$ ton truck) off a tight curve by Methodist Creek (at about the $22\frac{1}{2}$ mile marker). He died, but at least there were no passangers. They were using these Army camo dump trucks with benches in them as personnel carriers, with no radios to call mile markers.

Bob-O and I went to a meeting at the Petersburg Fire Station outside of Cecilville one evening and had a fuse blow in my Volvo. We were left with no headlights, just running lights and one brake light. We breezed by the Sheriff's roadblock at the Cecilville intersection, shouting out the windows that we knew the road and could make it home with flashlights.

Bless him, he didn't believe us and sent the next rig through the roadblock to follow us home and light the way. It was a Forest Service guy in an official green pickup. He did it, even though he was supposed to be somewhere else.

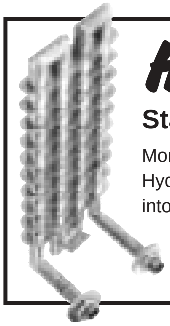
We either ate Red Cross food (cold bagged lunches) or went to Cecilville for dinner. Snipes Resort was now a fire camp kitchen and you could eat a fresh hot meal there. Most times, we were too tired to go that far. I just wanted to sleep for a week where there were no radios. I told myself I wouldn't clean the house or wash the dishes till I knew if the cabin was going to burn down. I couldn't stick it through though.

Not Safe Yet

The wind picked up and was blowing steadily. It blew the smoke away, so air support for fighting fires was started. I would go out every half hour or so and scan the ridge tops for smoke or flame. We were just hoping that it would rain and this would all end. That, however, was not to be.

Access

Kathleen Jarschke-Schultze continues to have one adventure after another at her home in Northernmost California. c/o *Home Power* magazine, PO Box 520, Ashland, OR 97520
kathleen.jarschke-schultze@homepower.com



HAPPENINGS

Send your renewable energy event info to happs@homepower.com

INTERNATIONAL
Free instructions, photos, drawings, & specs to build solar cookers & water systems with local materials, purchased with local currency. Sunstove, www.sungravity.com

El Paso Solar Energy Association bilingual Web site. Info en Español on energy & energy saving. Free download of PV Systems book. www.epsea.org/esp

Green Empowerment finances microhydro & other RE projects in Nicaragua, the Philippines, & Borneo. Volunteers needed. www.greenempowerment.org

Solar On-Line (SóL) Internet courses. Year-round. PV Technology & Opportunities: A Qualitative Overview; PV Systems Design: Basic Course; PV Systems Design: Professional Course; PV System Installation: Hands-On! Solar Homes; Healthy Buildings; & Solar Energy for International Development. SoL, PO Box 217, Carbondale, CO 81623 Phone/Fax: 720-489-3798 info@solenergy.org • www.solenergy.org

AUSTRIA
Mar. 5–7, ’03; World Sustainable Energy Day, Wels, Austria. Forums & speakers mostly on European & international energy trends. Christiane Egger, O.Oe. Energiesparverband, Landstrasse 45, • A-4020 Linz, Austria +43-732-7720 14386 • Fax: +43-732-7720 14383 • office@esv.or.at • www.esv.or.at

BRAZIL
May 15–17, ’03; REsolutions South America, São Paulo. Trade show & conference. Info: ++55 11 3873-7614 • info@wbe.com.br

CANADA
Jun. 7, ’03; 8th Annual EV Show; Vancouver. Info: www.veva.bc.ca

Jun. 8–13, ’03; Hydrogen & Fuel Cells ’03. Vancouver. Info: Suite 101 – 1444 Alberni St. #101, Vancouver, BC V6G 2Z4 800-555-1099 or 604-688-9655 Fax: 604-685-3521 hfc2003@advance-group.com www.hydrogenfuelcells2003.com

Alberta Sustainable House; open house 3rd & 4th Saturdays, 1–4 pm. Cold-climate features & products for health, environment, conservation, RE, recycling, efficiency, self-sufficiency, appropriate technology, autonomous & sustainable housing. Free. 9211 Scurfield Dr. NW, Calgary, AB T3L 1V9 Canada • 403-239-1882 • Fax: 403-547-2671 jdo@ucalgary.ca

Vancouver Electric Vehicle Association. Call for meeting info. PO Box 3456, 349 West Georgia, Vancouver, BC V6B 3Y4 Canada 604-878-9500 • info@veva.bc.ca www.veva.bc.ca

CUBA
May 3–12, ’03; Havana, Cuba. XIX Latin American Conference on Rural Electrification: For a Cleaner Future. International conference, see what Cuba is doing with RE, networking, equipment & technology fair, and site visits. Rachel Bruhnke, Global Exchange, 2017 Mission St. #303, San Francisco, CA 94708 • 415-575-5531 rachel@globalexchange.org www.solarenergy.org/Cuba_conf.html

GERMANY
Feb. 11–13, ’03; E-world–Energy & Water. Essen, Germany. International trade fair & congress. +49 (0)201 10 22 hoenscheid@conenergy.com

ITALY
Apr. 10–12, ’03; EOLICA EXPO, Naples. Wind energy exhibition. Solar Energy Group Srl, Via Gramsci, 63-20032 Cormano, MI (Italy) 02-66301754 • Fax: 02-66304325 info@eolicaexpo.com • www.eolicaexpo.com

NEW ZEALAND
Feb. 15–16, ’03; Canterbury Sustainability Expo, Christchurch. Alternative energy, building, heating, efficiency, gov. info, composting toilets & greywater, alternative transport, education, speakers, demonstrations, & exhibits. John Veix, PO Box 6302, Christchurch, New Zealand 64 25 576 527 • john@gosolar.co.nz www.gosolar.co.nz

SCOTLAND
Feb. 22–Mar. 21, ’03; Ecovillage Training; Findhorn, Scotland. Transfers tools & techniques for creating sustainable communities. Findhorn Foundation, The Park, Findhorn, Scotland IV36 3TZ +44 0 1309 691653 • Fax: +44 0 1309 691163 bookings@findhorn.org • www.findhorn.org

SWEDEN
Jun. 14–19 ’03; ISES Solar World. Göteborg, Sweden. Scientific technical RE conference. Congrex Göteborg AB, PO Box 5078, 402 22 Göteborg, Sweden • +46 31 81 82 20 Fax: +46 31 81 82 25 ises2003@gbg.congrex.se www.congrex.com/ises2003

VIRGIN ISLANDS
Apr. 28–May 9, ’03; PV Design & Installation workshop; St. John. See COLORADO for SEI contact info.

WALES
Feb. 21–23, ’03 (again May 23–25); Intro to RE weekend course, Univ. of Wales, Aberystwyth. RE technology, incl. solar, wind, & hydro. Green Dragon Energy, 01974 821 564 • dragonrg@talk21.com www.greendragonenergy.co.uk

NATIONAL U.S.
Ham HF net. Amateur radio operators involved with RE & interested in an informal net, please contact Craig Miller, W8CR, 4085 Home Rd., Powell OH 43065 • w8cr@qsl.net.

Pollution prevention videos. Appalachia: Science in the Public Interest offers 42 videos, incl. Solar Dry Composting Toilets, Solar Hot Water Systems, PV, Solar Space Heating, Solar-Powered Automobiles, Quilted Insulated Window Shades, & more. Broadcast-quality tapes available. ASPI Publications, 50 Lair St., Mt. Vernon, KY 40456 • 606-256-0077 Fax: 606-256-2779 • aspi@kih.net www.kih.net/aspi

American Wind Energy Assoc. Info about U.S. wind industry, membership, small turbine use, & more. www.awea.org

State & Fed. incentives for RE info. North Carolina Solar Center, Box 7401 NCSU, Raleigh, NC 27695 • 919-515-3480 Fax: 919-515-5778 • www.dsireusa.com

Energy Efficiency & Renewable Energy Clearinghouse (EREC): Insulation Basics (FS142), New Earth-Sheltered Houses (FS120), PV: Basic Design Principles & Components (FS231), Cooling Your Home Naturally (FS186), Automatic & Programmable Thermostats (FS215), & Small Wind Energy Systems for the Homeowner (FS135). EREC, PO Box 3048, Merrifield, VA 22116 • 800-363-3732 • TTY: 800-273-2957 energyinfo@delphi.com • www.eren.doe.gov

Ask an Energy Expert: online questions to specialists. Energy Efficiency & Renewable Energy Network (EREN) • 800-363-3732 www.eren.doe.gov

National Wind Technology Center. Assists wind turbine designers & manufacturers with development & fine tuning. Golden, CO 303-384-6900 • Fax: 303-384-6901

Stand-Alone PV Systems Web site: design practices, PV safety, technical briefs, battery & inverter testing. Sandia Labs www.sandia.gov/pv

Federal Trade Commission free pamphlets: Buying an Energy-Smart Appliance, Energy Guide to Major Home Appliances, & Energy Guide to Home Heating & Cooling. Energy Guide, FTC, Rm 130, 6th St. & Pennsylvania Ave. NW, Washington, DC 20580 202-326-2222 • TTY: 202-326-2502 www.ftc.gov

Solar Curriculum for schools. 6 week science curriculum or individual sessions. Free! 30 classroom presentations & demos using free or low-cost materials. Susan Schleith, Florida Solar Energy Center • 321-638-1017 www.fsec.ucf.edu

ARIZONA
Feb. 3–8, ’03; PV Design & Installation workshop; Tucson. See COLORADO for SEI contact info.

