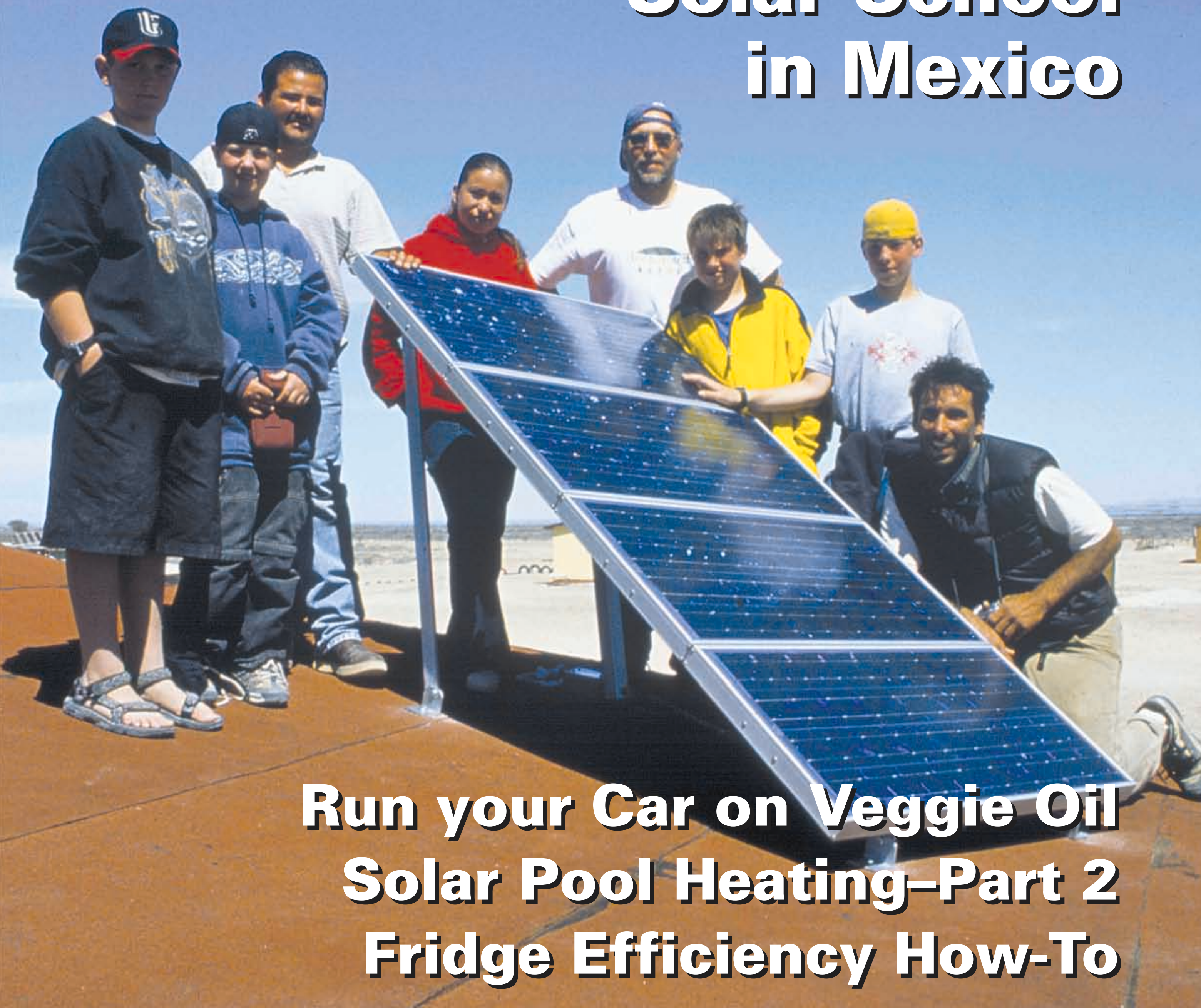
home power

The Hands-On Journal of Home-Made Power

Issue 95 June – July 2003

Solar School in Mexico



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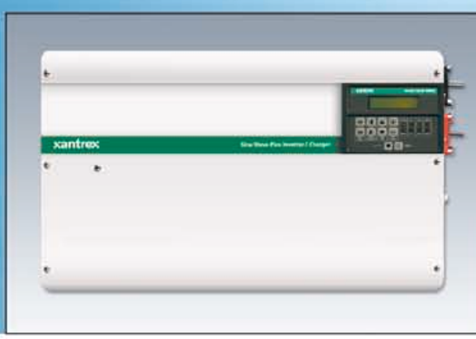

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Richard Perez
Home Power Magazine

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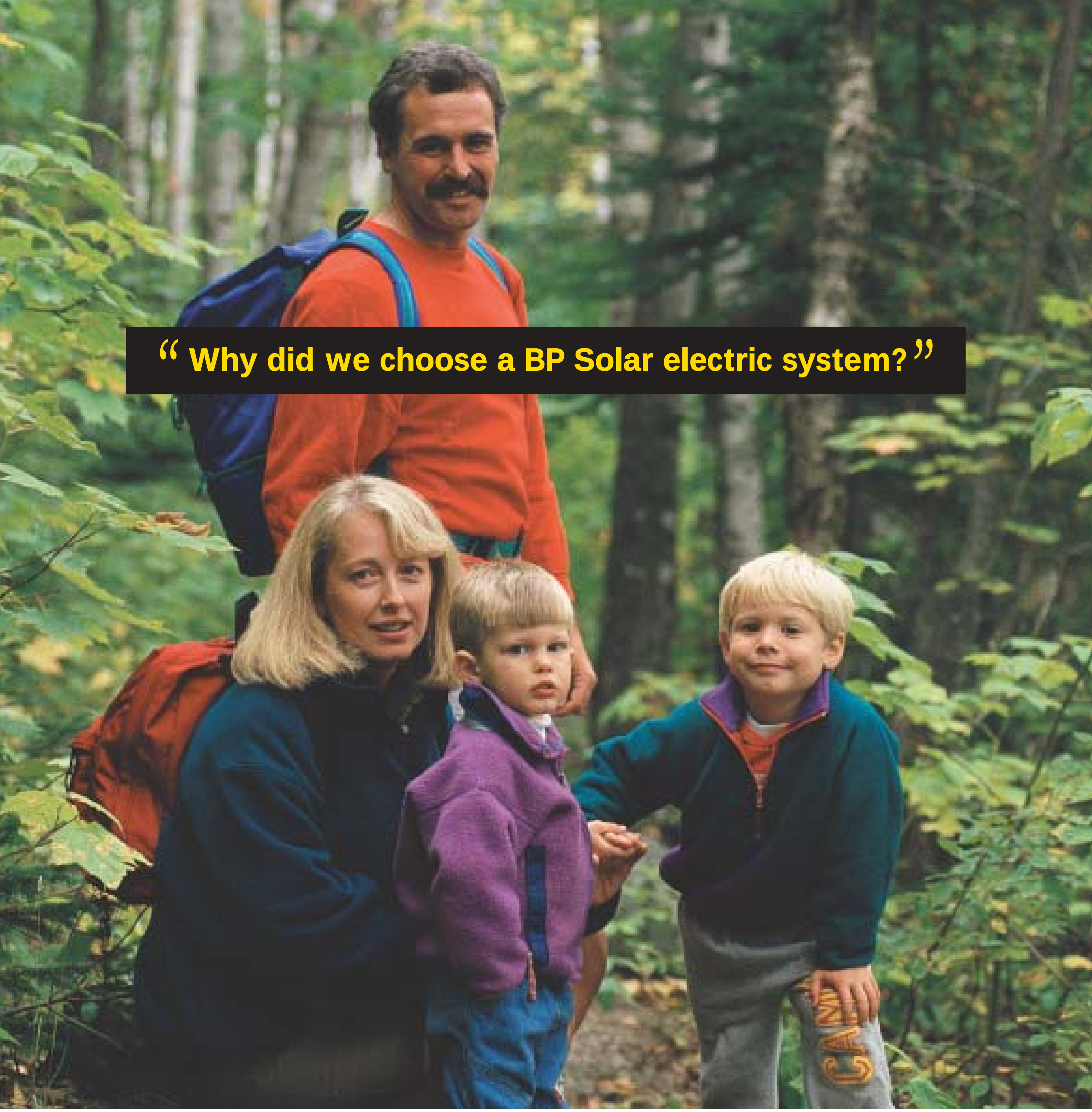

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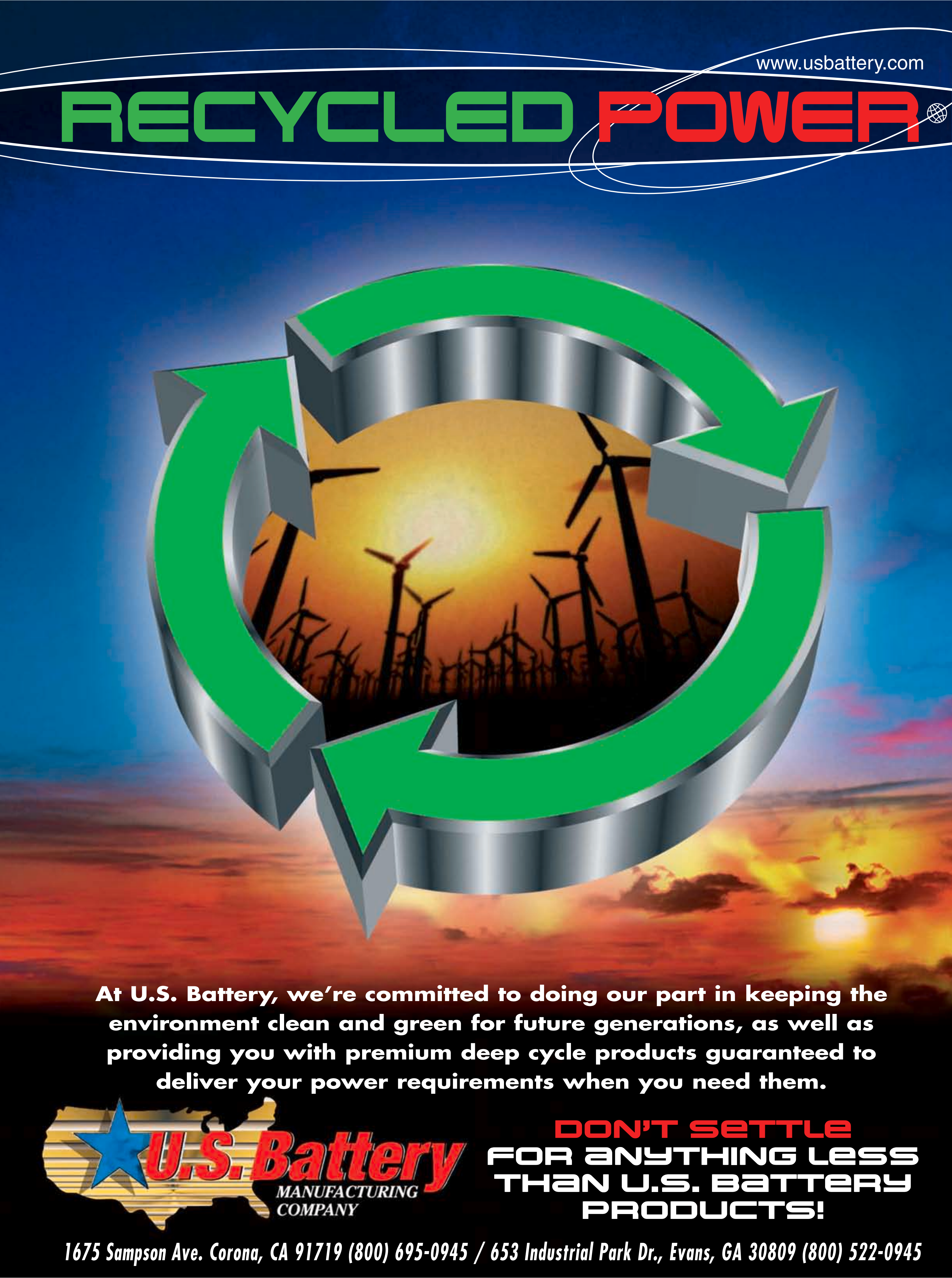
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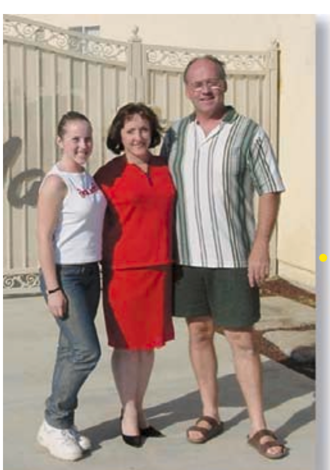

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On the Cover

Scott Ely, with teachers and students from both Boulder, Colorado and Laguna San Ignacio, Mexico install PV panels on the Mexican school's roof. Photo by Chris Leonard.

Regulars

Home Power's New Look

Home Power's original design was incredibly long-lived. Stan Krute and I created it back in the day. The year was 1986. The design was tailored to the fact that the magazine was printed on newsprint (like a newspaper) on newspaper presses—hardly the most accurate printing process.

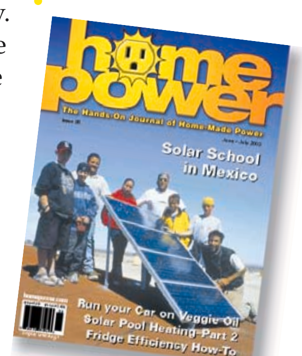
These days, *Home Power* is printed on very accurate, high speed, printing presses. We're using modern electronic prepress techniques—digital photography, PostScript art, and higher resolution type fonts made possible by digital direct-to-plate printing techniques.

After seventeen years, we decided it was high time to make a substantial change to the magazine's appearance. We didn't make this change lightly. Our new look is the result of many months of work by the *Home Power* crew. Ben and Eric, *Home Power's* art department, were fearless moderators during passionate design collaboration that went on for hours, days, and months.

A magazine's design is much like the user interface of a computer program, or a well organized kitchen. The reader, nerd, or cook becomes accustomed to where things are and how they work. *Home Power's* new design maintains some of the successful interface styles of the original design—continuous articles uninterrupted by advertising, and large page numbers and headers. It also adds some new design elements, like more technical sidbars.

Of course, we want to look good too. The most important motive of our redesign is to entice, convince, and teach more people to use renewable energy. There has never been a time when the world and its people needed RE more than right now. Renewable energy can make us free—free to live where we want, even beyond the utility lines, free to have a clean environment, free from monthly electricity bills, free from power outages, and free from energy-induced wars. We at *Home Power* are on a mission—we are going to change the way people make and use energy. We are going to change this world one rooftop at a time. Read this magazine—join us!

– Richard Perez for the *Home Power* crew



Think About It

Even after all these years, the Sun never says to the earth, "You owe me."
Look what happens—with a love like that, it lights the whole sky.

Hafiz, the Great Sufi Master

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

Paper and Ink Data: Cover paper is Aero Gloss, a 100#, 10% recycled (postconsumer-waste), elemental chlorine-free paper, manufactured by Sappi Fine Paper. Interior paper is Ultra LWC Glossy, a 45#, 100% postconsumer-waste, totally chlorine-free paper, manufactured by Leipa, an environmentally responsible mill based in Schwedt, Germany. Printed using low VOC vegetable-based inks. Printed by St. Croix Press, Inc., New Richmond, WI.

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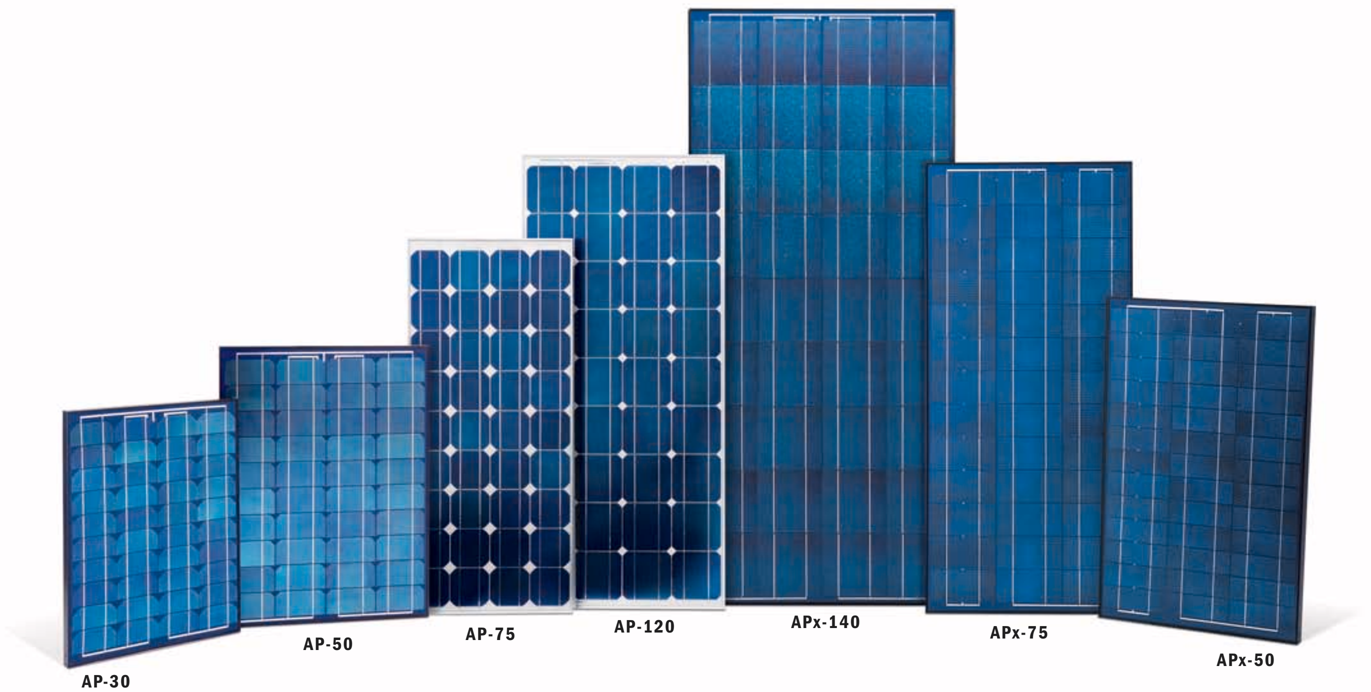

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RE Education—Connecting in Baja

Scott Ely
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Photos by Chris Leonard

The benefits of renewable energy are many, particularly in the sustainability of communities in developing countries. Our neighbors in Mexico have been using renewable energy for years. Some of the projects there have been quite successful, while others have created more problems than they have solved. With my recent trip to Baja, Mexico, I had the goal of building a model for renewable energy system design, installation, and education in developing countries.