Tax credits for solar in AZ. ARI SEIA 602-258-3422

Scottsdale, AZ. Living with the Sun; free lecture series, 3rd Wed. each month, 7–9 PM, City of Scottsdale Urban Design Studio. History & current concepts, design, applications, solar heating & cooling, architecture, landscaping, PV, & cooking. Dan Aiello • 602-952-8192; or AZ Solar Center, www.azsolarcenter.org

CALIFORNIA
Mar. 3–8, '03; Women's PV Design & Installation workshop; Santa Cruz. See COLORADO for SEI contact info.

Mar. 8–9, '03; Utility Interactive Systems workshop; Sacramento. See COLORADO for SEI contact info.

Mar. 10–15, '03; PV Design & Installation workshop; Grass Valley. See COLORADO for SEI contact info.

Mar. 29–30, '03; Utility Interactive Systems workshop; San Diego. See COLORADO for SEI contact info.

Apr. '03; PV Design & Installation workshop; Arcata, CA. 5 days, includes 2 system installations: intertie, & intertie with battery backup. Call for dates: Redwood Alliance, PO Box 293, Arcata, CA 95518 • 707-822-7884 info@redwoodalliance.org www.redwoodalliance.org

Oct. 1–3, '03; Sustainable Energy Expo & Conference; Los Angeles Convention Center. Business conference & trade show. John Mikstay • 646-432-1102 www.sustainableexpo.com

Arcata, CA. Campus Center for Appropriate Technology, Humboldt State Univ. workshops. & presentations on alternative, renewable, & sustainable living. CCAT, HSU, Arcata, CA 95521 • 707-826-3551 ccat@axe.humboldt.edu www.humboldt.edu/~ccat

Rebates for PV & wind. CA Emerging Renewables Buydown Program, CA Energy Comm. • 800-555-7794 or 916-654-4058 renewable@energy.ca.gov www.consumerenergycenter.org/buydown

Energy Efficiency Building Standards for CA. CA Energy Comm. • 800-772-3300 www.energy.ca.gov/title24

Solar e-Clips, free weekly e-mail newsletter. CA news & info solar energy. Subscribe: www.californiasolarcenter.org

COLORADO
Carbondale, CO. SEI hands-on workshops & online distance courses. PV Design & Installation, Solar Water Pumping, Advanced PV, Wind Power, Microhydro, Solar Cooking, Environmental Building Technologies, Solar Home Design, & Straw Bale Construction. Solar Energy International (SEI), PO Box 715, Carbondale, CO 81623 • 970-963-8855 Fax: 970-963-8866 • sei@solarenergy.org www.solarenergy.org

IOWA
Prairiewoods & Cedar Rapids, IA. Iowa RE Assoc. meets 2nd Sat. every month at 9 AM. All welcome. Call for changes. IRENEW, PO Box 355, Muscatine, IA 52761 • 563-288-2552 irenew@irenew.org • www.irenew.org

KENTUCKY
Livingston, KY. Appalachia: Science in the Public Interest. Projects & demos in gardening, solar, sustainable forestry, more. ASPI, Rt. 5, Box 423, Livingston, KY 40445 606-453-2105 • aspi@kih.net www.kih.net/aspi

MASSACHUSETTS
Mar. 12–15, '03; Building Energy 2003 Conference & Trade Show; Boston. Green building & RE. See below for NESEA info.

Greenfield Energy Park. Ongoing energy demos & exhibits. NESEA, 50 Miles St., Greenfield, MA 01301 • 413-774-6051 Fax: 413-774-6053 • nhazard@nesea.org www.nesea.org

MICHIGAN
Urban Enviro workshop, Ferndale, MI. 2nd & 4th Thurs. 7–9 pm. Sustainability, energy efficiency, RE, & consumer issues. Free. Michael Cohn, 22757 Woodward #210, Ferndale, MI 48220 • 313-218-1628

Intro to Solar, Wind, & Hydro. West Branch, MI. First Fri. each month. System design & layout; on or off grid; for homes or cabins. Info: 989-685-3527 • gotter@m33access.com

MONTANA
Whitehall, MT. Sage Mountain Center: one-day seminars & workshops, inexpensive sustainable home building, straw bale constr., log furniture, cordwood constr., PV, more. SMC, 79 Sage Mountain Trail, Whitehall, MT 59759 • 406-494-9875 cborton@sagemountain.org

NEW MEXICO
Feb. 6–Mar. 6, '03; Intro to Homemade Solar Electricity. Mimbres Valley Learning Center, Deming, NM • 505-546-6556 ext. 103

NEW YORK
Apr. 21–26, '03; PV Design & Installation workshop; Woodstock. See COLORADO for SEI contact info.

RE Loan fund: low interest financing: NY Energy $mart Program, NY State Energy R&D Authority • 518-862-1090 ext. 3315 Fax: 518-862-1091 • rgw@nyserda.org www.nyserda.org

NORTH CAROLINA
Saxapahaw, NC. How to Get Your Solar-Powered Home. Seminars 1st Sat. each month. Solar Village Institute, PO Box 14, Saxapahaw, NC 27340 • 336-376-9530 Fax: 336-376-1809 • solarvil@netpath.net

OHIO
May 5–9, '03; Biodiesel Fuel workshop; Cleveland. See COLORADO for SEI contact info.

OREGON
EORenew Workshops. Feb. 7: Basics of Solar Heating & Hot Water; Feb. 21: Design Your Own Solar Electric System; Feb. 28: The Secrets of Saving Money on Energy; Apr. 5–6: Building a Mobile Solar Water Pumper, Prineville; Jul. 22–24: Pre-SolWest hands-on solar installation class, John Day. See below for SolWest info.

Feb. 21–23, '03; Successful Solar Businesses; Ashland, OR. All aspects of small RE business. Richard Perez, Bob-O Schultze, & Bob Maynard. See display ad in this issue for info.

Mar. 1–2, '03; Conscious Living Expo, Deschutes, OR. Business, lifestyles, & the arts. Incl. some RE stuff. Green Guides, 557 NE Quimby, Bend, OR 97701 • 541-388-9040 Fax: 541-318-6169 • editor@colivingnow.com www.colivingnow.com

Jul. 25–27, '03; SolWest Renewable Energy Fair, John Day, OR. EORenew, PO Box 485 Canyon City, OR 97820 • 541-575-3633 info@solwest.org • www.solwest.org

Cottage Grove, OR. Adv. Studies in Appropriate Tech., 8 weeks, 4 interns per quarter. Aprovecho Research Center, 80574 Haxelton Rd., Cottage Grove, OR 97424 541-942-0302 • apro@efn.org www.efn.org/~apro

PENNSYLVANIA
Mar. 21–22, '03; Passive Solar Greenhouse workshop, Spring Grove, PA. Design, construction, & year round production. Steve & Carol Moore, 1522 Lefever Ln., Spring Grove, PA 17362 • 717-225-2489 sandcmoore@juno.com

Penn. Solar Energy Assoc. meeting info: PO Box 42400, Philadelphia, PA 19101 610-667-0412 • rose-bryant@erols.com

PV grants for Penn. available through the Sustainable Development Fund sdf@trfund.com • www.trfund.com/sdf

Philadelphia Million Solar Roofs Partnership 215-988-0929 ext. 242 hannahl@ecasavesenergy.org www.phillysolar.org

RHODE ISLAND
Energy Co-op provides RE, energy efficiency & conservation services, & group purchases of EnergyStar products. Erich Stephens 401-487-3320 • erich@sventures.com

TENNESSEE

Apr. 14– 19, '03; PV Design & Installation workshop; Summertown. See COLORADO for SEI contact info.

Summertown, TN. Kids to the Country: nature study program for at-risk urban TN children. Sponsors & volunteers welcome. The Farm, Summertown, TN 38483 • 931-964-4391 Fax: 931-964-4394 • ktcfarm@usit.net

TEXAS
Mar. 24–29, ’03; PV Design & Installation workshop; Austin. See COLORADO for SEI contact info.

Jun. 21–26, ’03; SOLAR 2003, Austin. Annual American Solar Energy Society conference. ASES, 2400 Central Ave. #G-1, Boulder, CO 80301 • 303-443-3130 • Fax: 303-443-3212 ases@ases.org • www.ases.org

El Paso Solar Energy Assoc. meets 1st Thur. each month. EPSEA, PO Box 26384, El Paso, TX 79926 • 915-772-7657 • epsea@txses.org www.epsea.org

Houston Renewable Energy Group: meets last Sun. of odd months at TSU Engineering Building, 2 PM. HREG, PO Box 580469, Houston, TX 77258 • jferrill@ev1.net www.txses.org/hreg/

VIRGINIA
Info & services on practical solar energy apps in VA. VA Solar Energy Assoc., the VA Solar Council, & the VA SEIA. Info: VA Div. of Energy • 804-692-3218

WASHINGTON STATE
Apr. 5, ’03; Intro to RE workshop, Guemes Island, WA. Intro to solar, wind, & microhydro for home owners. US$75. Lecture and tours. Info: see SEI in COLORADO listings. Local coordinator: Ian Woofenden • 360-293-7448 ian.woofenden@homepower.com

Apr. 7–12, ’03; Solar-Electric (PV) Design & Installation workshop. Guemes Island, WA. System design, components, site analysis, system sizing, & hands-on installation. US$550. Info: see SEI in COLORADO listings. Local coordinator: Ian Woofenden 360-293-7448 ian.woofenden@homepower.com

Apr. 14–19, ’03; Homebuilt Wind Generators with Hugh Piggott, Guemes Island, WA. Learn to build wind generators from scratch, including carving blades, winding alternators, assembly, & testing. US$550. Info: see SEI in COLORADO listings. Local coordinator: Ian Woofenden • 360-293-7448 ian.woofenden@homepower.com

Apr. 21–24, ’03; Microhydro-Electric Systems workshop. Guemes Island, WA. Classroom and lab sessions are followed by tours of systems, including a tour of Canyon Industries, hydro turbine manufacturer. US$450. Info: see SEI in COLORADO listings. Local coordinator: Ian Woofenden 360-293-7448 ian.woofenden@homepower.com

WISCONSIN
June 20–22, ’03; RE & Sustainable Living Fair (a.k.a. MREF); Custer, WI. Exhibits, workshops on solar, wind, water, green building, alternative fuels, organic gardening, energy efficiency, & healthy living. Home tours, silent auction, Kids’ Korral, entertainment, keynote speaker. See below for MREA access.

MREA wokshops: Solar Space Heating, Wind System Install, PV Installs, Straw Bale, Masonry Heaters, Sustainable Living. MREA, 7558 Deer Rd., Custer, WI 54423 715-592-6595 • Fax: 715-592-6596 mreainfo@wi-net.com • www.the-mrea.org

ENERGY FAIRS
See: www.homepower.com

the Wizard speaks...

Transition

It doesn't take a genius to figure out that, sooner or later, most of our sources of carbon-based fuels will be gone. Even if there were no environmental concerns, and these are monumental, we would have to find new primary energy sources. The transition needs to start now.

In many times and places, there is more electrical capacity than needed. In many cases, fuel is being wasted just to keep generators running to meet potential needs. In these instances, the excess energy should be used to make hydrogen and store it for later use.

This stored hydrogen can be used to begin eliminating carbon-based fuels in the area of transportation. This will have economic and security benefits, as well as environmental ones. Meanwhile, we can begin to replace primary sources with renewables. Eventually, carbon-based sources can be phased out completely.

We need to start now. Barring a scientific breakthrough in energy production or efficiency, it is going to take a very long time to accomplish this goal. It's up to you.

Remembering Arlo Hagler
I'd like to remember alternative energy technician Arlo Hagler, who wired many remote homesteads in Humboldt, Mendocino, and beyond. Arlo died October 5, 2002 of advanced stomach cancer. Considering all the folks' homes way beyond the grid that Arlo electrified, this brother really left a lot of light behind on this planet. We miss him! Bert Snow, Laytonville, California

Arlo was a wonderful, kind, and gentle man. He is well known and respected for his countless volunteer hours in the community. He is perhaps best known around my neck of the woods for his weekly Environment Show on KMUD, the local alternative radio station, and his many volunteer hours as an air-time engineer. Michael Welch • michael.welch@homepower.com

Product Testing
Dear *Home Power*, I just wanted to thank you for the excellent inverter comparison article by Henry Cutler in *HP91.* It was well written, and the data collection and analysis were rigorous and complete. This type of controlled component comparison is absolutely necessary if small-scale RE is to succeed on a larger scale. Kudos to Mr. Cutler for bringing a level of professionalism to the task that is, unfortunately, all too rare in these circles.

I also wanted to ask if there is any national or international standards organization or testing group that tests small-scale RE components to verify product claims and specifications. I know many components are UL certified for safety, but is there an equivalent testing organization for performance? If not, I think it is high time that one be developed. Thanks for a great magazine. Sincerely, Fortunat Mueller, Hartford, Connecticut

Hello Fortunat. The National Renewable Energy Labs (NREL) has done testing of RE system products, but they usually do not release comparative info. They probably don't want to do anything that could favor one business over another, and sometimes they are hired by manufacturers, who may not want the results published.

When something like that inverter comparison article is submitted to Home Power, *we want to share the important and well-documented info with our readers. Documentation, accuracy, and test methods are the keys. Tests that might adversely affect the popularity and sales of particular products must be properly and precisely done. We would really like to do more of that sort of thing, but we need folks as skilled as Henry to do the comparisons.*

Sometimes that sort of product testing and ensuing publicity has unexpected results. Shortly after Henry's article became public, Xantrex announced that a fix would soon be available for their SunTie inverters. We feel that publishing that article encouraged the manufacturer of the less efficient product to take another look and create a fix! If it works out, what could be better?

We are willing to publish this kind of info, but it would be difficult for us to become the comprehensive testing institution that the industry needs. We just don't have the resources. There would need to be a staff, both technical and administrative, lots of high-priced test equipment, labs, and an office. There would also need to be a basis for impartiality. It could not be funded directly by the companies that manufacture the items being tested, though possibly that could work through an independent third party.

Independent Power Providers could be a vehicle for starting such an independent venture, since they represent installers and not the manufacturers. Drake Chamberlin (see Letters, HP76*, the cable testing article in* HP80*, and several other articles and letters on the* NEC *over the years) has been very interested in starting up a lab to test equipment and come up with new installation methods and hardware ideas, though I don't recall him mentioning comparative testing of different brands of equipment.*

I think the industry is wide open for this idea, and I would not mind personally contributing an annual fee to such an organization. Michael Welch • michael.welch@homepower.com

Off-Grid & Local
Dear *Home Power* folks, Thanks, in part, to your magazine, I have been off-grid solar-voltaically for three years. To do so in Duluth has required me, in the midst of the city, to pare my electrical life to about 800 watt-hours per day. Two factors aided me greatly. First, I had no time schedule—the whole project took about two years. The second factor was working with Chris LaForge of Great Northern Solar, my local RE guy. Which brings me to the point of this letter.

Please encourage the Internet ads to also give a "land address." I am not naive enough to believe that the products still don't come from all over the surface and subsurface of our planet. But at least I will give preference to the "more local" businesses if I can help it. Thank you from my almost Luddite heart. Sincerely, Dan-O Proctor, "The Una-Baker," Change the World with Bread, a worker-owned cooperative, Positively 3rd Street, Duluth, MN, 55805
Business phone: 218-724-8619 • I have no home phone, no e-mail, no TV, no car; my home is at peace.

Cost Effective?
Dear *Home Power*, We are trying to decide if solar energy would be cost effective for us. We live in western Washington. The summers are fine, but during late fall and winter, it can be pretty dismal around here. We have sited the house to take advantage of the southern exposure. The house is approximately 2,400 square feet. We will be heating with gas. Can you give us an idea of the average cost of purchasing and installing solar-electric panels
and all necessary equipment? Thank you, Keith Grosso
akgrosso@worldnet.att.net

Hi Keith. That's one of the most common questions we get, and one we usually dodge. The size of the house has very little to do with it. It's all how you and your family live, and your appliances.