Earthsense is the educational division of Sunsense, my renewable energy distribution and installation business in Carbondale, Colorado. In early 2002, the Sojourner School (a charter school in Boulder, Colorado) received funding from the Natural Resources Defense Council (NRDC). They contacted Earthsense about a solar-electric project in Mexico.

Students from Sojourner were heading to Baja for an interactive experience that included lessons in animal preservation, Latin American culture, soul searching, and renewable energy. They needed assistance with a solar-electric system installation at a school in the remote village of Laguna San Ignacio. I jumped at the opportunity.

The Bigger Picture

As Earthsense became more and more involved with planning for the project, it became clear that solar electricity was just one piece of a larger puzzle. The Sojourner teachers and students emphasized the need for a wholistic experience. After numerous discussions with Tony Moats—teacher, trip organizer, and all-around good guy—the project took on new meaning. This was not just another PV installation.

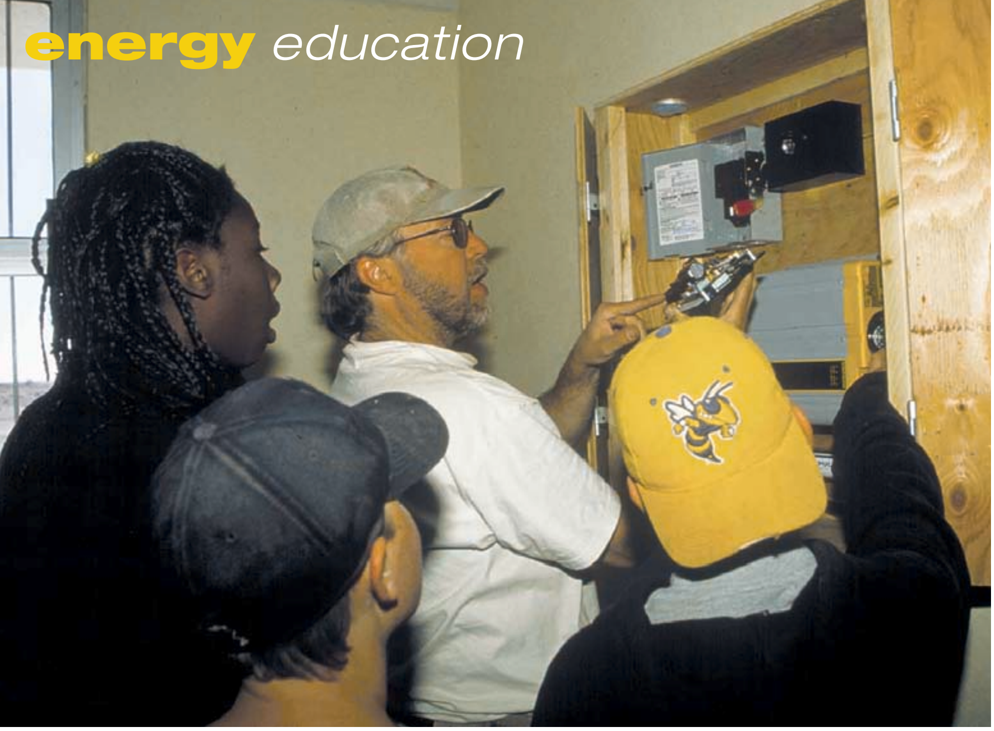
The chance to explore the local culture, community, and environment, while integrating renewable energy education, provided a wonderful serendipity. The project seemed to have a flow, a connection within its framework. Our goal was to educate both the local community and the Sojourner students about renewable energy. By doing so, we hoped to introduce the concept of sustainability to the village. Sustainable practices, such as using renewables, would shape an economic base that also preserves the environment. Having a pristine environment fosters better ecotourism. Everybody wins!

The renewable energy component of this project was the catalyst for the other experiences. The folks at the Sojourner School were looking for a provider of renewable energy products and services with a focus on education. One of our Sunsense dealers, Joe Callahan from Simple Solar in Boulder was aware of the Earthsense education mission and put us in touch with Sojourner.

Joe had done some preliminary sizing and cost analysis, but his schedule would not allow him to make the trip. After numerous e-mail communications and a visit to Sojourner, Earthsense was ready to join the team and energize the wholistic tour with solar energy.

Teamwork overcomes obstacles, and like solar energy, is a limitless resource.

A typical house in Laguna San Ignacio with a single solar-electric panel and a satellite dish.



The author discusses current technology with the next generation.

fuse to a 12 V, ProSine 1,000 W sine wave inverter (with meter), to provide a high quality 120 VAC sine waveform for the sensitive loads.

Prior to our departure for Mexico, some head scratching was required to design enclosures for both the batteries and the balance of system (BOS) components. Simplification and budget warranted plywood structures and ordinary hardware. Passive ventilation was provided for both enclosures, and a dust collection filter was inserted to keep the equipment as clean as possible. Both enclosures are accessible for educational purposes, yet lockable for security and safety. The BOS enclosure incorporates a duplex receptacle for 120 VAC, while the battery box was sized to add another battery in the future if necessary.

System Overview

The solar-electric system for the Luis Echeverria School was designed to power a computer, monitor, and printer or a TV and VCR, and perhaps a light or two. It was sized for four hours of run time per day and four days of battery storage.

The four, roof-mounted, BP Solar SX65, 65 W rated, solar-electric panels would charge two, Concorde PVX12225, sealed batteries through an RV Power Products Solar Boost 2000E charge controller and fused disconnect. Direct current from the batteries would feed through a 110 A

PV System Sizing

Energy Usage Calculations	Amount
TV/VCR or computer system (load)	200 W
200 W x 4 hours daily use	800 WH
With 85% inverter efficiency	920 WH
AH per day: 920 WH ÷ 12 VDC	77 AH

PV Sizing Calculations	Amount
Daily PV charging needed	77 AH
With 15% PV temperature derate	89 AH
Module current needed: 89 AH ÷ 5.5 peak sun hours	16 A
Number of SX65 modules needed: 16 A ÷ 3.7 A each at peak power	4

Battery Sizing Calculations	Amount
Battery storage needed: 77 AH per day x 4 days autonomy	308 AH
With 90% battery efficiency	339 AH
Number of PVX12225 batteries needed: 339 AH needed ÷ 225 AH per battery	2

Culture Shock

Armed with solar equipment, parts, tools, and a limited Spanish vocabulary, we (my companion Chrissy, canines Kodi and Komet, and I) headed south to meet up with the Sojourner folks in the town of San Ignacio. Having visited Mexico 25 years ago, I had forgotten the shock of simply crossing the border. Entering at Tecate, we instantly became foreigners. Tourist visas, money exchange, narrow roads, poverty, litter, and language barriers became the norm. It was an interesting introduction to a neighbor so close, yet so far.

As we moved south, the culture began to grow on us. Traffic, narrow roads, poverty, litter, and language barriers persisted. Not exactly what we had expected, but things would change.

After a night of camping and more driving, we arrived in San Ignacio, a true oasis in the desert. Beautiful palm trees, quaint buildings, shops, and a pleasant local flavor greeted us. The Sojourner contingent was waiting there for us, a welcome sight.

With greetings exchanged, the convoy headed west over a seemingly endless washboard road. It was 30 miles (48 km) of bone-jarring, dusty, sandy road strewn with auto parts (go figure). Talk about remote! After three hours (and numerous pit stops), we arrived in Laguna San Ignacio. Our home for the next few days would be La Fridera, a small fishing camp/ecotourism business, and the home of Antonio and Maria Aguilar.

Mammalian Visitors

The town of Laguna San Ignacio is actually a widespread array of small, "resourceful" homes and structures. It lies on the barren Pacific Coast about halfway between the U.S. border to the north and Cabo San Lucas to the south. Primarily a fishing village, the lagoon attracts a large population of gray whales each winter. This breeding

What do whales have to do with renewable energy?

They, like kids and solar power, are all part of the natural world.

As each generation develops connections with the natural universe, it will better be able to live as a harmonious member of nature.

What is good for whales, is good for kids.

ground provides an incredible opportunity to interact with these huge and wonderful mammals. It also provides the opportunity for ecotourism.

Ecotourism in Laguna San Ignacio is a somewhat complicated situation. Contrary to what you might think, relatively few local people benefit from ecotourism. While a number of local families own permits for whale watching ventures, the majority of the approximately 25 permits are owned by larger, more well-funded outfits from elsewhere. This makes it difficult for the locals to compete. One study estimates that more than 90 percent of the income generated from whale watching actually leaves the lagoon.

In addition, the tourist and whale watching season is relatively short (January through March), and limited on either end. So while this contributes to the local economy, the people of Laguna San Ignacio are still very dependent on fishing-related activities for subsistence. Worse yet, the fishing industry in the lagoon is on the decline.

Recently, a large corporation, in partnership with the Mexican government, proposed a huge salt plant near the lagoon. Would there be prosperity, jobs, more tourists, and paved roads? This was attractive to some; unthinkable to others. A heated debate followed, and the project has been shelved, for now. Most fear that the salt plant would severely damage the ecosystem of the lagoon and thus eliminate the ecotourism and fishing industries. Others think that the salt plant could co-exist with the whales, and the depressed economy would then flourish.

Living with Less

The resourceful people of Laguna San Ignacio know how to live with less. And though it may not always result in the most pleasing aesthetics, we can all learn a lesson in functionality and simplicity. One fine example of this was the satellite dish turned upside-down and mounted as an umbrella for much sought-after shade.

Among the goals on this trip was to help the people of Laguna San Ignacio find ways to capitalize on their abundant renewable energy sources, and to build a more sustainable local economy. The educational component was fundamental in developing this mindset.

Not surprisingly, most houses have some semblance of a renewable energy system. One and two-panel solar-electric systems abound, along with the occasional small wind genny. Batteries are typically housed outside, exposed, and are likely to have corroded terminals. Controls and metering are limited, and fusing is virtually nonexistent. Surprisingly, the majority of the systems have been operational for years and continue to provide electricity for simple needs.

Positive connections are made—
students from both schools wire the PV array.

Kids from diverse backgrounds learn technical and philosophical lessons about energy's place in nature.

School in Session

Our first full day in Laguna San Ignacio began with an introduction to the local environment, primarily the gray whales. And the Sojourner kids were not the only students. The adult chaperones along with the "solar folks" all participated in the discussion and tutorial about whale watching etiquette, including safety, respect, and sharing the experience with everyone.

The whale watching experience is one that will never be forgotten by anyone in the group. The mammoth creatures were so playful and friendly! As we rode the waves into the lagoon aboard a small dinghy, we could see water spouts all around. Drawing closer and positioning ourselves appropriately, the whales would come up to the boat for attention. And we provided plenty. Some of the whales drew close enough for petting, and even a smooch on their rubbery brow—a true connection to the animal planet!

The following days provided an education of a different sort. The Sojourner students and the local schoolchildren met on the school grounds for introductions—Sojourner kids on one side, local kids on the other. With Renee and Tony moderating, the kids introduced themselves enthusiastically.

Following the introductions, we broke into three groups. One group was responsible for the assembly and installation

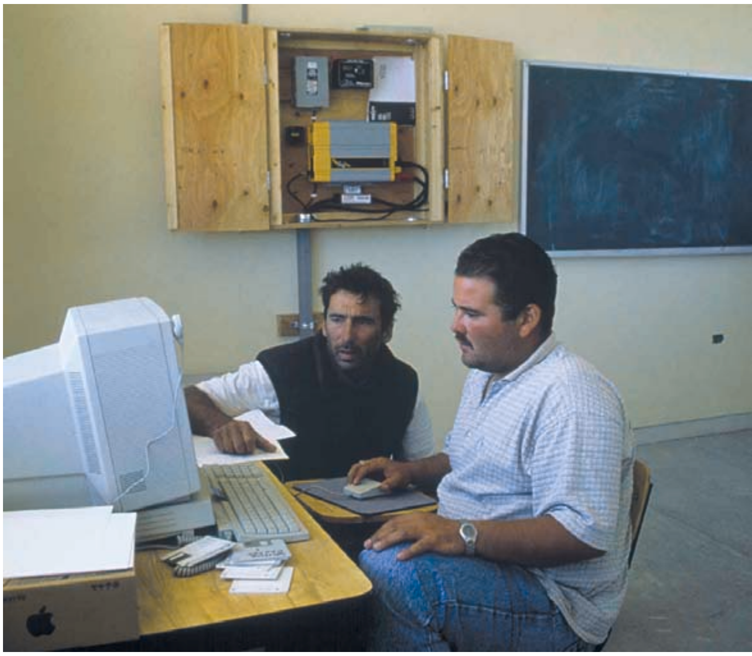
After inspecting some of the local work, it was time to assess our situation. We contacted the local headmaster, Renee, who was responsible for overseeing the installation. Of course, this relationship was a two-way street. Renee would teach us some Spanish, and we would teach him about renewables.

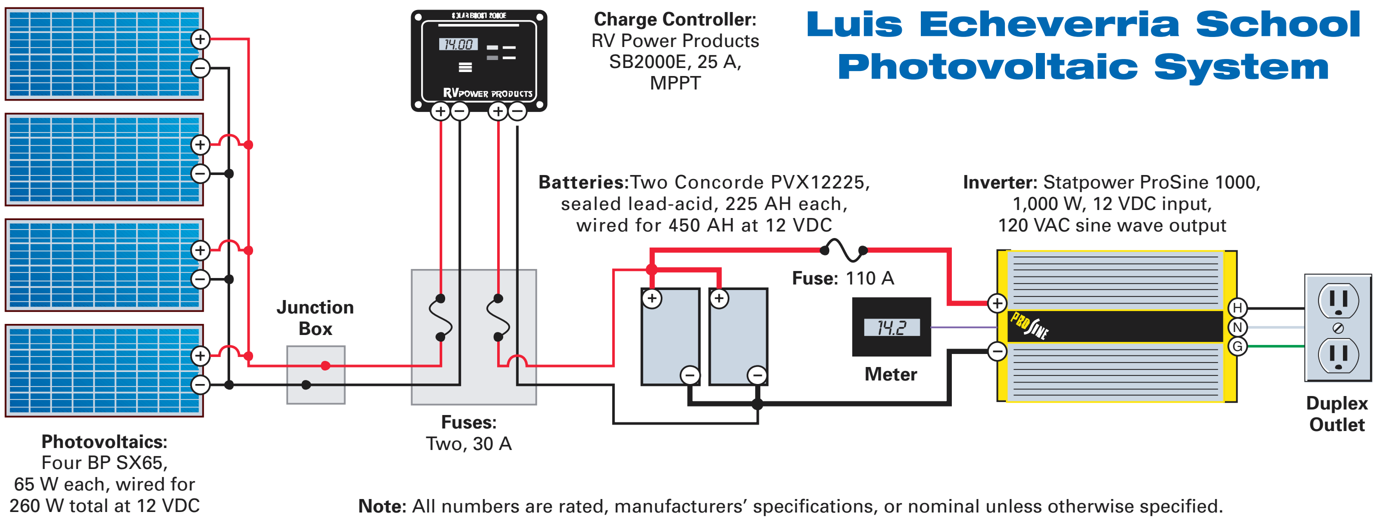
The school building was concrete, with metal doors and bars over the windows. The wind whistling through the bars provided an eerie, horror-movie tone that accompanied us throughout the project.

PV System Costs

Item	Cost (US$)
4 BP SX65 solar panels, 65 W	$1,260
ProSine 1000 inverter	731
2 Concorde PVX12255 batteries, 225 AH	664
Installation	600
Battery & component enclosure	400
Wire & hardware	300
RV Power SB2000E controller	242
Roof/ground PV mount	187
Shipping	150
Instruction manual & solar guide	100
Fuse block, 110 A	64
Service disconnect with 30 A fuses	43
Total	$4,741

Tony (kneeling) and Renee boot up the school's computer on the PV system for the first time.





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

of the solar-electric system. Another group was designated to design and paint a mural on the school. A third group was responsible for filming the entire operation on video. There was certainly enough work to go around.

The Electrical Connection

Of course, as the ringleader of the solar-electric project, my job was to instruct both the Sojourner students and the local students in the basics of solar electricity, as well as installation techniques. Interest was so high that the local villagers also participated in portions of the project! And though language barriers were present, they were eased by the fact that a number of the Sojourner students were fluent in Spanish.

Our first day on the job was hectic. Array assembly was the first order of business. Lessons on system sizing and design, series and parallel circuits, solar-electric panel concepts, and peripheral material specs were covered. In addition, the balance of system equipment was unveiled. Component descriptions and design concepts were discussed in preparation for the installation the following day.

Not everyone was ready to learn about electrons, but awareness of the series and parallel relationships within nature can start at an early age.

Well, that's where the wind came in. All night long and the following day the wind blew, and blew hard. Sand and dust covered everything. It was a challenge just to be outside! No boats ventured into the lagoon. People were holed up inside reading, writing, playing games, and listening to the wooden windows rattle. Discussions began on the possibility of adding wind power to the system in the future. As you might expect, our plan for mounting the solar-electric panels on the roof was out for that day. We did, however, have other plans.

Education is perhaps the most important link in the chain of life.