Remember this: for every $1 you spend on energy efficiency and conservation, you will save $3 to $5 on the cost of a solar-electric system. Efficiency is the most cost-effective move you can make. Once you get to the point of maximum efficiency, then you can start talking about how much your system will cost. A good *installer/dealer of RE equipment can really help you through this entire process. Michael Welch • michael.welch@homepower.com*

Guerrilla Efficiency

Dear *HP*, About a year and a half ago a friend of mine injured his leg while moving some furniture. During the week or so that he was walking on crutches, the bulb in his dining room ceiling fixture died, and he asked me if I would help him replace it. I had a spare CF bulb lying around, and I used it to replace the incandescent that had gone bad. I get a lot of (mostly) good natured abuse from my friends about being a plastic-recycling-worm-composting-spotted-owl-soul-kissing environmentalist, so I figured out that it would just be simpler to replace the bulb with a CF and not tell anybody. It's burning to this day, and I confess that when I visit, I chuckle inwardly knowing that Geoff is quietly and unknowingly doing something environmentally sound.

I also left a few CF bulbs in place when I moved out of a townhouse that I was renting, after deliberating on the matter and deciding that it would be better for me to buy new ones to put in my new place. I have no idea if they are still there. I live in the great state of Maryland, so please put us down for two on your guerrilla efficiency map.

On the topic of CFs in restaurants, I would like to commend Pizza Hut. They have gone almost exclusively to CF bulbs. We tree huggers tend to be pretty negative, and when I see something positive, I like to point it out. Sincerely, Dr. Wombat

Another Efficiency Guerrilla

Hi *HP*, On a recent stay at Sun Mountain Lodge in eastern Washington, I noticed that the family game room (the guest rooms are TV free!) had lampshades with incandescent spot marks. Upon investigation, I confirmed my concern—75 watts blazing away, day and night. A guerrilla efficiency opportunity (GEO) became apparent. I just happened to have an extra 20 watt, Energy Star qualified CFL that fit the random act, and then I anonymously informed the front desk about the sensible good works. I recommend picking up CFLs when you see them on special buys, to have them handy for the next GEO. Sincerely, GEOffREy

Dimmers for Efficiency Guerrillas

You guys spreading the word of energy efficiency by changing lightbulbs to compact fluorescents is a good idea, but I must warn folks of one important technical issue. Many restaurants place their lighting on dimmers! Since many of the compact fluorescent replacement bulbs are not designed to run at less than 100 percent power, they could live a short life in their new home. What's worse is if the owner of the restaurant takes your offer up, and decides to replace all the bulbs, then dims them down and burns them all out. This could end up leaving a sour taste in their mouth for this wonderful technology! Steven Winner steven.winner@verizon.net

Notebook Computer Energy Use

Hi *Home Power* folks, I just came across the most pertinent article I have ever seen on notebook computer energy use, including a lot on lithium-ion battery care. It is "A Long and Happy Life," in *PC Magazine*, October 15, 2002, pages 70–73, by Bill Howard. It's online at www.pcmag.com/print_article/0,3048,a=31232,00.asp. Aloha. John Bertrand • caber@kona.net

Great article, John. We would like to quote this small section from it:

> *With determined effort, you can extend battery life by 20 to 25 percent. Steps 1 and 2 alone get you halfway there.*
>
> 1. *Turn down the LCD brightness.*
> 2. *Use built-in power management.*
> 3. *Turn off wireless and wired Ethernet when not in use.*
> 4. *Set screen blanking to 1 or 2 minutes.*
> 5. *Add RAM.*
> 6. *Close unused programs.*
> 7. *Fully drain, then recharge lithium ion batteries every few months.*
> 8. *Remove unused PC cards.*
> 9. *Removed unused notebook-powered USB devices.*
> 10. *Avoid "weight-saver" batteries.*
> 11. *Don't watch DVDs, and don't play graphics-heavy games.*

Michael Welch • michael.welch@homepower.com

Meter Madness

Hello *Home Power*, Our crew just installed a Trace 2424E, 230 V, 50 Hz inverter at an orphanage in Cambodia, and found that our output voltage read just 180 instead of 230. The lights, fans, and computers in the orphanage seemed to run without complaining, and we think that we have traced the problem to the multimeter, not the inverter. We were using a U.S. made multimeter, which does not measure true RMS, and the modified square wave has it fooled. This is suspect practice, but is there a "cheat sheet" conversion that we can use in the short term, or does the reading depend on the meter? Any suggestions for new meters? Thanks for your help, Peter Banwell, Khmer Solar, Phnom Penh, Cambodia • psbanwell@yahoo.com

Hello Peter, You have correctly identified the metering problem. There is no accurate conversion factor, since it depends on waveform (which is constantly changing on modified square wave inverters) and the digital multimeter (DMM) doing the measurement.

You should buy a Fluke 87 DMM. It will accurately measure non-sinusoidal waveforms. Price is about US$350 and worth every penny. This DMM also has many other features (minimum/maximum recording and true arithmetic averaging), which makes it an essential tool for anyone involved with RE systems. Richard Perez • richard.perez@homepower.com

Battery Cable Improvements

Richard, Thank you for sharing with us your battery cable making method. As you can see from the photo, we had to make standoffs to clear the caps. We made them out of 3/4 inch copper tubing crushed flat. Haven't had a chance to use them electrically yet so I'm a little concerned about their ampacity. I told my friend Kenny that when he is pulling a heavy load, he should feel them for a temperature rise and if they're getting warm we can put a second set on to double the ampacity. Those are 6 volt, 225 AH golf cart batteries, so I'm thinking we'll be OK.

A couple of things we did differently from your instructions that saved a little time and materials:

1. Rather than folding the end 180 degrees, we first just folded it 90 degrees in the vise and beat the 90 tight while still in the vise. We had no leaks, so then we experimented by not folding it at all. We just spread the wires, installed the tubing, squeezed it tight in the vise, beat it flat on an anvil with a 4 pound beater, and then reinstalled it vertically in the vise and clamped down on the tip of the copper real tight. A little flux ran out through the tip, but no solder. (That might not work if a light-duty vise is being used—we were using a 5 inch industrial-duty vise.)

2. By clamping the copper by the tip during the soldering phase, we found it was much easier to see what we were doing. Also, since there were two of us, one person could use two torches, one on either side, while the other fed the solder. When we cut them off, there were no visible voids in the connection.

Ed Carroll • mredca@bigvalley.net

Hello Ed, Thanks for the tips and improvements on my connector making process. Instead of tubing for those standoffs, consider using a short piece of either 1/4 inch or 3/8 inch thick bus bar. This comes in widths of 1 inch. That should provide plenty of ampacity and greater mechanical strength. Richard Perez richard.perez@homepower.com

Doing It without Batteries?
My wife and I are having our retirement home designed. We want to generate as much energy on site as possible. We plan to use a combination of solar and wind generated electricity. As a total newcomer to the practice of renewable energy, I've always been intimidated by the appearance of how much work would be involved in maintaining and monitoring the storage batteries. Our architect is suggesting that we do without batteries; we could use what we generate, and if we need more at a particular moment we could buy it from the utility company. If we generate more than we need at a particular moment, we could sell it to the utility company. Is this possible and feasible? I'm new to your magazine and don't recall such a system or idea being discussed before. Any guidance and suggestions on this idea would really be appreciated. Thank you. Steven Barry, Portland, Oregon (but building near Moscow, Idaho) • paradocs@teleport.com

Hi Steven. Yes, it is entirely possible to do as you suggest, using the grid during times when your system is not generating. In fact, most states have net metering laws that allow you to offset your utility usage with any surplus that your system had previously generated. It certainly simplifies and saves money to use batteryless RE systems.

All that said, I am still a proponent of battery backup. Batteryless RE systems stop producing when the grid goes down. I like the idea of having at least a small battery bank so that you can run things if the grid goes down. This is more important in some locations than others. For example, 20 miles north of my town, which usually only gets 1 to 2 hour utility outages, 2 to 3 week *outages are too frequent. For those folks, a large battery backup is most appropriate.*

Batteries have a bad reputation, but really it is not that much hassle to maintain them. It also helps system owners keep in touch with how much energy they are consuming, and the general operation of the RE system.

As long as your system is properly set up, checking the batteries about once a month is all that is needed. But monitoring the batteries on a day-to-day basis is best. That is done with conveniently located meters to check their state of charge. Then an every-other-month equalization charge of the batteries is needed. It's really no big deal.

If you are worried about maintenance, a wind generator may not be right for you, unless you can contract out the maintenance work with the installer of your system. Wind generators are more finicky than PVs. They are designed to use harsh environmental factors to make electricity, so they need to be watched carefully and maintained.

Most architects are not up to date on RE electrical systems, though they are usually capable of physically integrating a system into a home's design. Of course, that is not always the case, but usually I recommend that folks deal directly with a reputable installer of RE electrical systems to make sure that they have the advantage of a specialist's info in this critical decision you are about to make. Then let your RE installer work with the architect on system integration. Michael Welch michael.welch@homepower.com

Hello Steven, I have a few thoughts to add to Michael's response. The only residential-scale U.S. wind generators that have batteryless inverters are the Bergey Excel (10 KW machine), and some of the older Jacobs, gear-driven turbines. SMA, a German company that manufacturers the Sunny Boy batteryless PV inverters, makes a batteryless inverter for small wind turbines called the Windy Boy. But right now these inverters are not readily available for U.S. voltages, and they're not listed by UL or an equivalent testing agency.

The reason for this is that a wind generator's voltage varies greatly based on turbine rpm, which is directly related to wind speed. It's a relatively difficult inverter to build. In comparison, PV module voltage is relatively constant. As a result, batteryless PV inverters are much easier to design and build. I see the lack of batteryless inverters for wind systems as being a temporary problem. All the residential-scale U.S. wind generator manufacturers are working on batteryless inverters for their wind turbines. It's not a matter of if, but when we will have them.

Batteries installed in a grid-tied system add very little efficiency loss (about 2 percent) to a given system, because they are rarely cycled, and are kept at a full state of charge, either by renewable sources or the grid. The kink in the process is that the most commonly used battery-based, grid-tie inverter, the Xantrex SW series, always *keeps the batteries at float. Overnight, and during cloudy weather, grid electricity is used to keep the batteries fully charged and ready for a utility failure. The user has no control over this feature. In systems with small PV arrays (500 watts or less), this design flaw can result in a 50 percent overall efficiency loss when you look at renewable energy fed to the grid compared to grid energy used to keep the batteries at a full state of charge. As the PV array gets larger, this efficiency loss decreases.*

I ran a 2,500 watt SW series inverter in grid-tie mode that was fed by a small, 400 watt PV array. On average, 50 percent of the energy the PVs generated during the day was offset by grid *energy used overnight to keep the batteries fully charged. At the time, I lived in an area that almost never experienced grid failures. I didn't need the battery bank fully charged, ready for a power outage at any given moment. My lack of control of grid-charging drove me crazy.*

In an off-grid system, batteries result in efficiency losses between 2 percent and 25 percent. This is a totally moving target. The variables that affect this range are the age of the batteries, how deeply they're discharged, battery temperature and self-discharge rates, and battery type. But this doesn't apply to your grid-tied application.

If you do opt for a battery-based system, because you want to run a wind generator, or your location experiences frequent utility outages, use absorbed glass mat (AGM) batteries. These batteries are designed for float service, and are sealed. They require no maintenance or watering.

Feel free to contact me if you have any questions. I realize this response may be a little thick, since you're getting acquainted with a new technology. Thanks for going solar! Joe Schwartz joe.schwartz@homepower.com

What's Wrong with Wind?
Hello, *Home Power*, I'm mailing in my sub renewal and ran out of space in the comments section, so here goes. First off, congrats on a great and inspiring mag. I especially liked the discussions of wind energy and bird mortality. It was timely for us, since a wind farm is proposed for this area (east coast Vancouver Island, a reef off Campbell River to be precise). There is lots of opposition. We had a big, dirty, gas-fired co-gen plant (5 megawatt?) go on-line here recently and they have already asked permission to switch to coal—a cheaper fuel. Another multimegawatt plant burning coal has been proposed nearby, and there's not much opposition to these.

What's going on? British Columbia is more than self-sufficient in hydroelectricity, and sells to the big market for juice in California. We get the pollution here; California gets cheap electricity. The North American Free Trade Agreement was really designed to facilitate this process. We just got a new provincial government with an extreme free enterprise agenda, heavily financed by some U.S. mega corporations. Look for lots of cheap energy flowing south.

Some of your readers would like to see politics left out of the mag, but I see it as pivotal to the whole issue of renewables and sustainability. Keeping the people scared with all the security hype on the one hand and doomsday predictions of economic collapse if we stray off the fossil fuel path on the other is a great strategy for maintaining the current power structure. We both know this dirty, fossil fueled ship is gonna sputter to a stop sooner or later, and it's easier on everyone if we get off a few at a time and make a smooth transition. Just keep spreading the word and eventually we'll make the paradigm shift. All the best to you and the *Home Power* crew, Jim Palmer • palmerj@island.net

Hi Jim, Thanks for your good letter. It's beyond me why thinking *people oppose wind farms while continuing to use dirty electricity. Tom Gray of the American Wind Energy Association (AWEA) had a beautifully stated response to some wind farm opposition on AWEA's home wind generation e-mail list last month:*

> *The biggest problem we in the wind industry have with environmentalists is that we cannot compete with nothing. Nothing is perfect—it has no impact, by definition; it involves no change; and it's wonderfully compatible with the existing aesthetics of any site. Its only drawback is that it is not a real choice, because our electricity comes from somewhere, and the environmental cost of its generation is sometimes very high.*

Keep plugging, Ian Woofenden • ian.woofenden@homepower.com

Cotton, Wool, or Permanent Press
Dear *Home Power*, *HP92* arrived last week sometime. By the time I got it, it was soaked clear through. Just to inform your other readers who might have the same experience, I saved the issue at small expense.

First, I carefully toweled and inserted a sheet of plain 8.5 by 11 blank printer paper between each page. I let it sit overnight with about 100 pounds pressing it between two towels. Next day I carefully pulled each sheet of paper out of the mag after ironing it to get the pages flat and dry. I then turned the pages back again and ironed them flat on a clipboard until no steam rose from the page. I found that high settings caused the paper to bubble, so I set my iron on the moderate permanent press setting. I got most wrinkles out, except for page 141, which appears wrinkled beyond repair... Ed Brown • eucommia@harborside.com

How to Train New Solar Installers
In *HP92*, I wrote an article voicing my skepticism about a national certification program in the process of implementation by an outfit called the North American Board of Certified Energy Practitioners (NABCEP). Their program has a stated goal of improving solar installations, and is being considered for integration into a few state and utility solar incentive programs.

My opposition to this program has only increased since the article was written in September 2002. The cost of the certification is a major consideration. The NABCEP program relies heavily on a Florida program for licensing solar installers. The cost of getting a license in Florida to install only the DC side of a PV installation is astronomical.

According to one person who received a license last year, the required references cost $750; an optional exam prep school, $350; the application fee for the test, $354; the license itself, $209; and $209 every two years thereafter. There is also the lost time preparing for the exam, wading through the red tape, traveling to the exam, and taking it. In addition, the Florida program requires a continuing education requirement of fourteen hours every two years. If this is what Florida wants, fine. But don't try to saddle the rest of us with this unneeded classroom and book learning.

The NABCEP's goal of better solar installations is admirable, and I don't know of anyone in the solar industry who would challenge the goal itself. But, can their program really benefit the industry with all this classroom training and at what cost? Everyone in the building trades industry knows that you learn your trade in the field. Classroom environments can help with things like theory, concepts, regulations, and codes, but that's about it. Field training is where the rubber meets the road, and the building trades have been doing things this way for centuries.

The United States has probably the safest houses in the world and they weren't constructed with book learning and national certifications. How did American workers build all these buildings without the NABCEP? The answer is simple—it isn't needed.

There are much better alternatives to this purported national "voluntary" certification, and one of them is already being implemented in Wisconsin. Their program makes sense because it uses the tried and true method of training new installers—field training by experienced installers being paid to show new installers how to do it right. I recently spoke to two people in Wisconsin about their program, Bill Hurrle of Community Builders and a hydronic heating contractor in Berlin, Wisconsin. Bill is an old solar pro, and the heating installer wants to branch out into solar installations. According to them, the program in Wisconsin is budgeted to pay experienced hands like Bill for up to sixteen hours to train new solar installers, in the field. There is also a provision for another experienced installer to inspect the systems for functionality. The rebate on the installation is not paid until the system is signed off. The Wisconsin program also has checks right up front on the system design for both PV and solar heating, and other details that deserve consideration by anyone interested.

The details of the program are not the point here, nor is a debate on whether the Wisconsin program offers enough training. It's the idea of training new people in the field that counts. The idea is far from revolutionary, but is a breath of fresh air in the controversy surrounding national certification. Master craftsmen and journeymen have been training apprentices and helpers since before this country was formed. This works now, has worked for centuries, and isn't broken, so why try to fix it with a new and costly bureaucracy like NABCEP? Chuck Marken chuck@aaasolar.com

More Wrenches for NABCEP
[Letter to the RE-Wrenches e-mail list]
Amigos, Last week I attended the NABCEP board of directors meeting in Austin, Texas. For those of you who don't know, I sit on that board along with Don Loweburg. I let myself get drawn in to the deal for several reasons:

1. The organized labor presence was too high and the RE wrench presence was too low. NABCEP recognizes this and we are taking steps to even it out. NABCEP is pretty committed to making sure that the wrenches and nontraditional newbies have access to certification. The union reps were not happy campers with that position, but it is going forward anyway.