With the modules racked and ready, we simulated installation on the floor of the classroom. We discussed orientation, tilt angles, and shading issues (no need to worry in Laguna San Ignacio). We finished designing the balance of system layout, and mounted the equipment on the wall. The battery box was also located for easy access to the "power cabinet."

The last day of installation was calm and sunny, ideal for raising the array and for final hook-up of the components. We had heard that the schoolhouse structure was made of concrete, but we didn't think this meant the roof! Fortunately, we brought enough concrete anchors to mount the modules without a problem. Precise location of the anchors was important, because an error in layout would require unnecessary holes in the concrete roof.

After extensive layout and positioning, we secured the panels, ran the conduit, and made the panel connections to the service disconnect inside. Battery hookup, inverter hookup, and receptacle installation rounded out the day.

Knowledge & Power

Next was the most important education of all—system operation and maintenance. We reviewed the entire system with Renee and a couple of the villagers until the basics were understood. We backed up the verbal recap with a Spanish translation of the system operations and maintenance manual. The manual contains a review of system sizing, design, and solar-electric concepts, along with maintenance tips and schedules. Fortunately, the ProSine manual has a Spanish translation. The RV Power Products information is currently under translation. This is very helpful for international projects.

The first task for the solar-electric system was to power up a computer and printer. Setup was successful, and the computer began to boot up just like it was downtown. Renee was so excited, he immediately ran to retrieve an amplifier, microphone, and speaker. As he plugged these additional loads into the power strip, we stopped for a moment to once again extend our energy conservation lecture. We explained the limitations of the system, and warned against excessive consumption.

The group then unplugged the computer so they could use the solar-electric sound system. Now, with the mural complete, the solar-electric system energized, and the cameras still rolling, a grateful teacher, students, and village declared a day of thanks, and we all glowed in the light of our new-found friendship.

Tying It All Together

The experiences in Baja have left a long-lasting impression on everyone involved. The solar-electric system for the Luis Echeverria School has opened the door of knowledge for the students of Laguna San Ignacio. The community has grown through the education of the villagers as well as the connection with Earthsense. Earthsense has had the opportunity to teach, and perhaps more important, to learn. Above all, we have helped to secure and preserve the beauty and natural environment of Laguna San Ignacio for future generations.

Access

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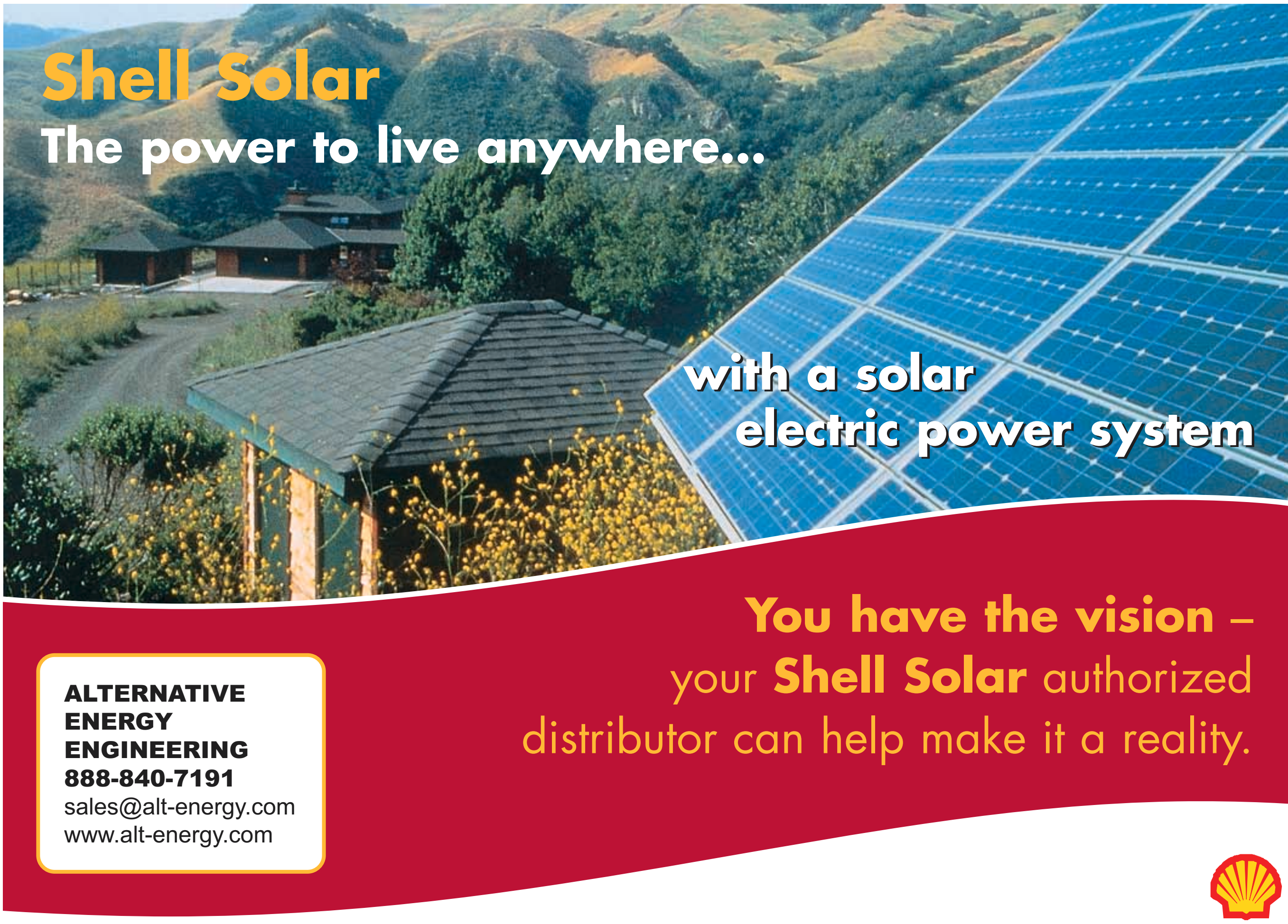
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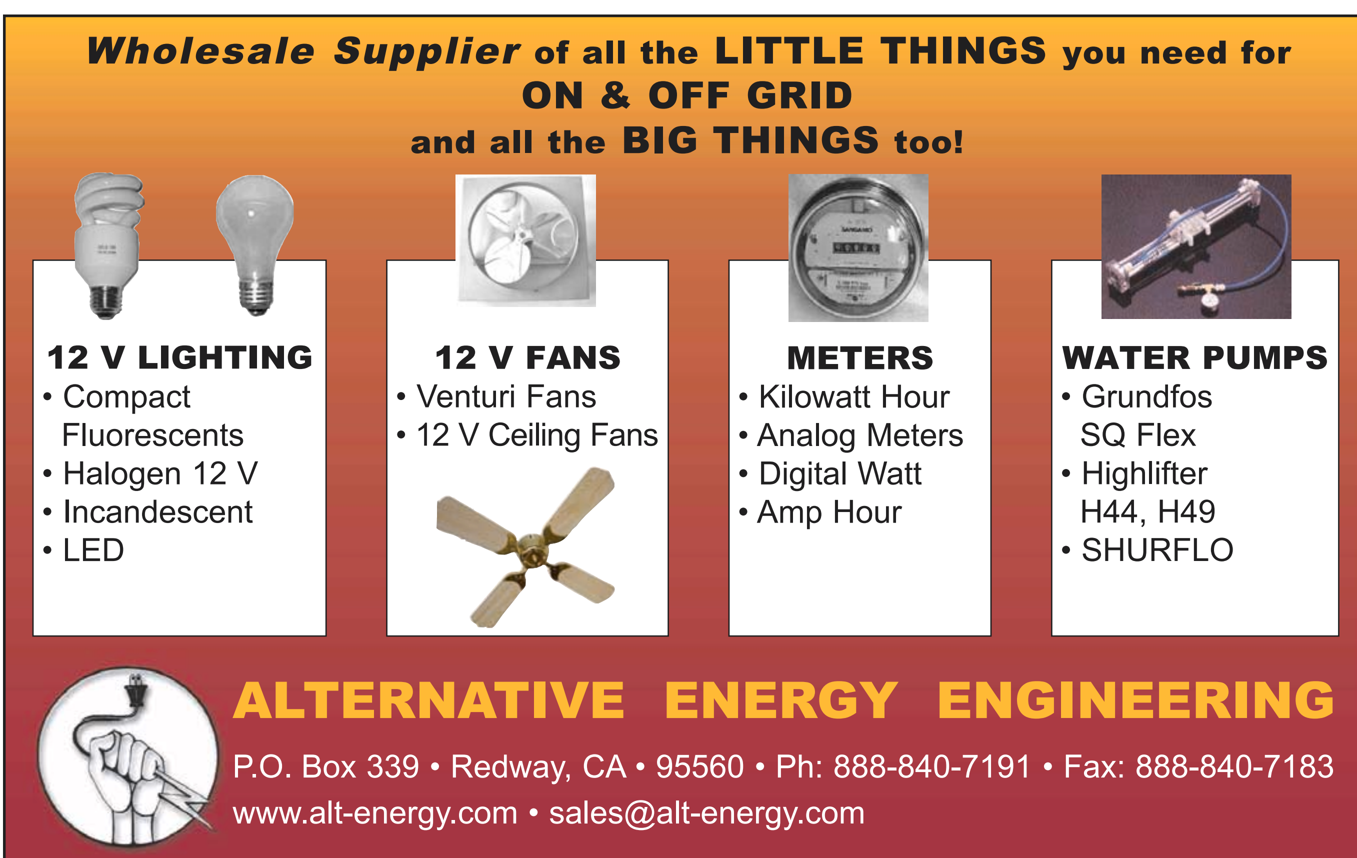
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Getting Off the Lifetime Utility Payment Plan

Daren Webster

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The Webster family's solar-electric system produces 100 percent of their annual power needs.

"What! Our Edison bill is $135? You've got to be kidding!" I said when my wife Martina returned from the mailbox. It was 1988 when that bill changed our household. That big electric bill shocked me into looking for a solution.

The very next day, I called Southern California Edison (SCE) for an "energy audit." This is a free service that SCE provides to their customers. I was so excited when the auditor arrived with his clipboard, calculator, pencil, pen, uniform, etc. When the audit was over and the results were ready, I asked him, "Well, why is my bill so high?" He replied, "Because you have all this stuff plugged in." I pressed for more, "What can I do to lower my bill?" He said, "Unplug all the stuff!" Well I knew that wouldn't work.

Surfing for Solutions

The Internet is such a wonderful thing. First, I found an article from *HP14* about phantom loads at www.homepower.com and quickly built a phantom load detector from the plans in the article. This is a very cool device that allowed me to identify energy gremlins in our home. When you plug an appliance that is "off" into the detector, if a phantom load is present, the LEDs light up. After eliminating the gremlins, our bill went down noticeably the very next month.

Later came compact fluorescents, evaporative cooling, and what I now call "watt swaps." This is when you remove six, 50 watt bulbs in a bathroom light bar and replace them with six, 25 watt bulbs, or better yet, unscrew three of the 50 watt bulbs so that only three illuminate when turned on. Another example is replacing the 60 watt bulb in the fridge with a 15 watt bulb. My wife didn't notice the difference! And why does the microwave light stay on when the food is cooking? I thought you were

not supposed to look in there while it's running! I took that bulb out—what a waste.

My Internet searches also yielded many sites on solar and wind-electric systems, and sparked (no pun intended) my interest. The concept of actually eliminating my electric bill was *awesome!* I quickly became an info-hungry, "solarite" wannabe.

From Wannabe to Solarite

Twelve years later, in February 2000, with a plethora of information, saliva building up, and a new 2,450 square foot house on four-tenths of an acre, I was ready to declare myself bill free and start my PV project. Behind the house, I built my 1,000 square foot workshop for our awards business (engraved signs, plaques, awards). I would put the array on the south-facing roof, which has a 22.5 degree, 5:12 pitch. The inverters would be housed inside the shop near the 100 amp subpanel, which would also allow the inverters to be very close to the array.

The size of the system was decided after calculating our electricity usage for our new home over a 17 month period, and estimating the KWH needed for a future pool and spa. Our average daily consumption was about 18.5 KWH per day with very disciplined usage. We figured 4 KWH additional per day for the electrically heated spa and 2 KWH for the pool's secondary system. (The primary system will use solar powered pumps for the heating and filtering.) Based on real performance data furnished by Scott Carlson of Carlson Solar about existing systems in my area, the calculations determined that a 5 KW system would work. Next, I needed to get some PV modules, then dig in with some wire and solder and get this baby going.

After talking to Scott, I was comfortable choosing Kyocera 120 watt panels. They have a 25 year warranty, and they are a well-established company. Next, I needed a couple of 2,500 watt inverters, and Scott suggested two SMA Sunny Boys. I said, "Who, what?" I had never heard of them—probably some "newbie" in the solar arena. Scott told me they are made in Germany. I said, "Cool, do you have a number, or Web address?"

With that information, I had my wife call SMA in Germany and ask all the questions I had written down. She was born in Germany and speaks the language so well that she sometimes still talks German in her sleep! After the translation, I was sold on the Sunny Boys and went down to Carlson Solar to order up my hardware, make my California Energy Commission (CEC) "buydown reservation," and just plain get excited!

> It was *unbelievable* how fast the meter was going backwards. It was smokin'…

Forty-eight Kyocera 120 watt panels and two SMA Sunny Boy 2500 inverters are the major system components.

Webster System Costs

Item	Cost (US$)
48 Kyocera KC120-1 PV modules	$22,185.60
2 SMA Sunny Boy 2500 inverters	3,850.00
Sales tax	2,082.95
8 lengths aluminum angle 2 x 2 in. x 25 ft.	300.00
Misc. conduit, wire, screws, etc.	250.00
2 Disconnects, 30 A	247.20
2 Square D breakers	44.00
Total System Cost	$28,959.75
CEC Rebate	$14,479.87
Total Cost	$14,479.88

Webster System Payback for One Year

Item	Amount
Total energy produced for year (KWH)	9,615
Total energy used for year (KWH)	11,777
Total energy forfeited off-peak (KWH)	1,400
Total energy forfeited on-peak (KWH)	377
Avoided cost	$2,029
Payback (yrs.), total cost ÷ avoided cost	7

Meeting Scott is a humbling experience in itself. He is the "Shell Answer Man" of solar—very professional, courteous, and beyond informed. In fact, in the picture dictionary under the definition of solar is surely a photo of Scott. He is *solar!* A walking, talking encyclopedia of unending knowledge, he is also 6 foot 7 inches tall. I felt like a wimp at 6 foot, 0 inches standing beside him.

His staff is also very helpful and informed. In addition to the great advice from Carlson Solar, I also spoke on the phone with John Berdner at SMA America. He instructed me to install 24 of the KC120s in series to each Sunny Boy—a total of 5,760 rated watts in the two series strings. This was so cool!

A few days later, the phone rang and my goodies were in and ready for delivery! I was so fired up! A big truck backed up to the garage and unloaded forty-eight KC120s, two SMA Sunny Boy 2500s, two disconnects, some USE wire, and eight, 25 foot (7.6 m) lengths of aluminum angle. "Gentlemen, start your engines!"

I started by cutting the 25 foot aluminum down to 12.5 feet (3.8 m). For each of eight racks, I attached six modules between two of these strips. The L-angles are attached to the outside edges of the modules with the angles facing up and outwards. I put a 1 inch (2.5 cm) air space between each module in the racks to provide more air circulation, since clearance under the PVs was minimal with my rack design. The airflow helps cool the PV cells, which increases the electrical output of the system. I installed the aluminum racks parallel to the rafters on the roof (vertical orientation) so rainwater would not dam up against the metal as it would if they had been installed parallel to the gutters (horizontally).

The aluminum angles were doubled up on top of each other to minimize the number of holes in the roof (see photo). Because the racks run up and down the roof instead of across, the chances of hitting a roof truss were low, so I through-bolted the entire array, using large fender washers, to the 1 inch (2.5 cm) thick roof. I used ample amounts of sealant around the holes, and especially just above them, to assure that water will be diverted away from the holes.

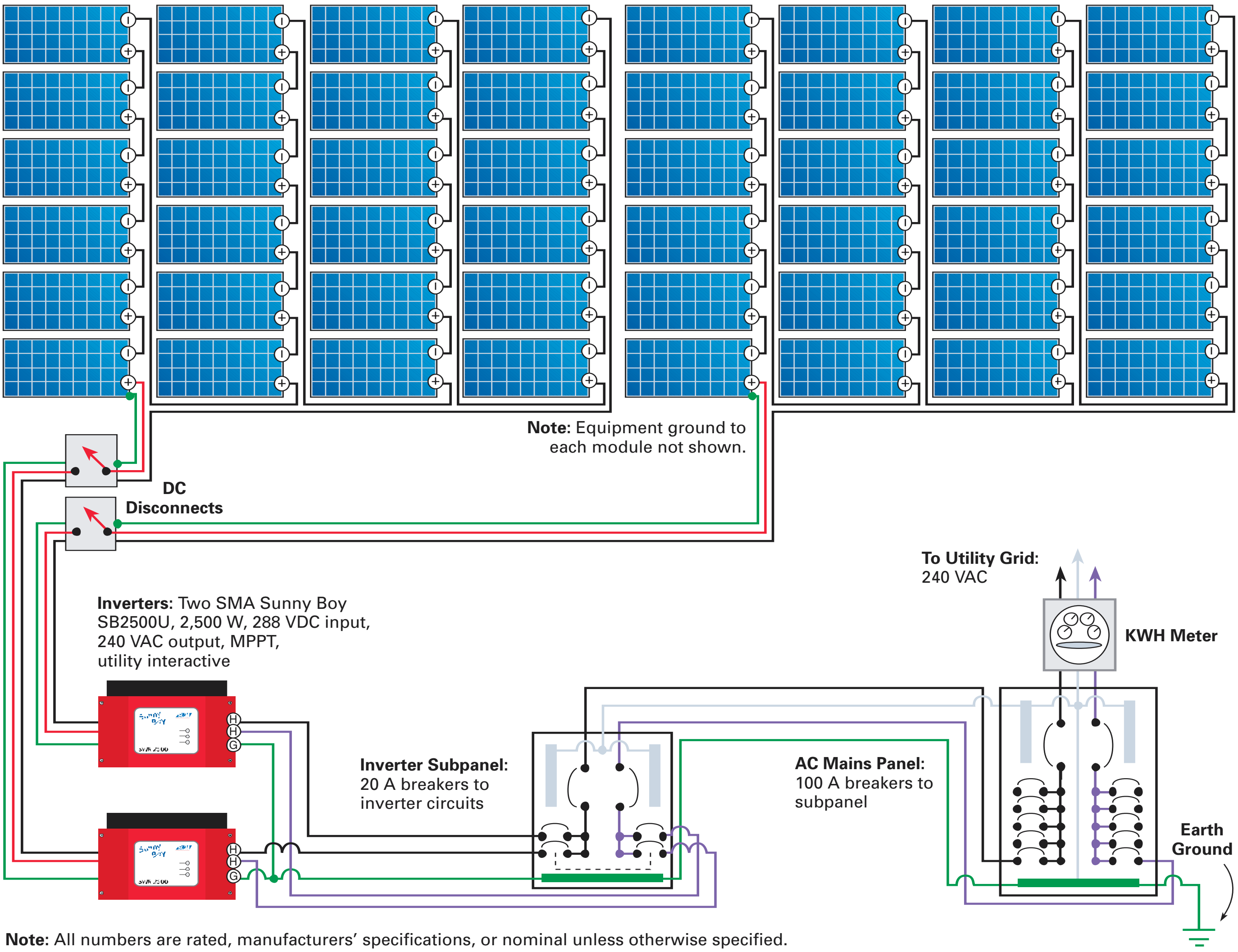
Connecting each panel was done with UV and moisture resistant #12 (3 mm^2) USE wire, with connectors crimped and soldered. Whew, that took some serious time to make 96 soldered connections! Each group of 24 panels is wired in series with only one positive and one negative wire going to the disconnects.