   Any of y'all who have read Chuck Marken's article in the most recent *Home Power* can probably relate to some if not all of his concerns. (Attaboy Chuck, your concerns needed to be expressed.) At this point, NABCEP has already dealt with some of them. NABCEP realized very quickly that the overwhelming union response to the original stakeholder questionnaire did not represent what was really going on in our industry. They have greatly modified the requirements to sit for the certification test to include as many of us independent working wrenches as possible.

2. Whether we like it or not, I believe that national certification is going to happen. Most of us OGs (old guys) can remember the happy days before *NEC* 690. While I still have some issues with that, I gotta admit that it is a good thing overall. Here's why it's going to happen and why we need to do it—money.

   For RE to continue to go mainstream, we will need incentive programs. (Yes, I fully agree that if the oil, coal, and gas incentives went away, we'd be cost effective tomorrow, but let's get real. That ain't gonna happen. Certainly not under Dubya, or the Demos for that matter. Even if Ralph had won, I doubt whether he would have had the juice to stop them.)

   Since incentive programs are funded through "public benefit" funds (the people's dough), it is reasonable and correct to require good value for money spent. A huge part of that is good design and installation. No arguments there, eh? While all states that currently have RE incentive programs allow (and will continue to allow) owner/builder installations, some are now seriously looking at promoting certified wrench installations in one way or another. As soon as the data is in from a few of these programs, we all know that it will show that real wrench installations will overall outperform the others. In Florida, data apparently already suggests that certified contractor installs cost a bit more but last far longer. It seems like a no-brainer to me that data like that will prompt other state programs to adopt similar provisions.

   At the same time, some manufacturers are looking at programs where installations by certified wrenches have increased warranties. In some cases, if you aren't licensed or certified and trained in their products, there is *no* warranty. How 'bout them apples?

3. Pride. I'm proud of what I do and I'm proud of my craftsmanship. Aren't y'all? While I don't need another certification to do my job, if there is one worth having that will tell my clients to hire the best and forget the rest, I want it. I'm all over it. Bring it on.

So, one way or another, I figure we should do this. In the best case, it will put more money in our pockets and allow us to compete with (and I hope say bye-bye to) the incompetents. I don't see this as putting the competent, but uncertified, shade tree wrench out of biz at all. He or she just may not get the higher end jobs. Oh well.

In the worst case, our industry goes the way of most electrical and plumbing trades—very controlled and hard to break into. I believe that by steering NABCEP, we can avoid this. Looking down the road, if NABCEP is a hit, we can steer state programs to some degree as well. After all, are we or are we not the experts around here?

OK, I figure this is bound to spark debate. Let's have it. If Don and I are to represent the wrenches effectively, we need to hear all of it. Just keep in mind, especially if you disagree with the whole concept, that we ain't the enemy... Best, Bob-O Schultze, Electron Connection • econnect@snowcrest.net www.electronconnection.com

Simple South
On page 135 of *HP92* is the continuation of a discussion of finding true solar south. A very simple method is to observe on any clock exactly what time the sun rises over *your* horizon, be that a desert flat horizon, a mountain to the east, or a tree line that is not going to be cut. Then observe on the same clock the time the sun sets behind whatever in the west, be that a desert flat horizon, a mountain to the east, or a tree line that is not going to be cut.

The time interval you have noted between these two is your solar day. Take exactly half that elapsed time and it is *your* solar noon, the point at which the sun has passed half your solar window, and usually the point at which your modules should be aimed. This may vary during the seasons in cases where sunrise and sunset obstructions are irregular, but in any given season, this gives a correct angle for that particular season at that array location. Steve Willey, Backwoods Solar Electric Systems steve@backwoodssolar.com • www.backwoodssolar.com

RE Radio Nets, Anyone?
Dear *Home Power,* I am a neophyte regarding renewable energy.

My original goal was to simply supply enough electricity to operate my amateur radio station for both leisure and emergency communications. After poring over back issues of <I> HP <I> , I now have grand dreams of going off grid completely!

I also noticed a relatively high number of hams involved in RE. Are there any formal/informal nets on shortwave dealing with RE? If not, I would be interested in hearing from any hams with hopes of starting a new net. I have tons of questions and am very interested how other hams are utilizing RE. Contact me and let's get it going! Craig Miller, W8CR, 4085 Home Rd., Powell, OH 43065 • w8cr@qsl.net

Maytag Neptune vs. Staber
Dear *Home Power*, That was an excellent article on the Maytag Neptune phantom load. Here is some additional information. Beware, all Neptune models have a suds recovery mode (their name). The unit senses, through motor current monitoring, that an excess of suds is present, and it will add extra rinse cycles using more water and energy. In the Staber and the Neptune, I find that 1/2 ounce of standard detergent was about the maximum when using soft water.

The newer Neptune model 5500A added a recirculating water pump, which may, if other things are equal, cause the unit to use slightly more energy per cycle. It was removed on the 5500B, 6500, and 7500 models.

The current 5500B model (with LED controls) has a phantom load of 3 watts. And even opening and closing the door and pushing the off button does not reduce it to zero, even though all of the LEDs go off. The timer mentioned in the article will work nicely. An external AC switch, if it is turned off after the washer is through, also works well since the clothes need to be removed to dry. Unplugging it is also relatively easy in many houses, where the AC receptacle outlets are accessible. Potential Neptune buyers should also know that the fancy 6500 and 7500 models with the LCD touch screen controls have an internal electric water heater that maintains the wash water temperature at factory set values.

I find that the Staber 2300 is easier and cheaper for the homeowner to fix. It has both a stainless steel inner drum and outer wash container, and may use slightly less energy than the Maytag. The Staber is available with a stainless steel lower housing at additional cost. The Maytag Neptune has a plastic outer wash container, more internal plastic parts, more cycles (for gentler clothes handling), handles unbalanced loads better, and has a more durable standard outer finish on the front and sides.

Earlier Stabers have developed dispenser leaks, but that has been addressed in current units. The Neptune had a recall on earlier units to replace a door gasket that developed mold, but the problem has been eliminated in current units. If bleach is not used regularly in the Staber, mold may develop on some internal parts. As a do-it-yourself person, I like the easy maintenance and simplicity of the Staber. My wife Patti likes the user friendly nature and more mature design of the Neptune. Both are good units for lowering energy usage.

It will be somewhat hard to make a direct comparison between the two because the Neptune has so many automatic correction features (adds hot water automatically to get warm, suds recovery, etc.) that remain hidden to the consumer, and it has so many different cycles. The service manual explains several of these "hidden" features.

The latest Energy Star ratings on them both give the following:

- Volume: Neptune, 2.9 cubic feet; Staber 2 cubic feet.
- KWH per year: Neptune, 322; Staber, 265
- Modified energy factor: Maytag, 1.64, Staber 1.48 (takes into account the amount of energy required to dry the clothes; the Maytag spins faster and longer than the Staber)
- Percent better than current DOE standard: Neptune, 199 percent, Staber, 151 percent

However, I found that the 26 KWH per year Maytag phantom load (at 3 watts) losses are not included in the Energy Star rating, so in a "normal" house, the Energy Star ratings don't tell all. John Wiles
jwiles@nmsu.edu

John, Thanks for the feedback regarding my Maytag article in HP*. Your comments will help others better understand the tradeoffs when trying to make a decision about clothes washers. My initial impression from your comments was disappointment. My hope was that Maytag was working on making the machine more efficient, but it sounds like that is not the case. A 24/7 phantom and a water heater would make it very difficult to justify in an off-grid home. The switch concept would fix the phantom, but the limited sunshine in Minnesota—especially in winter—would not allow an electric water heater.*

We also researched the Staber, but bought the Maytag, I suspect for many of the same reasons your wife prefers it. I also didn't think getting someone to service the Staber would be as easy as getting a Maytag serviced. Thanks for your comments. HP *readers will be more informed about their choices because you are willing to share your research. Tom Markman*
dekkt@msn.com

Ozonal Notes

Looking Down the Barrel…

Richard Perez

There are all sorts of barrels. Lately we're looking down two types, gun barrels and oil barrels. And we see the same thing at the bottom of each—darkness. War is intimately connected with both types of barrels. We use the gun barrels to ensure the full oil barrels.

Another War for Oil

It's highly likely that by the time this article is published, the United States will be involved in another war. The Bush administration has convinced Congress, many of our allies, and the United Nations that it's time to go to war against Iraq. While propaganda asserts that the justification for this war is domestic and international security, many of us suspect the real motive is our lust for oil.

Since 9/11, this nation's concerns regarding security are understandable. America was attacked by a faceless, stateless enemy—an enemy that can barely be identified, let alone located and brought to justice. America has come to know fear in a way that it never has before. Emotionally, we want something to be done. We want those responsible to be identified, caught, and punished, and we want to retaliate so we can once again feel in control and secure. But will war with Iraq accomplish this? In my opinion, no.

While Iraq is obviously a state that enslaves its own people, and probably would enslave other nations if it were able, it has never been shown to be directly responsible for the attacks on the U.S. that occurred on 9/11. The enemy we faced on 9/11 has no distinct nationality. Iraq is merely a convenient and available target. A war in Iraq will not bring the perpetrators of 9/11 to justice any more than it will protect us against future attacks. A war with Iraq does give the U.S. the opportunity to flex its military muscle, ensure a more constant supply of cheap oil, and probably most important, distract its citizens from the sad state of our ailing economy. A war with Iraq isn't a war for security, it's a war for control and profit.

Follow the Money

It's a certainty that the terrorists who attacked the U.S. on 9/11 were financed by oil money. The war toys employed by the Iraqis were bought with oil money. So, once again, we're entering into a war where Americans pay for both sides of the conflict—we finance our enemies every time we fill our gas tanks, and we finance our own war machine every time we pay our taxes.

Consider how this situation might be different if oil was removed from the equation. International terrorists would not have access to the wealth necessary to carry out their schemes. They wouldn't be playing with missiles and chemical and biological war toys. And the citizens of America would be more economically secure by saving the billions spent on oil and the military might necessary to ensure its constant supply.

Homeland Security?

After living in the mountains and off-grid for more than 30 years, I've come to know that the foundation of security is self-sufficiency. Harvesting your own renewable energy ensures that your electricity supply is secure. Growing a garden and raising your own livestock ensures your food supply. Working for yourself ensures your income. Self-sufficiency is the shortest and most definite path to security.

Consider self-sufficiency on a national level. During the last fifty years, the U.S. has lost its self-sufficiency. It has gone from being a creditor nation to being a debtor nation. We are no longer able to produce all we need. Instead we must pay other nations to supply our needs. This has ruined our once robust economy and the industrial base on which it rests.

Energy, mostly in the form of oil, is the dominant factor in this change. Energy runs as a common thread through every product and service we use. Our appetite for oil has sent billions of dollars out of this country, never to return. Our appetite for oil has financed the war machines of our enemies, forcing us to spend more on our own defense than the next ten lesser nations combined. The exhaust from our vehicles has ruined our economy as well as our environment, and now it's ruining our peace.

If we want to make our homeland secure, we must first make it self-sufficient. Since energy is the dominant cause of our insecurity, energy is the place to begin our drive towards self-sufficiency and security.

Only renewable energy offers us the energy self-sufficiency we need. In a few hours, the sunlight hitting the earth supplies more energy than the entire United States will consume in a year. The energy is there, and it's freely supplied by nature—all we need to do is intercept it, convert it, and use it.

The equipment needed to turn sunshine into usable energy was pioneered by American industries. We already know how to do this, and were once the largest producer of this equipment in the world. We should regain this status. We can make this nation energy self-sufficient through the use of renewable energy, and revive our economy by exporting RE technology to other nations.

This isn't just a matter of high technology devices such as photovoltaics, but also of known and proven low-tech approaches, such as biodiesel. Our transportation system now runs on oil. This oil is imported from other nations, and paying for it has ruined our economy and our peace. Consider what would happen if we were to shift our primary transportation fuel from oil to biodiesel. Our fuel could be grown locally on American farms. Our fuel supply would be secure and under our own control. The money spent on fuel would go to American farmers, not oil producing nations who bear us ill will.

On the environmental side, biodiesel offers us an annual carbon cycle—the carbon dioxide produced by burning this year's fuel crop will be fixed by the growth of next year's fuel crop. Compare this very short, one-year, carbon cycle with that of petroleum's hundred-thousand-year cycle. This is a surefire recipe for fuel self-sufficiency that yields security, and thereby peace.

Turn to the Sun!

What can one person do? It's obvious that we cannot rely on our oily government to embrace renewable energy and thereby lead us to energy self-sufficiency, security, and peace. Fortunately, renewable energy is something we can do for ourselves. We will make this transition one roof at a time, one vehicle at a time, one farm at a time. We can do it. And we must do it, for no one else is going to do it for us.

We should turn to the sun to stop the flow of our wealth overseas. We should turn to the sun to deny our enemies the wealth they need to attack us. We should turn to the sun to revitalize our economy. We should turn to the sun to clean our environment. We should turn to the sun for peace.

Access

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www.homepower.com

Q&A

Reactive Power
Hi Richard, I've been reading *Home Power* for a year or so and finally got off the fence and bought a Kill-A-Watt meter. If you have the time, I'd appreciate your help with a quick question. The Kill-A-Watt meter provides both apparent power (via Vrms x Arms functions) and active power (via the watts function) measurements. I understand that the difference between apparent power and active power is called reactive power. Question: Is reactive power actually consumed? Do we pay for it? I'm trying to complete a home energy spreadsheet and I'm not sure if I should be using apparent power measurements or simply watts (active power). I notice large differences for some loads (such as a VCR phantom load), and no difference for other loads (such as lights). Thanks in advance and keep up the excellent work. Regards, Al Whittemore, Malibu, California

Hello Al, AC electric power has two components—resistive, in which voltage and current are in phase, and reactive, in which voltage and current are not in phase. Both the resistive and the reactive components are "real" in that the generating source must produce both. The resistive component is consumed by appliances, but the reactive component, which is not consumed, must also be generated to supply the resistive component.

The electric energy meters used by all utilities in residential service only measure the resistive component. Hence, you get the reactive component supplied without charge by the utility—nice of them, huh? In industrial service, where the reactive component can be huge, the utility requires that the reactive component be reduced (mostly by using huge capacitors), since it places a large burden on the utility's generating sources.

For those making electricity using an inverter or a generator, the reactive component is very real. The additional energy required to generate this reactive component comes out of the batteries or the fuel tank. This is why it is so important that off-grid systems use appliances with the smallest reactive component (power factor as close to unity as possible). Richard Perez • richard.perez@homepower.com

Long Wire Run
Dear *Home Power,* I have a solar-electric system that I am very happy with. My twelve solar-electric panels and wind generator are located on top of a hill behind my office, 80 feet away. The system provides electricity for my office, a small cabin, and a storage shed. I run a 24 V Sun Frost refrigerator as well. I have recently acquired land adjacent to me that has a cabin on it. I would like to get electricity to the new cabin, but it is 500 feet away. I have identified other future needs that would require long AC wire runs in another direction. I would like to be able to run 20 to 30 amps at 120 volts at the end of this 500 foot line. Obviously the major considerations are voltage loss and the cost of heavy gauge wire.

I am trying to determine the best way to approach the problem. Should I build another small solar-electric system for every new building, or would it be wiser to invest in just one system and then transmit the electricity to where it is needed (up to 500 feet)? Would a transformer bumping the voltage up to 240 V for long wire runs be a practical solution? I have figured that 500 feet of #6 wire would carry about 12 amps with less than 2 percent voltage loss at 120 volts. If I put a transformer in front of it taking it to 240 volts, it would provide the 25 amps I am after. I figure the cost of this to be about US$1,000, quite a bit cheaper than buying new batteries, panels, inverter, and everything else needed for a complete system. Thanks for any response. Jeremy, Tonasket, Washington nagidog@starband.net

Hello Jeremy, A single system will be simpler, more efficient, and more cost effective. Forget transforming the AC to 240 volts. That requires two transformers each with a minimum loss of around 10 percent—too much. Also, both transformers would be operating 24/7, even when they are not loaded, and this would add up to more than 200 watts of idle loss—more than 5 KWH daily in lost energy.

Size the wire to do the job at 120 VAC. I'd recommend using #4/0 aluminum cable with a direct burial USE insulation. This is going to cost you about US$3,000 unless you can find a great deal. Forget using copper cable, since the cost would be astronomical. If you can reduce the current requirement of the new, remote cabin, smaller (and cheaper) cable could be used. Richard Perez • richard.perez@homepower.com

Tower Platform
Dear technical superhero, I have a Bergey 1500 wind genny on a Rohn 45G tower. The Bergey is mounted on a 4 foot stub tower atop the Rohn. My problem is that I'm 5 foot 4 inches tall and cannot reach the stator on the genny to remove it. Do you know of any company or person who makes a platform I could attach to the top of the Rohn and the stub to give me an additional 2

feet, allowing me to work on my Bergey? Please help. I want to repair my genny before the cold winds begin. Thanking you in advance from myself and any other short women who suffer from the same problem. Sincerely, P. Burkholder • ptudie@aol.com

Hi P., I'm not aware of any manufactured platforms for towers, though I hear that they are more common in Europe. You should check with Rohn. Your next option would be to find a local metal fabricator to build something custom. Remember that it will either need to be removable or out of range of the blades when not in use.