Working with the high voltage for a Sunny Boy inverter is serious business. I wired the modules on the racks inside the garage, out of the sun. There were eight racks of six modules each, all wired in series. Each rack was placed on the roof with positive and negative wire ends capped off temporarily with wire nuts. Four racks were wired to each other to make up the east array, and the other four made up the west array. The final connections between the racks and into the watertight junction box on the roof were made at 11 PM with a small flashlight. And the shinbone is connected to the leg bone!

Scott Carlson provided the materials, as well as help in the permitting process, design, and tech support. However, I did the actual installation of the system. If I was a contractor, I would have lost my shorts on this job because it took me a few weeks to install. I had some friends assist in the lifting of the six-panel racks. They were a diverse group of workers, including a homicide investigator (carries a gun), a welder, an IRS agent (nice guy, honest), a software

Doubling up the mounts minimized holes in the roof.

Webster Family Photovoltaic System



Daren installed his family's PV system himself— with a little help from his friends and a professional system designer.

architect (computer geek), a pool contractor, and me (an awards business owner). What a group!

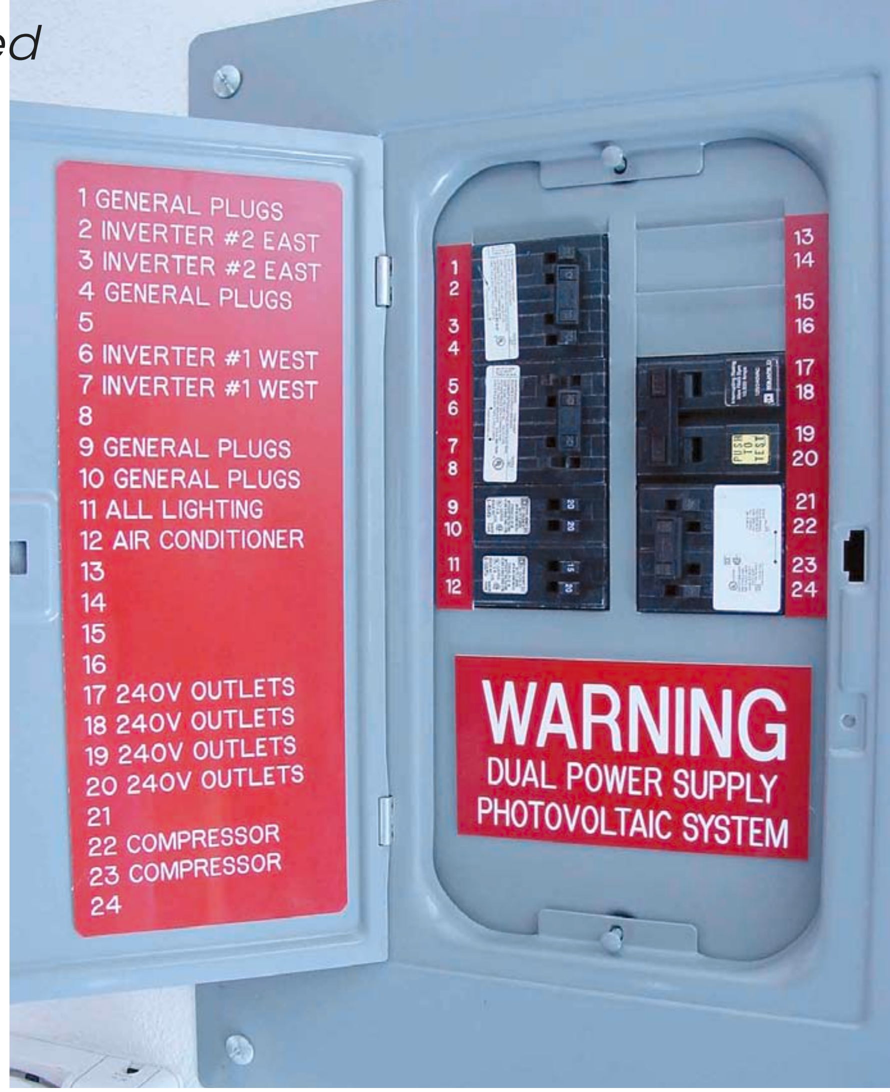
I started running 1/2 inch EMT conduit from the disconnects to the array and installed a small box where the wires are joined. Later, I ran EMT conduit from the disconnects to the SMA input side on one inverter and the output side of the other. I did this for aesthetic reasons. The wires cross inside the inverter, as opposed to outside the unit.

The AC wires were already in the wall and went to the subpanel. I had the foresight to put them there when building the shop. So all I needed to do was install the breakers and connect the other end to the inverter. To ground the array, I also had placed a #8 (8 mm^2) ground wire from the ground rod up through the subpanel and into the attic.

After I finished installing the equipment, I had my solar guru (Scott) come by and bless my work. After 5 minutes, he asked me to switch a wire in the Sunny Boys and stated that when finished I should call the county inspector! *Ta da!*

The inspector showed up two days later and walked up to me and said, "Hi, I am here to inspect your solar system; where are your batteries?" I replied, "I don't have any." He asked, "How does that work?" I answered, "Quite well!" What a goofball. This guy needed to go back to solar kindergarten. Well, he blessed the system and I instantly faxed my job card to SCE for permission to turn on the system.

I received a call from the SCE rep, and I immediately threw the Frankenstein switches, exclaiming, "It's alive!" I then ran out to the meter, with my wife 40 to 50 feet behind me, only to discover that the SMA 2500s would take a few minutes to initialize



The subpanel that the inverters feed is clearly, safely labeled.

Daren chose to mount the SMA inverters inside, even though they are designed to live outside. He added a muffin fan to help them stay cool.

before pushing energy into the grid. I returned to the inverters to watch the countdown, and when the display was approaching zero, I bolted back to the meter and shouted, "We have liftoff!" at the top of my lungs.

It was *unbelievable* how fast the meter was going backwards. It was smokin'… just kidding. Next I had Martina go inside and turn on one of our two, 3 ton air conditioners… and the meter was still going backwards, just more slowly. This was so cool! Then she turned on the second air unit and the meter went forward, but slowly.

Payback Time

I signed up for the SCE time-of-use (TOU) rate, which is based on specific time slots to determine the price of electricity. Basically, we pay a premium from 10 AM to 6 PM on workdays, and discounted rates on

Daren Webster's TOU / Net Billing Computations

			Winter		Summer			Winter		Summer			
From	To	Days	On Peak KWH	Off Peak KWH	On Peak KWH	Off Peak KWH	KWH Total	On Peak Chrg.	Off Peak Chrg.	On Peak Chrg.	Off Peak Chrg.	Energy Charge	Carried Total
09/20/01	10/07/01	17	0	0	-204	35	-169	$0.00	$0.00	($102.36)	$4.19	($98.17)	($98.17)
10/07/01	10/22/01	15	-170	8	0	0	-162	($26.51)	$0.85	($24.40)	$0.00	($50.06)	($148.23)
10/22/01	11/20/01	29	-269	-19	0	0	-288	($41.95)	($2.02)	$0.00	$0.00	($43.97)	($192.20)
11/20/01	12/24/01	34	-150	332	0	0	182	($23.39)	$35.26	$0.00	$0.00	$11.87	($180.33)
12/24/01	01/22/02	29	-203	188	0	0	-15	($31.66)	$19.97	$0.00	$0.00	($11.69)	($192.02)
01/22/02	01/24/02	2	-15	13	0	0	-2	($2.34)	$1.38	$0.00	$0.00	($0.96)	($192.98)
01/24/02	02/25/02	32	-290	30	0	0	-260	($45.23)	$3.19	$0.00	$0.00	($42.04)	($235.02)
02/25/02	03/26/02	29	-280	0	0	0	-280	($43.67)	$0.00	$0.00	$0.00	($43.67)	($278.69)
03/26/02	04/24/02	29	-315	32	0	0	-283	($49.13)	$3.40	$0.00	$0.00	($45.73)	($324.42)
04/24/02	05/23/02	29	-308	24	0	0	-284	($48.03)	$2.55	$0.00	$0.00	($45.48)	($369.90)
05/23/02	06/24/02	32	-67	-3	-182	125	-127	($10.45)	($0.32)	($91.32)	$14.95	($87.14)	($457.04)
06/24/02	07/23/02	29	0	0	-23	604	581	$0.00	$0.00	($11.54)	$72.23	$64.56	($392.48)
07/23/02	08/21/02	29	0	0	12	531	543	$0.00	$0.00	$6.28	$74.91	$71.59	($320.89)
08/21/02	09/23/02	33	0	0	39	817	856	$0.00	$0.00	$20.41	$115.25	$124.75	($196.14)

As shown in Southern California Edison bill.

Subtotal	($196.14)
Amount Owed to SCE	$0.00
Basic Charge	$12.14
TOU Meter Charge	$29.44
Rate Reduction	($4.16)
Total Adjustment	$37.42
Current Amount Due On Bill	$37.42

weekends, holidays, and outside of the peak hours. The "on-peak" rates are US$0.52 per KWH in summer and US$0.17 per KWH in winter. "Off-peak" is US$0.14 per KWH in summer and US$0.12 per KWH in winter.

Here's the punch line—from 10 AM to 6 PM, we are *sellers*, not buyers. The key to using this rate structure is shifting your loads outside of the peak time to maximize the credits that can be generated. Simply put, if you send 20 KWH into the grid during peak at US$0.52 each (US$10.40), you can buy back 74 KWH for the same US$10.40 at the off-peak rate of US$0.14 per KWH. Too cool!

We went online September 20, 2001 with the TOU rate, and we were able to credit US$457.04 to our account by June 24, 2002—all the time never having a monthly bill. We had only 3 months left to use the credit *and* the energy still being produced every day. We made a valiant effort to use up the surplus. But on September 23rd, the meter was read, and we had been unable to use all of our credit up. Once we get our spa installed, we will have no problem using up the surplus.

We actually forfeited US$196 worth. Our utility isn't required to pay for any energy generated once we offset our annual load. That US$196 equated to 1,400 KWH off-peak, or 377 KWH on-peak that we could have used if we hadn't run out of time. However, they sold my energy to someone else—that I am sure of! I wonder how they will show this in their accounting? Maybe they will use an Enron tactic.

The bottom line on all this is that our total energy produced was 9,615 KWH for the year. The total energy we used was 11,777 KWH for the year, and because of TOU, we didn't have to pay for any of it. My avoided electrical cost from the utility in year one was US$2,029. When that amount is divided into the US$14,479.88 cost after rebates, the simple payback is estimated at 7.13 years. And this doesn't even include the 15 percent California tax credit for homeowners, or the federal 10 percent business tax credit and accelerated depreciation. I don't need an accountant to figure out that this is a good deal.

Performance

Though the system has produced as much as 34.5 KWH in one day, the one year running daily average is 26.3 KWH. Monthly average is just over 800 KWH with the annual total being 9,615 KWH. During the middle of a particularly hot day in Hemet, California, where summer temperatures are often well above 100°F (38°C), I noticed that the SMA Sunny Boy inverters were displaying the message, "de-rating," and electrical output had been reduced. After reading the manuals and having Martina talk with SMA technical staff in Germany (and John at SMA America), I realized that the inverters were simply reducing production in an effort to cool themselves off.

My solution was to add a small, 5 inch (13 cm) "muffin fan" to cool off the heat sinks located on the top of each SMA inverter. Scott (the guru) feels that the fans' cooling effect

The Websters are a proud, solar powered family!

has increased the system output by almost 5 percent by stopping the inverters' need to derate (slow electrical production) to cool off. Also, electronics like to be cool, and they will probably last longer running at a lower temperature. I placed the fans on a timer so that they turn on only during the heat of the day.

What the Future Holds

Future projects include a PV direct Dankoff pump to push water through several solar pool heating panels and filter the pool for 6 to 8 hours a day. I am hoping to get 10 months of pool usage with no utility bills. Our spa will be heated during off-peak hours using AC.

Justifying my solar projects is easy. You see, it all boils down to a payment plan. You can finance your car for 3 to 5 years, and you understand that when you make the last payment, you are done! Solar is no different. When the system is paid for, you are done. Compare this to the Edison payment plan, which is, "Till death do you part," with their lifelong payment plan. With my solar-electric system, I have prepaid my electricity for the life of my PVs (at least 25 years under warranty), but the payment plan is finished with my 7 year payback. So follow my lead, and call your nearest solar-electric dealer.

Access

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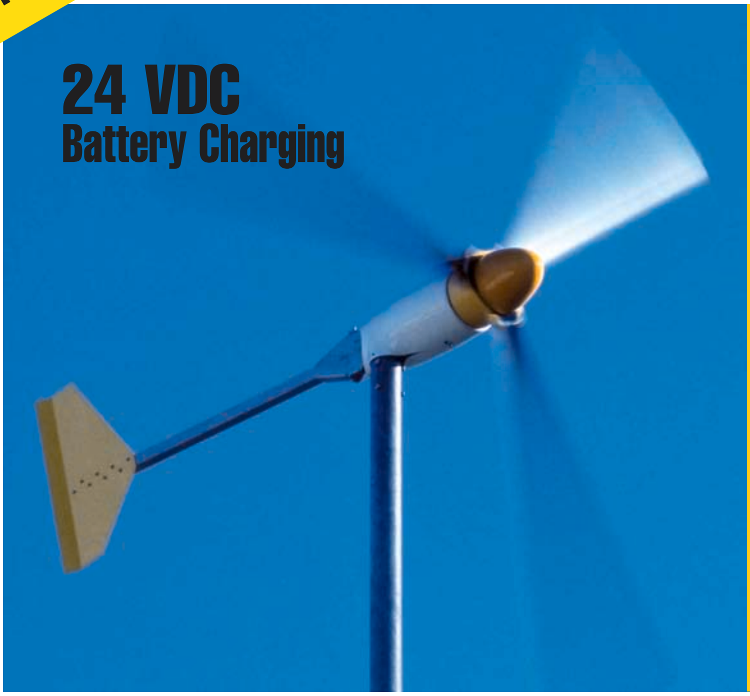

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- Bergey "Tornado-Tuff" Ruggedness
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- AutoFurl "No Worry" Storm Protection
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- Tower Winch System using Hand Drill Power
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Compare features, performance, price, reputation, and warranties. We think you will find that the Bergey XL.1 is the clear choice for your home power system. Get product information and find a dealer near you by visiting our web site: www.bergey.com.

PowerCenter Controller

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- 30A Solar Regulator
- 60A Dump Load Control Circuit
- Voltage Booster for Low Winds
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- "Wattmeter" LED Function
- Timed Equalization Function
- Push Button Rotor Brake
- Slow Mode Rotor Idling
- Easy Set-Point Adjustment
- Polarity Checker

Typical Performance: 5.2 kWh DC per day

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11.2 mph (5 m/s) Average Wind Speed at Hub Height, Rayliegh Distribution.
Based on manufacturer's published power curves.

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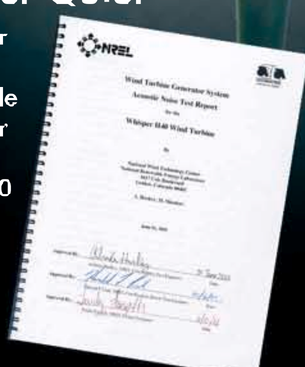

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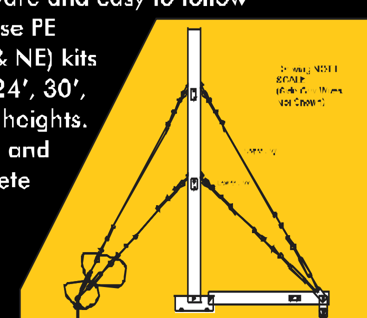

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What the Heck? 5

Amp-Hour Meter

Used In: Battery systems

AKA: AH meter, battery monitor, state-of-charge meter

What It Is: A fuel gauge for your battery bank

What It Ain't: Owned by the utility

Amp-hour meters let you know when your batteries are full, and when they aren't.

Batteries like to be full. As a rule, the more time batteries spend at a full state of charge (SOC) and the less deeply they're discharged, the longer they'll last. This is especially true with lead-acid batteries, and in off-grid renewable energy systems where the batteries tend to be regularly discharged overnight, and deeply discharged during periods of cloudy weather.

Renewable charging sources, like solar-electric panels and wind turbines, generate energy that can be stored in batteries. The rate that the batteries are charged and discharged is measured in amps. Amp-hour meters count the amperage both into the batteries from the charging sources, and out of the batteries to power appliances.

When an amp-hour meter is installed, the total capacity of the battery bank in amp-hours is programmed into the meter. The meter compares the amp-hours put into the battery (charging) to the amp-hours removed from the battery (discharging), and tells you how full the battery bank is, expressed as a percentage.

It would be silly to put a car's fuel gauge in the trunk. It's the same with an amp-hour meter. Put your meter someplace where you'll look at it often. That way you'll always have a handle on how much stored energy you have left, and when you need to fire up the stinking generator.

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Chilling the Watt-Hours

John Bertrand

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We were first thinking about solar powered homes in the 1970s and early 1980s, when sine wave inverters were just a dream. Most recommendations were to use a gas refrigerator or, at best, a super-efficient DC electric model. Later, when planning our solar home in the late 1980s, most RE dealers were starting to recommend inverters in systems, giving more credence to a 120 volt AC refrigerator. Many recommended the Sun Frost, which was favored for good reason—the mass-market refrigerator was an energy hog.

In the past twelve years, though, things have changed. Some mass-market models are breathing at the heels of the Sun Frost and similar brands in their use of energy. Plus, they offer a lot more convenience and lower prices, not to mention better aesthetics (not my highest priority, but certainly desirable).

Federal efficiency standards in the last decade have been forcing the manufacturers to do better. The lowest limits now permissible generally mandate at least 50 percent less energy use than models produced in 1990. Energy Star rated models are at least 10 percent better than this standard.

The American Council for an Energy Efficient Economy (ACEEE) has a Web site with the "best of the best in energy-efficient appliances." For 2002–2003, the most efficient top freezer model under 18 cubic feet is a Whirlpool that uses 372 KWH per year, or just over 1 KWH per day. These are respectable figures. The 2002–2003 list is dominated by the Kenmore brand, which holds 30 of 36 slots on the list, whereas the previous year's list didn't contain a single Kenmore.

Finding the right size and efficiency was just step one for us. Step two was to make the unit even more efficient.

The Long Search

While planning our new off-grid house, we not only had to plan the specific space for a refrigerator, we also had to decide whether to use a gas or electric unit. We were willing to live with some compromises. But we finally decided that, living in a warm, fairly moist climate (Hawaii) and having experience here with a small gas refrigerator, it would be far less hassle to have a modern, moderately sized, self-defrosting refrigerator if it could be relatively efficient.

Our planning period, in the late 1980s, corresponded to the first attempt by corporate America to create a more efficient mass-market refrigerator. An electric industries group set up a US$1 million prize for the most efficient new refrigerator design. Whirlpool won that prize and

With the fridge pulled out, the 3 inches (7.6 cm) of foam insulation can be seen.

on a Mass-Market Fridge

A piece of air conditioning filter is used to slow dust buildup on the coils. Front venting is pretty close to "normal."

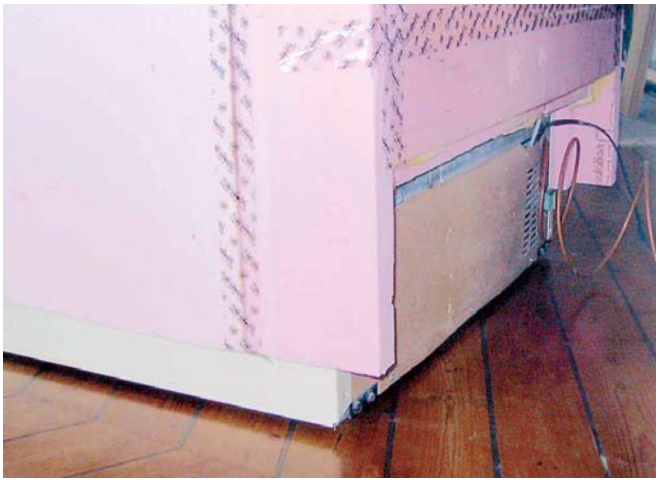
subsequently marketed a line of side-freezer models with increased insulation and more efficient compressor, among other things. Unfortunately, they priced the line considerably above the standard lines, and did not seem to do much real marketing for it.

Though a side-by-side is inherently less efficient than a top-freezer model, these units were very efficient for the time. When we were beginning to build in the mid-1990s, those models were still on the market. But I found out in 1997 that they were being discontinued. This seemed to be partly due to low sales and partly to the increasing efficiency across the industry, because of EPA standards (and the inability of the buying public to grasp the idea of long-term vs. short-term costs). In any case, I decided that since this model was still the most efficient on the market, I had best get one while I could, even though it would be awhile before we actually put it into use.

We purchased a nominal 22 cubic foot (0.62 m^2) Whirlpool, which had an EPA rating of 561 KWH per year or 1.54 KWH per day. The price was more than US$1,700 (this is rural Hawaii), though we did negotiate a US$300 discount because of some yellowing in the interior.

Refrigerator in enclosure, lined with foam insulation.

Finished! And only a little wider than the norm.



On the lower back, coils and compressor are left uninsulated to dissipate heat.

Increasing Efficiency

Even though the EPA-rated efficiency (which we confirmed with our own measurements) was very respectable, we wanted to make our new refrigerator even more efficient. I had planned the kitchen space to allow a complete enclosure around the refrigerator, with enough space for additional insulation. I could see that with the typical bottom mounted compressor, all the needed ventilation was at the bottom, front and back. I called Whirlpool technical service to confirm that as long as that area was not blocked, there would be no problem adding insulation to the rest.

When we were ready to put the unit into service, I proceeded with the task of insulating. My first attempt was a failure. I wanted to avoid applying the insulation directly to the refrigerator surface (heavens, we might want to sell it some day). So, I insulated the enclosure, using a layer of foam insulation in the enclosure wall followed by a layer of fiberglass insulation next to the refrigerator. After a few days, in checking the unit, I found that the fiberglass insulation was wet. Doing a little investigation, it appeared that the dew point had moved out into the fiberglass, which is not airtight.

So I bit the bullet and applied two 1 1/2 inch (3.8 cm) layers of dense Styrofoam insulation (left over from building our roof) directly to the top, sides, and back of the refrigerator, leaving the area around the compressor exposed on all sides. This was a little difficult in places. The sides had a slight curve to them. But I was able to get the layers of foam to conform pretty well. Using more layers of thinner Styrofoam would be even easier. I used 3M Super77 spray contact adhesive to fasten them.

On the back, there were some ridges in the metal that needed to be made airtight, if not completely filled. I used a common spray foam insulation for these few places. Then I used a heavy duty, 1 1/2 inch (3.8 cm) wide poly tape (from an air conditioning supply house) to seal all the edges, except the bottom so that if any moisture did form, it could run out. This seemed to lick the moisture problem, since the dew point was moved into the foam, which is airtight.

A vent is cut in the wall in the back of the enclosure. The copper coil is the feed for the ice maker.

The Results

When I put the insulated refrigerator into service and measured it over a week's time with my Watts Up? meter, it averaged out to about 1.2 KWH per day. During the occasional time when we had the ice maker on or when it was going through a self-defrost cycle, it was more like 1.3 KWH per day. The freezer temperature is kept close to 0°F (-18°C), and the refrigerator section at 36°F (2°C).

Now, after almost two years, I have just finished up the trim around the front of the enclosure, which had not been a high priority with other construction ongoing. I used the occasion to remeasure the energy use over several weeks,

Most of the time, the ice maker is inactive and the opening is plugged with a block of insulating foam.

and have come up with the same figures as before, with a slight rise to 1.3 KWH per day during a relatively hot (80°F; 27°C inside the house) and humid spell. We have had no moisture problems.

For us, the extra insulation has been a good move. We spent virtually nothing, while increasing the efficiency of our refrigerator by 20 percent, and have cut our energy drain by about 300 WH per day. Our refrigerator was already well-insulated; the savings may well be greater with a more average unit. A side benefit is somewhat less noise.

Things Are Getting Better

If we were buying a new refrigerator today, we might well opt for one we saw at a local store. It is a 20.9 cubic foot (0.59 m^3) Kirkland top-freezer model made by Whirlpool (US$650). Its label says that it uses 467 KWH per year, which is slightly less than the ACEEE listed unit, and shows how quickly things are changing. If the additional insulation worked as well on this model, we could project a yearly use of only 378 KWH or barely more than 1 KWH per day. But even as it comes, the unit's 1.28 KWH per day figure is very good.

A parting note on the selection of refrigerators in stores, at least around here: Most of the floor models I see are the least efficient models available, and our local electricity costs about 18 cents per KWH! Go figure! *Aloha.*

Access

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U.S. Dept. of Energy, Office of Energy Efficiency and Renewable Energy • www.eren.doe.gov
Tips for lowering refrigerator energy use: www.eren.doe.gov/buildings/consumer_information/refrig/reflower.html

EPA Energy Star Appliances • www.energystar.gov

Related Tests: *Consumer Reports*, August 2002, pages 25–27 • Comparison tests of many fridges, and gives repair history by brand.

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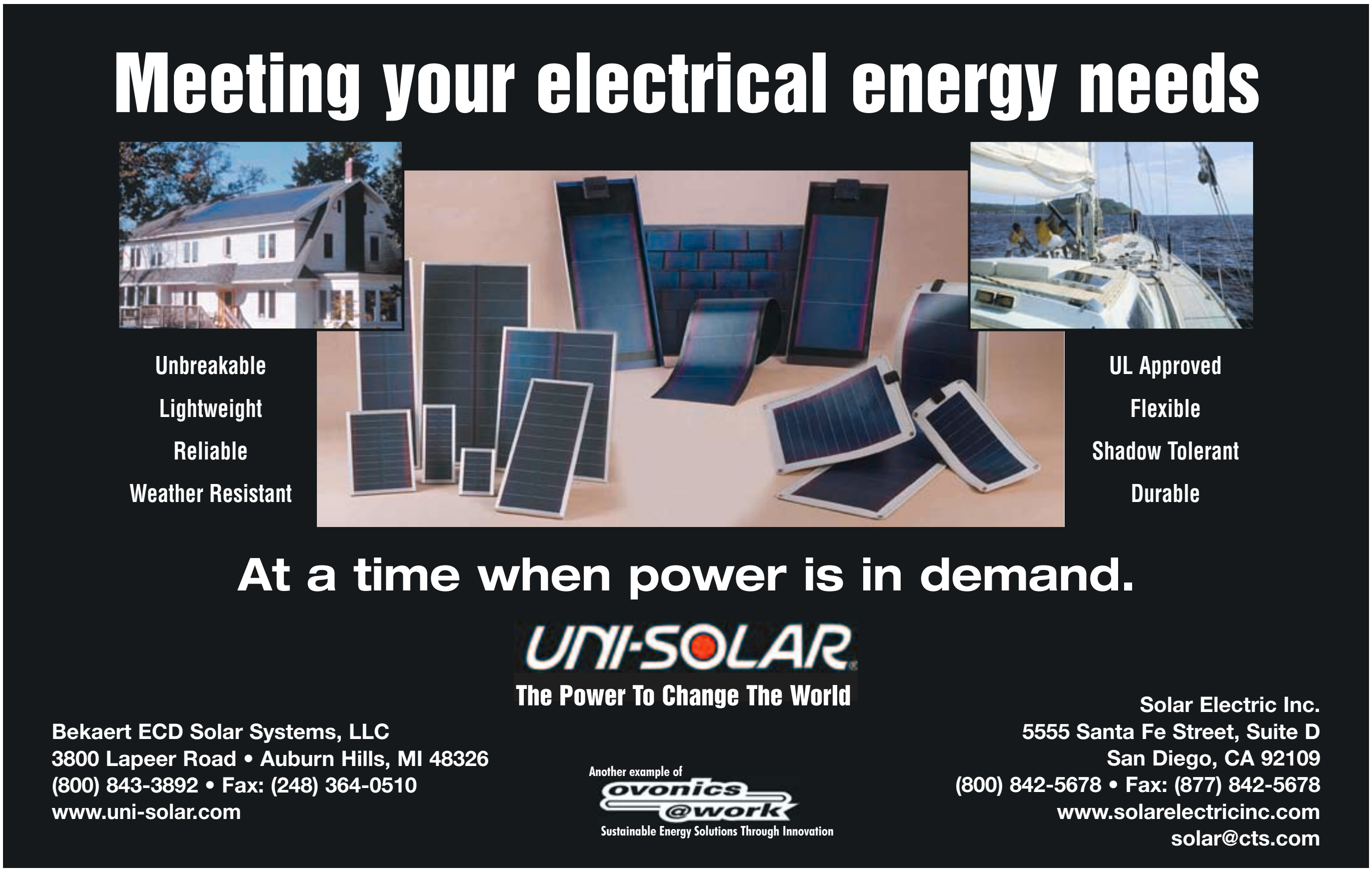
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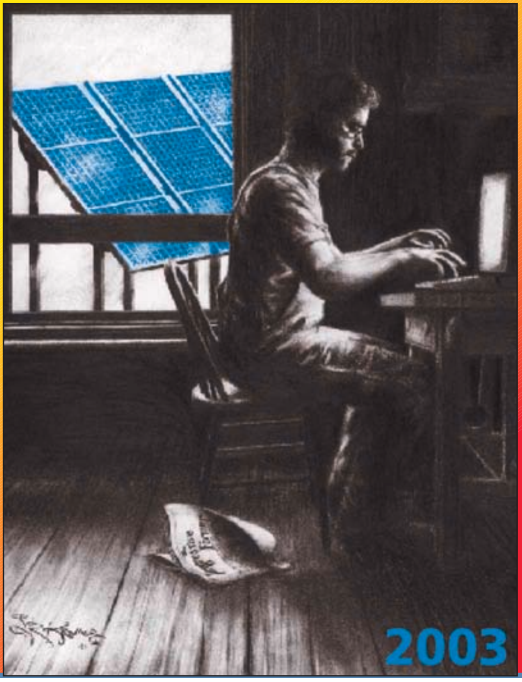

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SDHW Installation Basics Part 2: Closed Loop Antifreeze

Chuck Marken & Ken Olson

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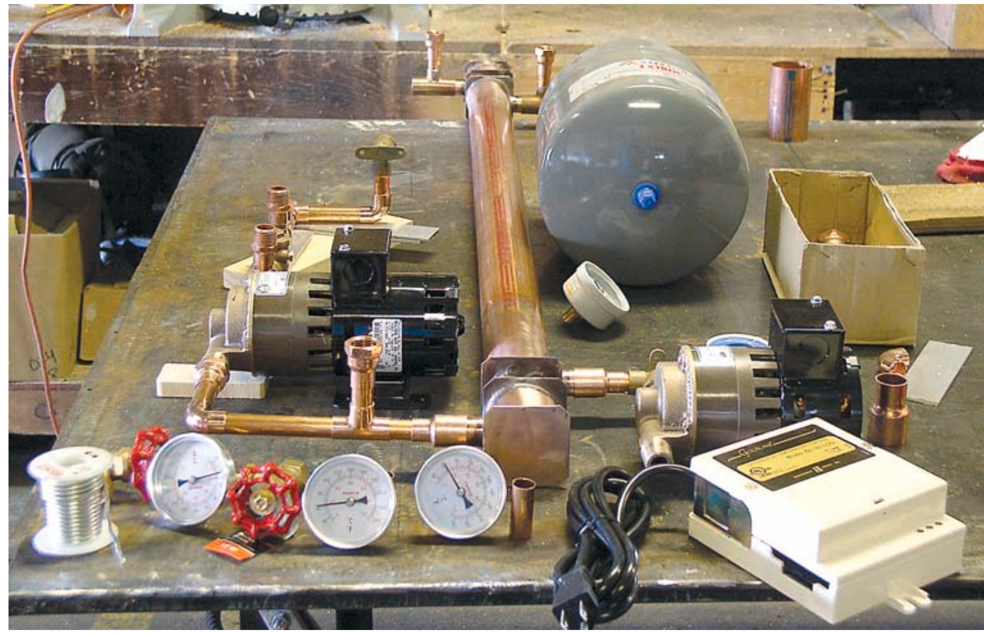
Closed loop antifreeze is one of the most common solar domestic hot water (SDHW) systems for cold climates. This article concentrates on the assembly and installation of closed loop antifreeze SDHW systems, hereinafter referred to as closed loop systems. "Installation Basics for SDHW Systems" in *HP94* covered aspects of installation common to most solar water heating installations, such as collector location and mounting, pipe runs, soldering and insulation, and the control system.

Nancy Cochrell of AAA Solar puts the finishing touches on a SDHW system.

The operation of the closed loop system, the function of each of its components, and some guidelines for sizing were covered extensively in *HP85.* In brief, freeze protection is accomplished by circulating a nontoxic antifreeze fluid to remove heat from the solar collectors and transfer it to the domestic water via a heat exchanger. The antifreeze remains contained within a closed loop, so it never mixes with the domestic water.

The collector loop setup is nearly identical to conventional closed loop hydronic home heating systems, which circulate water heated in a boiler through baseboard radiators or a radiant floor. Most plumbing and heating contractors recognize the closed loop system as a common design and are familiar with all the components on the parts list in this article.



Laying out the components and plumbing parts in advance prevents headaches after the soldering begins.

Modular Assembly Rules!

The major components, other than solar collectors and storage tanks, are easier to deal with if you have the space to assemble the parts into a component module before installation. Many modules in earlier systems had cosmetic covers, but this has been shown to cause excessive heat buildup, which can cause premature failure of certain pumps. The components can be placed anywhere consistent with good access and straightforward pipe runs, but they are usually installed near the storage tank.