Another and perhaps simpler option would be to add a couple of foot pegs to the tower. I generally weld nuts for 5/8 or 3/4 inch bolts to the stub tower. Then I use large carriage bolts for removable steps. I also weld an eyebolt or loop high on the stub tower to clip my harness into. Of course, welding on a standing tower is not easy, so perhaps a local metal fabricator can design something that would bolt together around the stub tower and provide steps and positive harness attachment. Regards, Ian Woofenden, semitechnical average hero • ian.woofenden@homepower.com

Testing MPPT Controllers

Looking at some back issue articles about maximum power point tracking (MPPT), I noticed that when testing the RV Power Products controllers, you used the onboard metering for the current in and current out, claiming that this is a measure of the current increase. Wouldn't a more accurate way of measuring this be to compare the measured current with the regulator in and out of the circuit? This would tell you how much better than a non-MPPT controller the performance is for a particular temperature and battery state of charge. When I do this with my SB2000E, the percentage of current increase is about half of what I get when using your method. Kim Girardin • kmgrdn@luminet.net

Hello Kim, The test method we used measured the current increase while the MPPT was in the circuit, that is, PV current versus current delivered to the battery with the MPPT operating.

You are correct that it would have been better to compare the current with the MPPT out of the circuit and also in the circuit. We just couldn't figure how to accomplish this on a second-by-second basis. PV current is constantly changing with battery voltage, module temperature, and solar insolation. This means that any comparison of current, must be made in less than a second if it is to be accurate. Otherwise the factors mentioned above change, and you're comparing apples to oranges. As with any MPPT, power increase will vary with many factors—battery voltage, type of module, module temperature, and solar insolation. Richard Perez • richard.perez@homepower.com

Amps To & Fro

I have lived in Baja for four years and have a solar home. I built the system myself with knowledge gained from solar books and talking to solar dealers in southern California. I have always been careful to use adequately sized wire. I use a wire sizing table from one of the solar books. I have recently been told that the 12 volt wire size is only critical when you are "pulling" amps, that is pulling amps from the battery bank to the inverter. It is not critical when "pushing" amps, that is, pushing amps from the solar-electric array to the batteries. Please advise. Thanks, Richard A. Van Dellen

Hi Richard, It doesn't matter which way the electrons are flowing—they still need an adequately sized wire. And they are always "pushed" by the voltage of the source, so I wouldn't describe it the way you did. Wire size is determined by four things: distance, voltage, amperage, and conductor material. We have a great wire sizing spreadsheet available in the "Solar Power" section of our Web site's download area.

In most systems, the wires between the battery and inverter will see the highest amperage in a system, so they will usually be much larger in size than the wires from the PVs to the battery. The peak amperage (electron flow rate) from the PVs to the battery is usually lower, so the wires are usually smaller. But you certainly don't want to undersize these wires either, since you want as much energy as possible to reach the batteries so you can use it. Regards, Ian Woofenden • ian.woofenden@homepower.com

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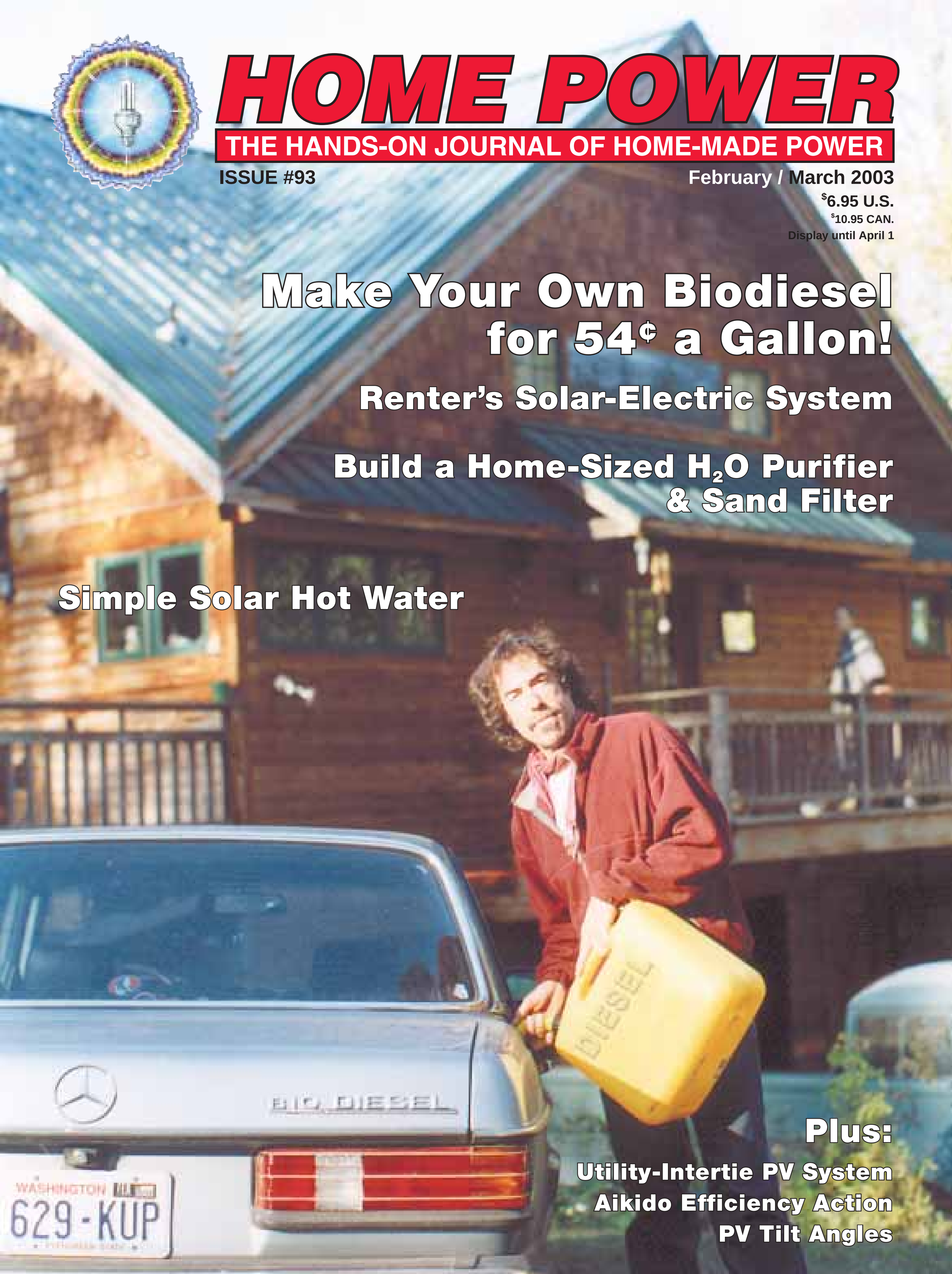


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- ☐ All electricity
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- ☐ Water heating
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In The FUTURE: I plan to use renewable energy for (check ones that best describe your situation)

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RESOURCES: My site(s) have the following renewable energy resources (check all that apply)

- ☐ Solar power
- ☐ Wind power
- ☐ Hydro power
- ☐ Biomass
- ☐ Geothermal power
- ☐ Tidal power
- ☐ Other renewable energy resource (explain)

The GRID: (check all that apply)

☐ I have the utility grid at my location.

I pay ______¢ for grid electricity (cents per kilowatt-hour).

____% of my total electricity is purchased from the grid.

☐ I sell my excess electricity to the grid.

The grid pays me _____¢ for electricity (cents per kilowatt-hour).

(continued on reverse)

I now use, or plan to use in the future, the following renewable energy equipment (check all that apply):

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❑	❑	Wind generator	❑	❑	Thermoelectric generator
❑	❑	Hydroelectric generator	❑	❑	Solar oven or cooker
❑	❑	Battery charger	❑	❑	Solar water heater
❑	❑	Instrumentation	❑	❑	Wood-fired water heater
❑	❑	Batteries	❑	❑	Solar space heating system
❑	❑	Inverter	❑	❑	Hydrogen cells (electrolyzers)
❑	❑	Controls	❑	❑	Fuel cells
❑	❑	PV tracker	❑	❑	RE-powered water pump
❑	❑	Engine/generator	❑	❑	Electric vehicle

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