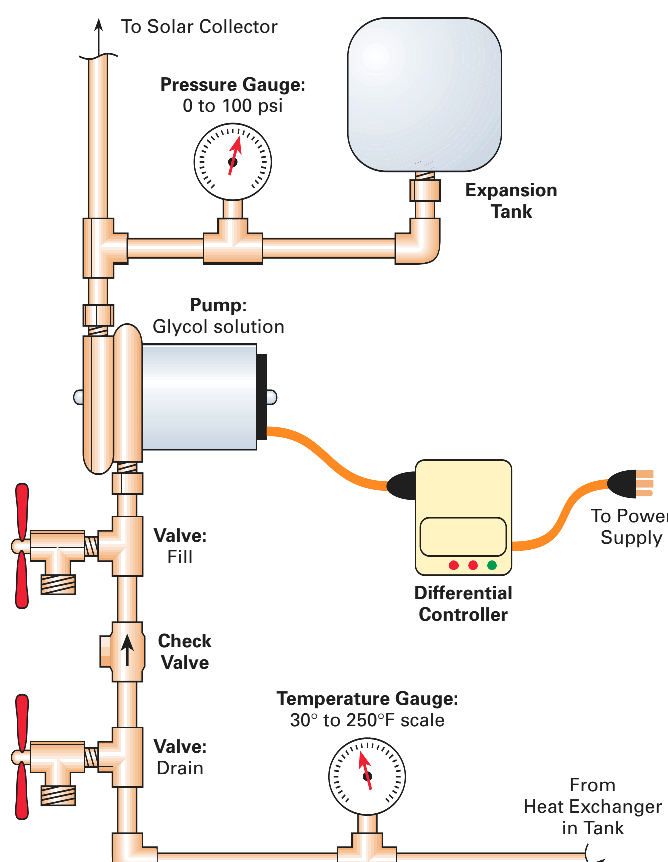
A 3/4 inch (19 mm) plywood board, approximately 2 or 3 feet (0.6 or 0.9 m) by 4 feet (1.2 m), is an excellent mounting surface for the component module. You can also use a square channel product called UniStrut for wall-hung equipment. If you have the space on a wall for a module of this size, the installation will be much cleaner, with less chance of piping errors. Placement of the components is based on convenience and access, and a few good rules as provided below and illustrated in the drawings.

When your module is completed, you will have either two or four connections to the rest of the system. For systems using an external heat exchanger, you will have four connections, including collector supply, collector return, heat exchanger supply, and heat exchanger return. For systems with a heat exchanger integrated within the storage tank, you will have only two module connections—one that goes to the collector and one to the tank heat exchanger.

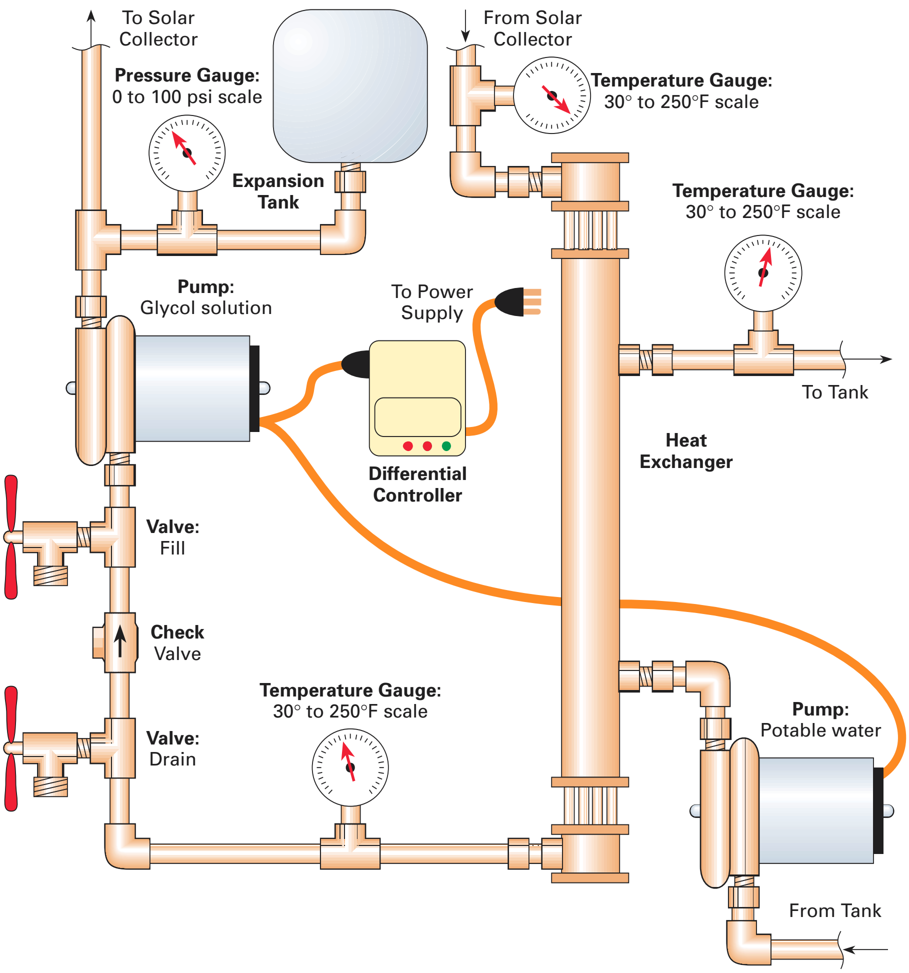
Rule #1

The pumps should be placed so that they are pumping the coldest fluid in the system. The coldest collector loop fluid is found after it has been circulated through the heat exchanger where it has lost most of its heat. The coldest DHW is at the bottom of the storage tank.

SDHW Module for Use with In-Tank Heat Exchanger



SDHW Module with External Heat Exchanger



Rule #2

Pumps should always be mounted so that the impeller shaft is horizontal. Mounting a pump with the shaft vertical will put too much pressure on the shaft bearings and cause premature failure. If possible, the pump(s) should pump upwards; this prevents trapped air from collecting in the pump chamber, which is possible with some pump models.

Rule #3

The check valve should be placed between the two boiler drain valves that are used for purging and filling the system. These boiler drains are also used for any future maintenance of the collector loop fluid.

Rule #4

The expansion tank, pressure gauge, and the boiler drain and check valve assembly are usually placed downstream from the heat exchanger, near the collector fluid pump. Therefore, they are on the cold side of the loop as well.

Rule #5

If you place the expansion tank with the pipe fitting down (tank upside down), the tank will continue to function if the internal bladder fails. An expansion tank placed with the fitting horizontal will still hold air with a bladder failure, and may continue to function. A tank placed with the fitting up, upon failure, will introduce all the air in the tank to the collector loop piping. This is a common cause of failure in older systems.

Rule #6

A coin vent may be located anywhere that an air pocket is likely to form within the piping. Air pockets are most likely to form where the fluid is at its hottest, or where the piping makes a downward turn. A coin vent is usually placed at the collector outlet where the piping turns downward. Another may be located at a similar location in the collector loop at the closed loop module assembly.

Don Keefe mounts the expansion tank upside down—on purpose.

A pressure test fitting made from a Schrader valve and a female hose fitting.

Putting It All Together

The parts should be laid out dry before putting them together. You will need to cut pipe to the sizes needed, and fit the pipe into the various fittings and adapters. All of the piping, fittings, adapters, and components should be soldered before attaching them to the module backing. Gaskets should be removed from valves and other components, and set aside before soldering. Reassemble them once the fittings have cooled down.

The assembly can be pressure tested with a small air compressor if you are unsure of any joints in the system. You can make a small attachment for the pressure test with a hose connector and Schrader valve (tire valve) as shown. This can be screwed onto one of the boiler drain valves in the open position. Cap the inlets and outlets, and the pressure gauge will indicate the assembly pressure.

If the system holds a pressure of about 50 psi for 30 to 60 minutes, you can be assured of its integrity. If the pressure gauge falls during this time and the leak is not apparent, a solution of soap and water can be applied with a spray bottle to detect very small leaks. Soap bubbles will appear at the leaking joint(s).

When you feel that the module is leak-free, the entire assembly should be fastened to the module backing and the backing fastened to the wall with screws or lag bolts. Four screws or lag bolts, one at each corner, should be enough since the whole apparatus only weighs 30 to 40 pounds (17–18 kg).

The piping to and from the collectors and storage tank can be soldered with the module in place. Some installers prefer to use unions at connections to major system components, such as the closed loop module or the heat exchanger. Unions are merely a convenience for maintenance and repair if removal or replacement is anticipated.

SDHW Closed Loop Parts List

At a minimum, a SDHW closed loop installation with collectors placed on a roof, will require the parts listed below.

Solar Collector(s)

Solar collectors capture the heat from the sun and are the main components of the system. In addition to your collectors, you will need mounts and hardware, roof jacks, silicone caulking, and roof sealant. (See “Installation Basics” *HP94*.)

Pump(s)

A closed loop system uses a low head, centrifugal circulating pump with a cast iron, stainless steel, or bronze body and is able to pump at least 0.5 to 1 gpm (2–4 lpm) for each 4 by 8 foot (1.2 x 2.4 m) collector. If your system has an external heat exchanger, you will need an additional circulating pump on the water side of the heat exchanger. This pump should have a bronze, stainless steel, or high-temperature plastic body. Be sure you have pump-to-pipe flanges if you use flanged pumps. (See “Installation Basics” *HP94*.)

Differential Control

A differential control activates the system whenever useful solar heat can be collected. It senses the difference in temperature between the solar collectors and the storage tank and turns the pump on or off accordingly.

You will also need two sensors and a 120 VAC receptacle and cord set, unless the control includes a cord set. Thermostat wire for the control sensor wiring should be #20 or #22 (0.5 or 0.3 mm^2), two-conductor jacketed cable. Use stainless steel hose clamps for fastening the sensors to the pipes. Connect the sensor wires to the sensors with electronic solder, coat with silicone sealant, and cover the connections with small wire nuts. (See “Installation Basics” *HP94*.)

Heat Exchanger

The heat exchanger, which transfers the heat from the solar heated antifreeze to the domestic water in the storage tank, can be either external or inside the tank. (See "Heat Exchangers" *HP92*.)

Storage Tank

Solar hot water is typically stored in a tank that is separate from the backup water heating system. Your storage tank may come with or without an integral heat exchanger.

Continued on page 46

Parts List, Continued

Expansion Tank
A #15 bladder-type expansion tank is sufficient for fluid volumes up to 4.7 gallons (18 l). For greater volumes, you may use multiple tanks, or a #30 is sufficient up to 12.5 gallons (47 l).

Pressure Relief Valve
A pressure relief valve rated at 50 to 75 psi is usually adequate to protect the closed loop piping.

Pressure Gauge
A pressure gauge that registers in the range of 0 to 100 psi will work.

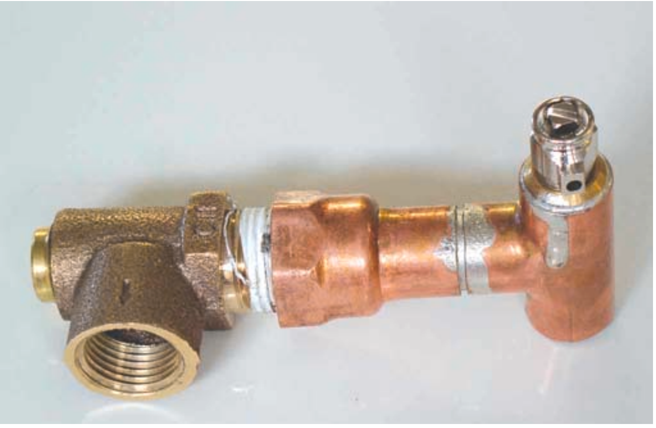
Coin Vent or Automatic Air Vent
Coin vents are preferred. Automatic air vents may be problematic outdoors in freezing climates. Manual coin vents are adequate for closed loop systems where no makeup fluid is automatically introduced into the system. (Makeup water is a common feature in large hydronic heating systems where water is automatically introduced into the system to make up for losses or leaks over time. This is not common in solar water heating systems.)

Boiler Drain Valves
You will need two boiler drain valves for purging and filling the system.

Check Valve
Spring-type check valves are recommended to prevent forward or reverse flow at night. However, swing-type check valves are recommended for use with PV powered DC pumps, which may not generate enough force to open a spring-loaded check valve.

Miscellaneous Plumbing Parts
You will need some 3/4 or 1 inch Type M copper tubing and various copper elbows, tees, adapters, and unions as required. You will also need solid wire solder (type 95/5; don't use rosin core solder intended for electronics) and flux, high temperature pipe insulation, insulation covering, and propylene glycol—approximately 1 gallon (4 l) per collector.

Options to Think About
Consider adding dial thermometers or choosing the option of digital temperature readouts on the control if available. Another nice option is the addition of three ball valves for the hot water bypass assembly. Ball valves are preferable to gate valves because the position of the handles indicates whether the valves are open or closed.



A pressure relief valve and air vent is installed at the highest piping point in the system—the outlet of the solar collector(s).

Connecting to the Heat Exchanger
Connecting the preassembled module to a tank with an integrated heat exchanger is rather straightforward. The heat exchanger outlet (cold) feeds the pump inlet, and the collector outlet connects to the heat exchanger inlet (hot). The tank's standard water inlet and outlet connections should be fitted with dielectric unions where copper pipe connects to the steel tank. This prevents galvanic corrosion between dissimilar metals.

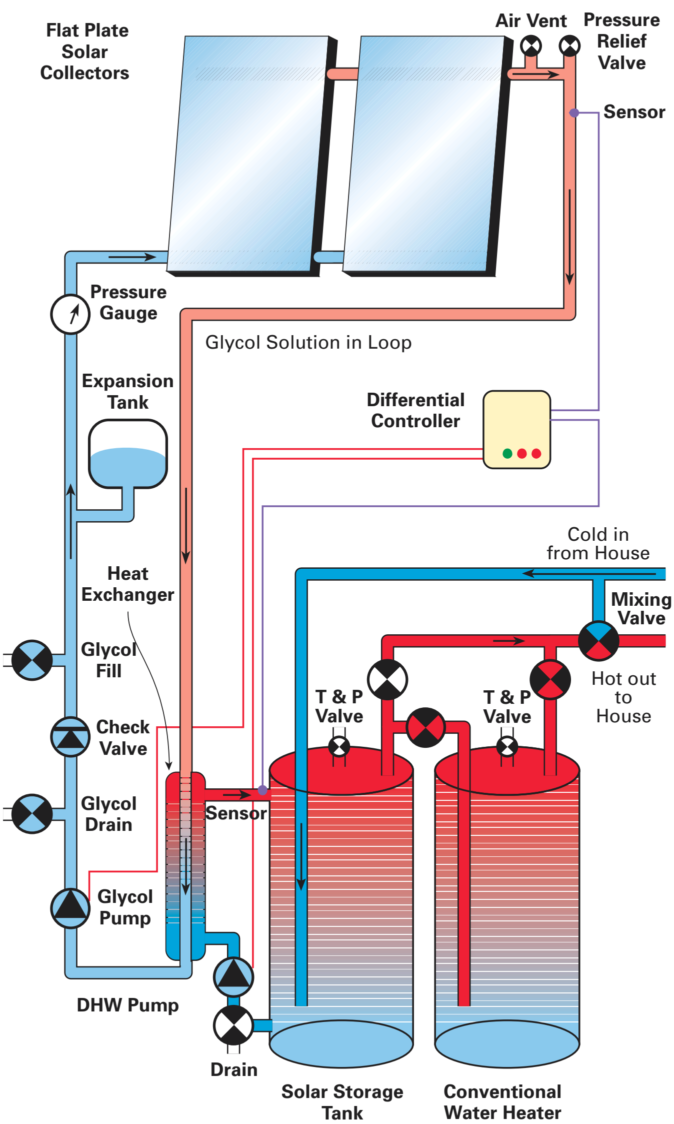
A temperature/pressure relief (TPR) valve must be installed on the storage tank if there are any valves between the storage tank and the conventional water heater. The outlet of the TPR valve should either discharge at a floor drain, connect with a tee to the TPR discharge of the conventional water heater, or be piped outside. If you pipe it outside, make sure the open end faces downward and is at least 6 inches (15 cm) and not more than 24 inches (61 cm) above ground level.

One and Two-Tank Storage Systems
Most SDHW systems use a separate tank to store solar heated water. This is in addition to the backup auxiliary water heater. Cold water supply from the house will feed the cold inlet of the solar tank. The hot outlet of the solar tank will feed the cold inlet of the auxiliary gas or electric water heater. You can install a bypass valve assembly as shown in the diagram to bypass the auxiliary tank during months when the sun heats 100 percent of your hot water.

You may consider installing a single tempering valve downstream from the tanks to avoid sending exceedingly hot solar heated water to the tap during those bountiful sunny and warm months. But tempering valves can be a problem in areas with hard water. The spring in the valve that mixes the water can become clogged in a few years, and the valve interior may need to be cleaned or replaced.

For smaller systems with an external heat exchanger and electric backup, you can save space by modifying a single, oversized, standard electric water heater to function as both backup and solar hot water storage. See the "One-Tank" how-to article in next issue for directions on making these modifications.

Complete SDHW System with Tank Storage



For situations with limited space, you also might consider using a tankless or on-demand heater for auxiliary backup. In this case, the hot outlet of the solar storage tank feeds the inlet of the on-demand heater. For this configuration to work, you must be sure that the on-demand heater is able to sense the incoming water temperature and regulate the outlet temperature. This way it will only operate to the extent that the solar preheated water needs to be boosted in temperature. The AquaStar "S" model functions in this way and is therefore compatible with solar water heating systems. (See "Solar Hot Water, Homebrew Style," *HP88*).

Tankless water heaters may need cleaning after a few years in locations with hard water. If you need to clean automatic coffee makers with vinegar frequently, this same type of periodic maintenance may be required with a tankless water heater.

Collector Loop Fluids

When the collectors are securely mounted and all components are assembled and wired as shown in these drawings and according to the manufacturers' instructions, you are ready to test the whole system for leaks, purge it, and fill it with an antifreeze solution or synthetic oil.

The most common fluid used in closed loop systems is a 50-50 solution of propylene glycol and water. This will give freeze protection down to approximately –30°F (–34°C). Propylene glycol is similar to car antifreeze (ethylene glycol), but is nontoxic. Ethylene glycol is not recommended, but may be used in systems with double-walled heat exchangers. You should be aware of its toxicity and the potential danger from possible future leaks.

Most propylene glycol is distributed with inhibitors or buffers that prevent it from turning acidic over long periods of time. These inhibitors (aluminum hydroxide is a common one) can break down at high temperatures (above 280°F; 138°C). When the buffers are gone, the glycol solution can turn acidic. A higher temperature (325°F; 163°C) propylene glycol is available, but the boiling points of both of these glycols are the same—approximately 225 to 250°F (107–121°C), depending on system pressure.

Synthetic oils have an advantage over glycol solutions because they will not boil under any temperatures produced by flat plate solar collectors. They make a system maintenance-free in this respect. The disadvantages of silicone oil are reduced efficiency due to its lower specific heat, limited availability, and high cost. A gallon of 50-50 glycol solution costs an average of US$7 to US$10. Silicone oil can cost US$75 a gallon or more.

Two other synthetic oils have been used in closed loop systems, bray oil and dyala oil, but the use of these requires a heavy caution. Neither of these oils is compatible with the butyl rubber used in O-rings, gaskets, and the bladder in expansion tanks. These oils need special O-rings and gaskets made from Viton, a material manufactured by Dupont. Expansion tanks are no longer made with bladders of this material, and that poses a significant installation problem when considering these synthetic oils as an option.

Purging & Checking for Leaks

Other options are available for purging and filling the system, but the method employed most often uses a charge pump capable of creating more than 15 psi pressure in the closed loop. It must also be capable of lifting the charge fluid as high as the collectors. A charge pump can be as simple as a drill-operated pump found in many catalogs and home centers. This type of pump has hose fittings on either end, and connects easily to the system's boiler drain valves. Three washing machine hoses, two common garden hoses, and a five-gallon bucket or other suitable container completes a minimum setup for purging and filling the system.

A closed loop SDHW system will have many solder joints, and it is a good idea to clean the system out before charging it with an antifreeze solution. To do this, you will need a garden hose or two to drain the system if the component module is located where you don't want water on the floor. Washing machine hoses have female thread hose connections on both ends. Using two of these hoses, connect one end of each hose to the two boiler drain valves. Connect the other end of each washing machine hose to each of the boiler drain valves. The other end of each washing machine hose is connected to one of the garden hoses. One garden hose is connected to a hose bibb to supply water, and the other is used to direct the discharge water outdoors or to a drain after it has been circulated through the system.

The supply water from the hose bibb is circulated through the boiler drain fill valve located downstream from the check valve. The arrow of the check valve should point to the fill valve. The water can only go one way, and will eventually return through the other boiler drain (discharge) valve located upstream from the check valve. If the sun is shining when you purge the system, the collector will heat the water a bit and help clean out the flux, in addition to purging any other debris that might be in the system.

When the water appears at the discharge hose, let it run at full flow for a few minutes to get the air out of the system. You may then shut off the upstream (discharge) boiler drain and slowly close the downstream (fill) boiler drain where the water is being introduced. Watch the pressure gauge and let the house pressure bring the system up to about 25 to 40 psi. Then shut the valve completely.

Turn the differential control to the "on" position and make sure it is plugged in. If the system is wired correctly, the pumps should start up, even without sunshine. If the sun is shining, you will be able to feel a difference in temperature between the pipes to and from the collectors. This assumes that most of the air was forced out of the system by the garden hose water. You can then let the system run for a few minutes or longer if you wish—the hotter it becomes, the better it will clean out any flux left in the system. While the system is circulating the water, you can disconnect the downstream supply (fill) garden hose from the hose bibb, after tuning it off.

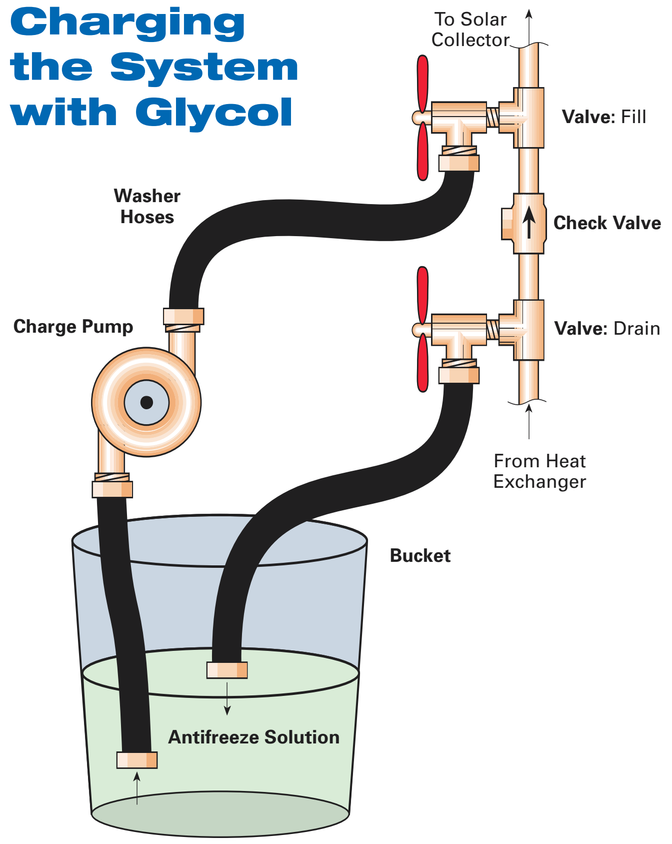
This is also a good time to visually inspect all joints in the system for leaks. When the water has circulated for at least thirty minutes, turn the control to "off" and immediately open both boiler drain valves to allow the water to drain from the system. To drain all the water out, you may need to open the air vent at the collectors to introduce air at the top of the system.

Charging the System with Antifreeze

Fill the bucket with a 50-50 solution of water and propylene glycol. You will almost always need about 2 gallons (7.6 l) of solution per collector (1 gallon of glycol) but the quantity will vary with the collector manufacturer, size of the collector, and size of piping in the system. Make sure to have a little extra if in doubt.

You will now only use the washing machine hoses. One hose is connected to the supply boiler drain valve, downstream of the check valve, with its other end connected to the charge pump output. Another hose goes from the pump to the bottom of the bucket, and the third hose goes from the discharge boiler drain valve, upstream from the check valve, to anywhere in the bucket. You may need to elevate the bucket so that both hoses can reach it. The hose attached to the pump will need to reach the bottom of the bucket.

Charging the System with Glycol



Open both valves all the way. Start the pump. Solution in the bucket will be sucked up into the closed loop. You will know that the system is full when the solution returns to the bucket from the other hose. The return hose will contain a good deal of air that is being forced out of the system. Let the fluid circulate until the return hose is flowing smoothly with no air bubbles. Close the upstream (discharge) valve at this time. The flow in the return hose will stop and the pressure will increase.

Keep the pump on until the system pressure is about 15 to 25 psi and then shut the fill valve downstream of the check valve. Shut the pump off. Turn the control switch to the "auto" position, and if the sun is shining, the pump(s) should turn on. Leave the hoses connected. The system will normally still have a small amount of air at the top. This air can be released if you have installed a coin vent or automatic air vent at the top of the system. Unscrew the coin vent or push on the stem in the Schraeder valve of the automatic vent until only liquid appears. Be careful—it might be very hot, depending on the amount of sunlight.

Follow-up & Maintenance

Installation follow-up starts with casual observation during the first couple of weeks after starting the system up. The system should turn on shortly after the sun comes up, but exact times are hard to gauge. The turn-on time changes with the seasons and the temperature of the cold water. The system should also turn off before sundown. Micro-bubbles of air are usually present in the water used in the antifreeze solution, and these will tend to gather at the very top of the piping. A couple of weeks after the system is started up, the coin vent should be opened slightly to release any accumulated air. If you used an automatic air vent, this should have purged the air automatically.

A good, quick check of your system operation may be made at the pipes coming to and from the collectors. When the sun is shining and the water in the storage tank is cold or cool, there should be a very noticeable difference in the temperature of the two pipes. If not, there is something wrong with the system. We'll discuss what might be wrong in a future article in this series.

We have covered the practical installation considerations of a closed loop type of solar domestic hot water system. This is one of the most common types of systems with reliable freeze protection. In subsequent issues of *Home Power*, we will follow up with installation of the drainback-type SDHW system and the troubleshooting, maintenance, and repair of both these types of systems.

Access

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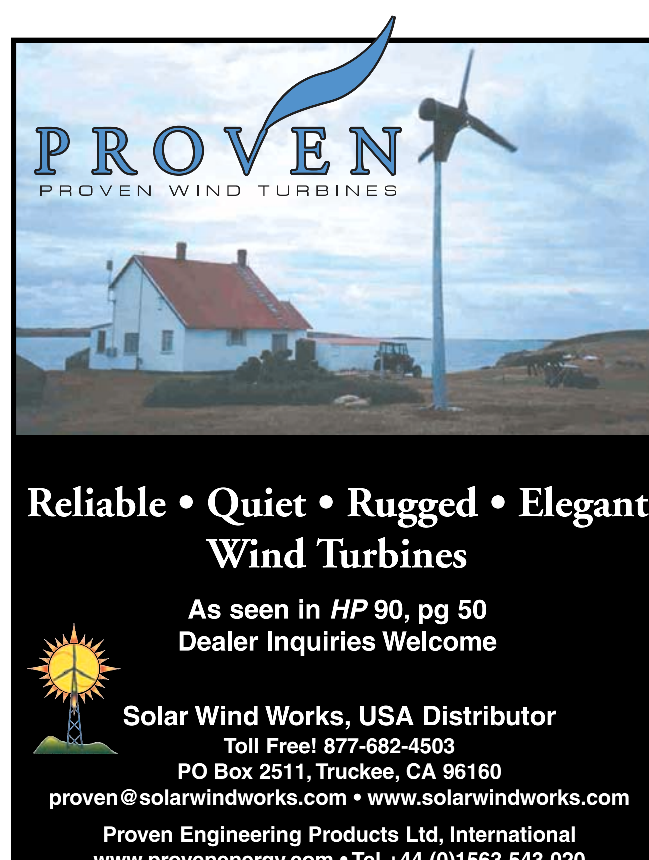

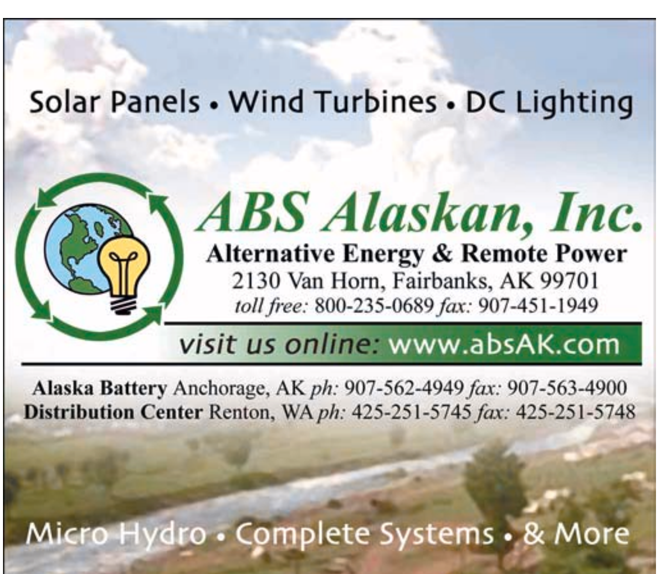


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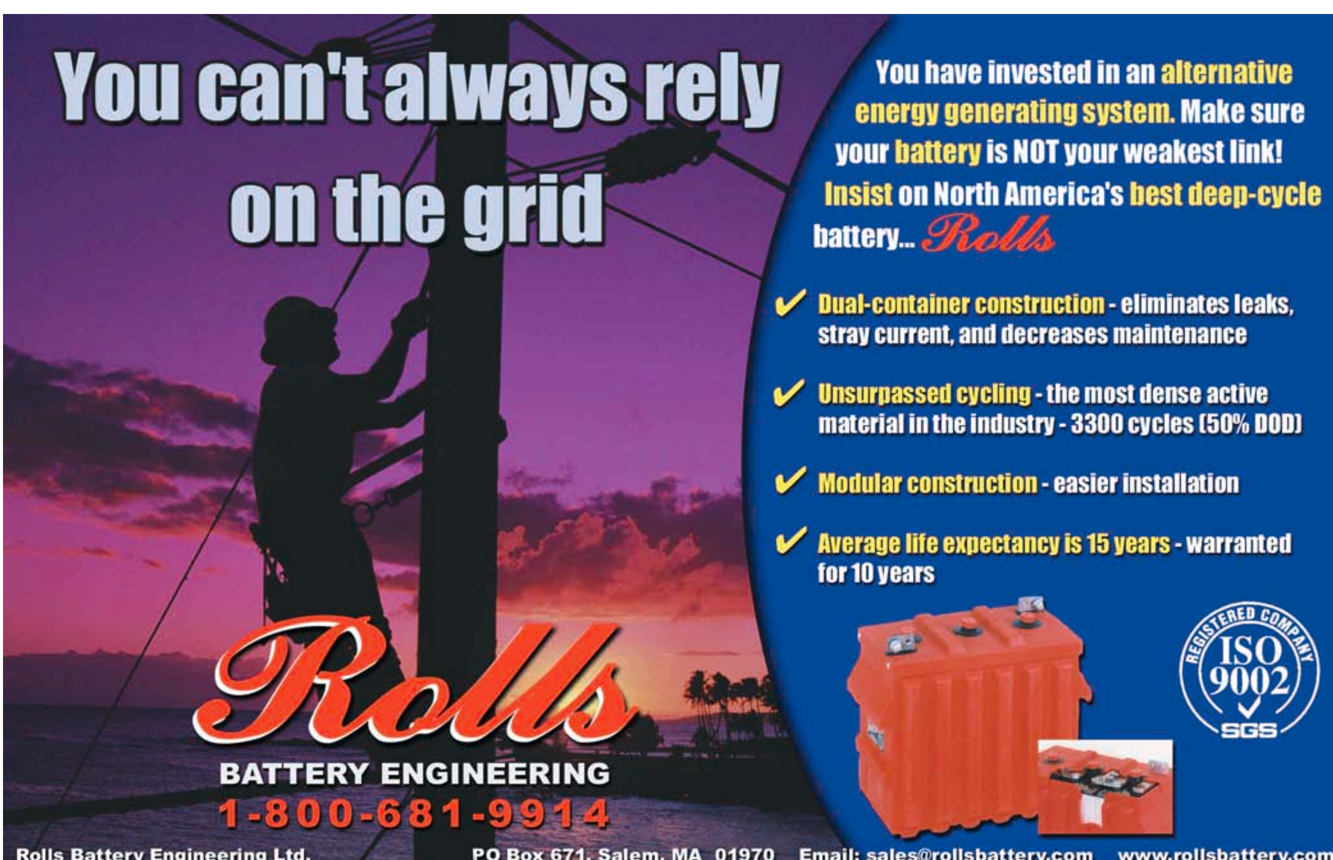
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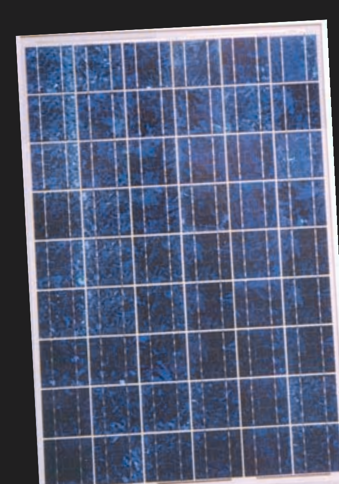

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New Bell Solar Battery Converts Sun's Rays Into Electricity

Bell Telephone Laboratories demonstrate new device for using power from the sun

Scientists have long reached for the secret of the sun. For they have known that it sends us nearly as much energy daily as is contained in all known reserves of coal, oil and uranium.

If this energy could be put to use there would be enough to turn every wheel and light every lamp that mankind would ever need.

Now the dream of the ages is closer to realization. For out of the Bell Telephone Laboratories has come the ***Bell Solar Battery***—a device to convert energy from the sun directly and efficiently into usable amounts of electricity.

Though much development remains to be done, this new battery gives a glimpse of future progress in many fields. Its use with transistors (also invented at Bell Laboratories) offers many opportunities for improvements and economies in telephone service.

A small ***Bell Solar Battery*** has shown that it can send voices over telephone wires and operate low-power radio transmitters. Made to cover a square yard, it can deliver enough power from the sun to light an ordinary reading lamp.

Great benefits for telephone users and for all mankind will come from this forward step in harnessing the limitless power of the sun.

BELL TELEPHONE SYSTEM

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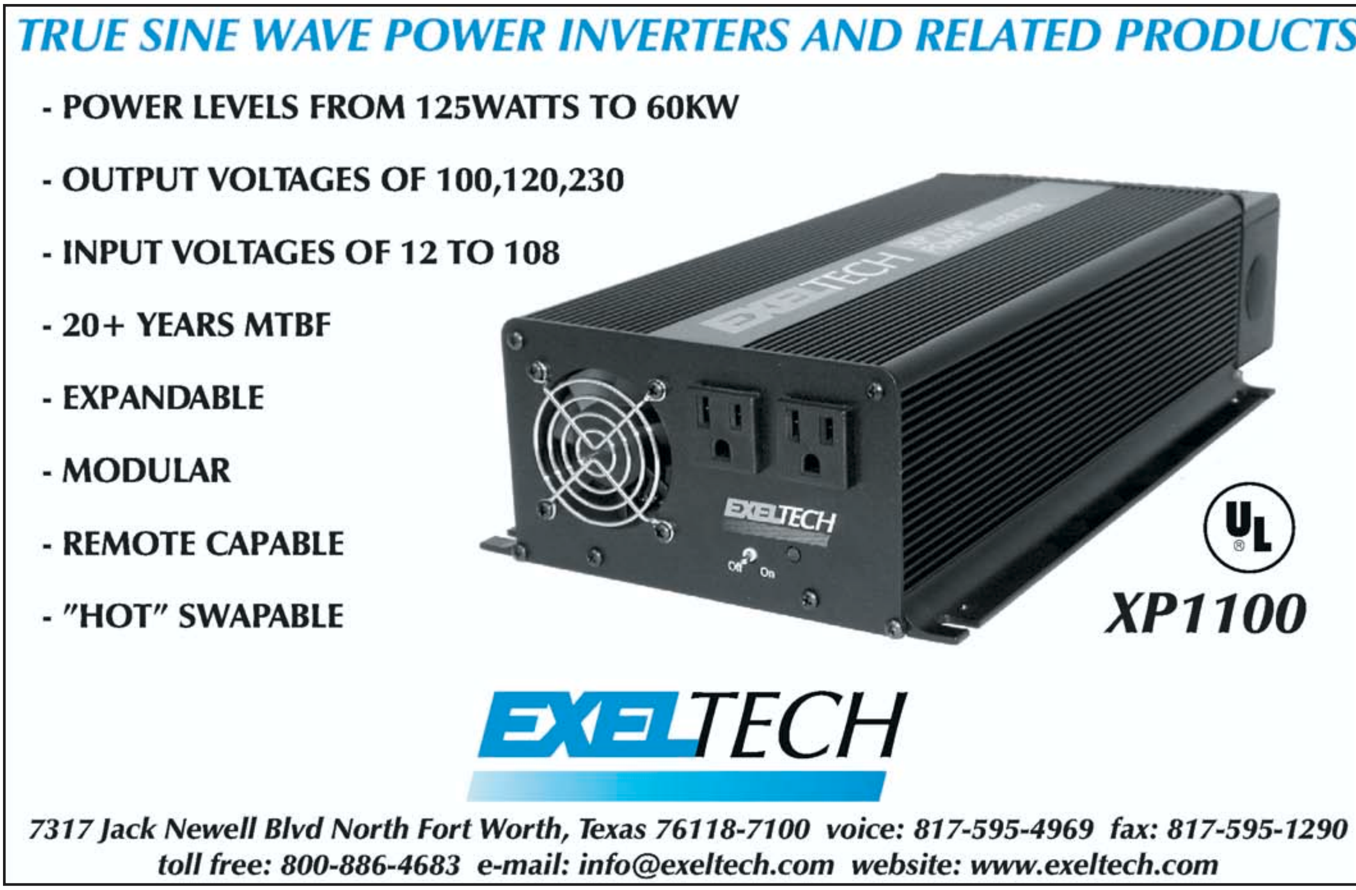
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The Silicon Solar Cell Turns Fifty

John Perlin

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The first advertisement for the Bell solar cell. It appeared in the August 1954 issue of *National Geographic*.

The solar cell that has spawned today's booming photovoltaic industry had a most unexpected birth. But aren't many children surprises?

In 1953, the Bell telephone system had a problem. Traditional dry cell batteries that worked fine in mild climates degraded too rapidly in the tropics and ceased to work when needed. The company asked its famous research arm, Bell Laboratories, to explore other freestanding sources of electricity. It assigned the task to Daryl Chapin. Chapin tested wind machines, thermoelectric generators, and steam engines. He also suggested that the investigation include solar cells, and his supervisor approved the idea.

Chapin soon discovered that selenium solar cells, the only type on the market, produced too little power, a mere five watts per square meter, and converted less than 0.5 percent of the incoming sunlight into electricity. Word of Chapin's problems came to the attention of another Bell researcher, Gerald Pearson. This was not strange, since Pearson and Chapin had been friends for years. They had attended the same university, and Pearson had even spent time on Chapin's tulip farm.

At the time, Pearson was engaged in pioneering semiconductor research with Calvin Fuller. They took silicon solid-state devices from their experimental stage to commercialization. Fuller, a chemist, had discovered how to control the introduction of the impurities necessary to transform silicon from a poor to a superior conductor of electricity.

Gerald Pearson, Daryl Chapin, and Calvin Fuller (left to right), the principal developers of the silicon solar cell, measuring current from one of the first solar-electric cells.

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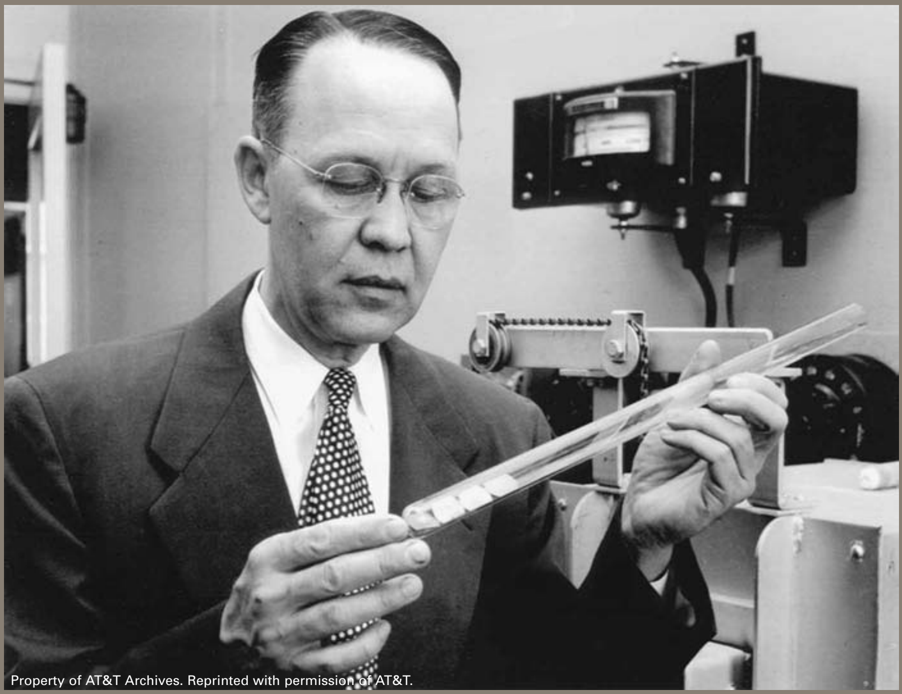
P-N Junction

Fuller provided Pearson with a piece of silicon containing a small amount of gallium. The introduction of gallium made it positively charged. Pearson then dipped the gallium-rich silicon into a hot lithium bath, according to Fuller's instructions. Where the lithium penetrated, an area of poorly bound electrons was created, and it became negatively charged. A permanent electrical force developed where the positive and negative silicon meet. This is the P-N junction, the core of any semiconductor device.

The P-N junction is like a dry riverbed, which has an incline that provides the means for flow, should it fill with water. The P-N junction will push electrons in an orderly fashion, commonly called electrical current, when some type of energy hits those loosely bound electrons nearby with enough power to tear them away from their atomic glue. Shining lamplight onto the lithium-gallium doped silicon provided the necessary energy, and Pearson's ammeter recorded a significant electron flow. To Pearson's surprise, he had made a solar cell superior to any other available at the time.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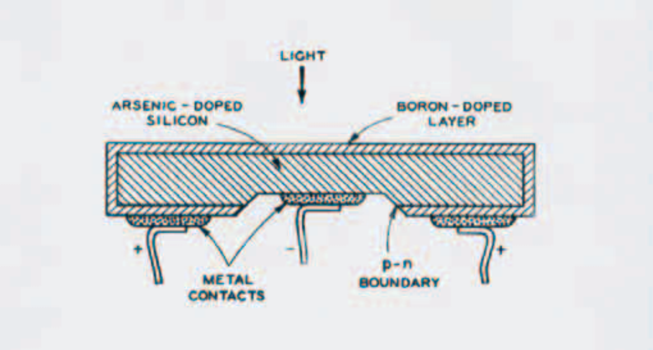
Calvin Fuller placing arsenic-laced silicon into a quartz-tube furnace where he introduced a controlled amount of boron to the material. This resulted in the first solar cell that could generate significant amounts of electricity.

Silicon Is the Answer

Hearing of his colleague's poor results with selenium, Pearson went directly to Chapin's office to advise him not to waste another moment on selenium, and to start working on silicon. Chapin's tests on the new material proved Pearson right. Exposing Pearson's silicon solar cell to strong sunlight, Chapin found that it performed significantly better than the selenium—it was five times more efficient.

An original cross-section diagram from Bell Laboratories of the first Bell power cell doped with boron and arsenic.



Theoretical calculations brought even more encouraging news. An ideal silicon solar cell, Chapin figured, could use 23 percent of the incoming solar energy to produce electricity. But building a silicon solar cell that would convert around 6 percent of sunlight into electricity would satisfy Chapin and rank as a viable energy source. His colleagues concurred and all his work focused on this goal.

Try as he might, though, Chapin could not improve on what Pearson had accomplished. "The biggest problem," Chapin reported, "appears to be making electrical contact to the silicon." Not being able to solder the leads right to the cell forced Chapin to electroplate a portion of the negative and positive silicon layers to tap into the electricity generated by the cell. Unfortunately, no metal plate would adhere well, presenting a seemingly insurmountable obstacle to grabbing more of the electricity generated.

Moving the Junction

Chapin also had to cope with the inherent instability of the lithium-bathed silicon, which moved deep into the cell at room temperatures. This caused the location of the P-N junction, the core of any photovoltaic device, to leave its original location at the surface, making it more difficult for light to penetrate the junction, where all photovoltaic activity occurs.

Then, an inspired guess changed Chapin's tack. He correctly hypothesized, "It appears necessary to make our P-N junction very next to the surface so that nearly all the photons are effective." He turned to Calvin Fuller for advice on creating a solar cell that would permanently fix the P-N junction at the top of the cell.

Coincidentally, Fuller had done just that two years earlier while trying to make a transistor. He then replicated his prior work to satisfy his colleague's need. Instead of doping the cell with lithium, the chemist vaporized a small amount of phosphorous onto the otherwise positive silicon. The new concoction almost doubled previous performance records.

Solar Cell vs. Atomic Battery

Still, the lingering failure to obtain good contacts frustrated Chapin from reaching the 6 percent efficiency goal he was aiming for. While Chapin's work reached an impasse, arch rival RCA announced that its scientists had come up with a nuclear-powered silicon cell, dubbed the atomic battery. Its development coincided with the U.S. Atoms for Peace program, which promoted the use of nuclear energy throughout the world.

Instead of photons supplied by the sun, the atomic battery ran on those emitted from Strontium 90, one of the deadliest nuclear residues. To showcase the new invention, RCA decided to put on a dramatic presentation in New York City. David Sarnoff, founder and president of RCA, who had initially gained fame as the telegraph operator who tapped out the announcement to the world that the Titanic had sunk, hit the keys of an old-fashioned telegraph powered by the atomic battery to send the message, "Atoms for Peace." The atomic battery, according to RCA, would one day power homes, cars, and locomotives with radioactive waste—Strontium 90—produced by nuclear reactors.

What its public relations people failed to mention, however, was why the Venetian blinds had to be closed during Sarnoff's demonstration. Years later, one of the lead scientists involved in the project came clean: If the silicon device had been exposed to the sun's rays, solar energy would have overpowered the contribution of the Strontium 90. Had the nuclear element been turned off, the battery would have continued to work on the solar energy streaming through the window.

The director of RCA Laboratories did not mince words when he ordered his scientific staff to go along with the deception, telling them, "Who cares about solar energy? Look, what we have is this radioactive waste converter. That's the big thing that's going to catch the attention of the public, the press, the scientific community."

The director had gauged the media well. *The New York Times*, for example, called Sarnoff's demonstration "prophetic." It predicted that electricity from the atomic battery would allow "hearing aids and wrist watches [to] run continuously for the whole of a man's useful life."

Cells with a Future

RCA's success stirred management at Bell Laboratories to pressure the solar investigators to hurry up and produce something newsworthy as well. Luckily for them, Fuller had busied himself in his lab to discover an entirely new way to make more efficient solar cells. He began with silicon cut into long, narrow strips modeled after Chapin's best performing cells. That's where the similarity ended.

Instead of adding gallium to the pure silicon and producing positive silicon, Fuller introduced a minute amount of arsenic to make the starting material negative. Then he placed the arsenic-doped silicon into a furnace to coat it with a layer of boron. The controlled

The success of the boron-doped silicon solar cells that allowed the Bell scientists to achieve their goal is shown in this table. Bell produced the first true solar cells, and spawned today's PV industry.

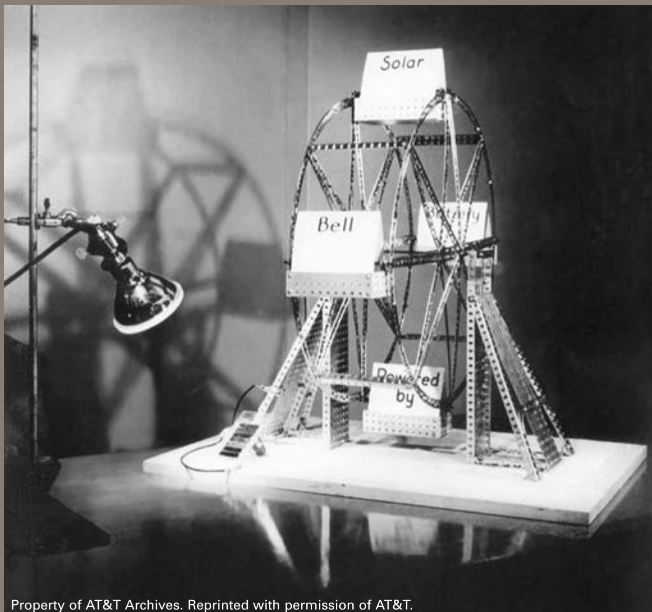
TABLE I

Total Resistance (including Meter)	Cell #88, Area = 4.85 cm^2: Current	Cell #88: Power	Cell #90, Area = 4.85 cm^2: Current	Cell #90: Power
0.11 ohms	114 mils		110.5 mils	
1.08	110	13.1 mw	109.0	12.8 mw
1.50	108.5	17.65	107.5	17.3
2.16	105.2	23.85	104.5	23.6
3.20	96.0	29.5	94.0	28.3
4.69	79.6	29.7	78.0	28.5
6.81	61.5	25.7	60.0	24.5
10.01	44.6	19.9	44.0	19.4
10,000	0.0552		0.0535	

Cell #88: Open circuit voltage = 0.552 v
Max. Power = 61 watts/m^2
= 5.65 watts/sq. ft.

Cell #90: Open circuit voltage = 0.535 v
Max. Power = 58.8 watts/m^2
= 5.47 watts/sq. ft.

Image credit to Lucent Technologies.



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One of Bell's first silicon solar modules powers a Ferris wheel built from an Erector set at the first public demonstration on April 25, 1954.

introduction of an ultrathin layer of boron gave the cell a P-N junction extremely close to the surface. The Bell team had no trouble in making good electrical contacts to the boron-arsenic silicon cells, resolving the main obstacle in extracting electricity when exposing them to sunlight.

All cells built according to Fuller's new method did much better than previously. One, however, outperformed the rest, reaching the efficiency goal Chapin had set. The best-performing cell seemed to have the ideal width for peak performance. Bell scientists built cells to the same dimensions as that best-performing cell.

Chapin then confidently referred to these as "photocells intended to be primary power sources." Assured of success, the Bell solar team began putting together modules to publicly demonstrate this major breakthrough. On April 25, 1954, proud Bell executives held a press conference where they impressed the media with Bell solar cells powering a radio transmitter, broadcasting voice and music.

One journalist thought it important for the public to know that "linked together electrically, the Bell solar cells deliver power from the sun at the rate of fifty watts per square yard while the atomic cell announced recently by the RCA Corporation merely delivers a millionth of a watt" over the same area. *U.S. News & World Report* believed one day such silicon strips "may provide more power than all the world's coal, oil, and uranium."

Harnessing the Sun

The New York Times probably best summed up what Chapin, Fuller, and Pearson had accomplished. On page one of its April 26, 1954 issue, it stated that the construction of the first PV module to generate useful amounts of electricity marks "the beginning of a new era, leading eventually to the realization of one of mankind's most cherished dreams—the harnessing of the almost limitless energy of the sun for the uses of civilization."

Just think: fifty years ago the world had less than a watt of solar cells capable of running electrical equipment. Today, fifty years later, a billion watts of solar-electric modules are in use around the world.

They run satellites; ensure the safe passage of ships and trains; bring water, electricity, and telephone service to many who had done without; and supply clean energy to those already connected to the grid. We hope that the next fifty years will see solar cells on rooftops throughout the world, fulfilling the expectation triggered by the pioneering work of Chapin, Fuller, and Pearson.

Access

John Perlin, 102 North Hope Ave., #80, Santa Barbara, CA 93110 • solarperlin@aol.com • This article is an adaptation from material in John's book, *From Space to Earth: The Story of Solar Electricity*, reviewed in *HP75*.

The author thanks the National Renewable Energy Laboratory and the National Center for Photovoltaics for funding his work, which formed an exhibit as a highlight of the 3rd World Conference on Photovoltaics Energy Conversion, May 11-16, 2003, Osaka, Japan, and has become a permanent exhibit at the National Renewable Energy Laboratory.

From Space to Earth: The Story of Solar Electricity, John Perlin, 2002, ISBN 0-674-01013-2, 240 pages, paper, US$22.95 from Harvard University Press, 79 Garden St., Cambridge, MA 02138 • 800-405-1619 or 401-531-2800 • Fax: 800-406-9145 or 401-531-2801 • customer.care@triliteral.org • www.hup.harvard.edu/catalog/PERFRX.html

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Solar Pool Heating Basics, Part 2

Tom Lane

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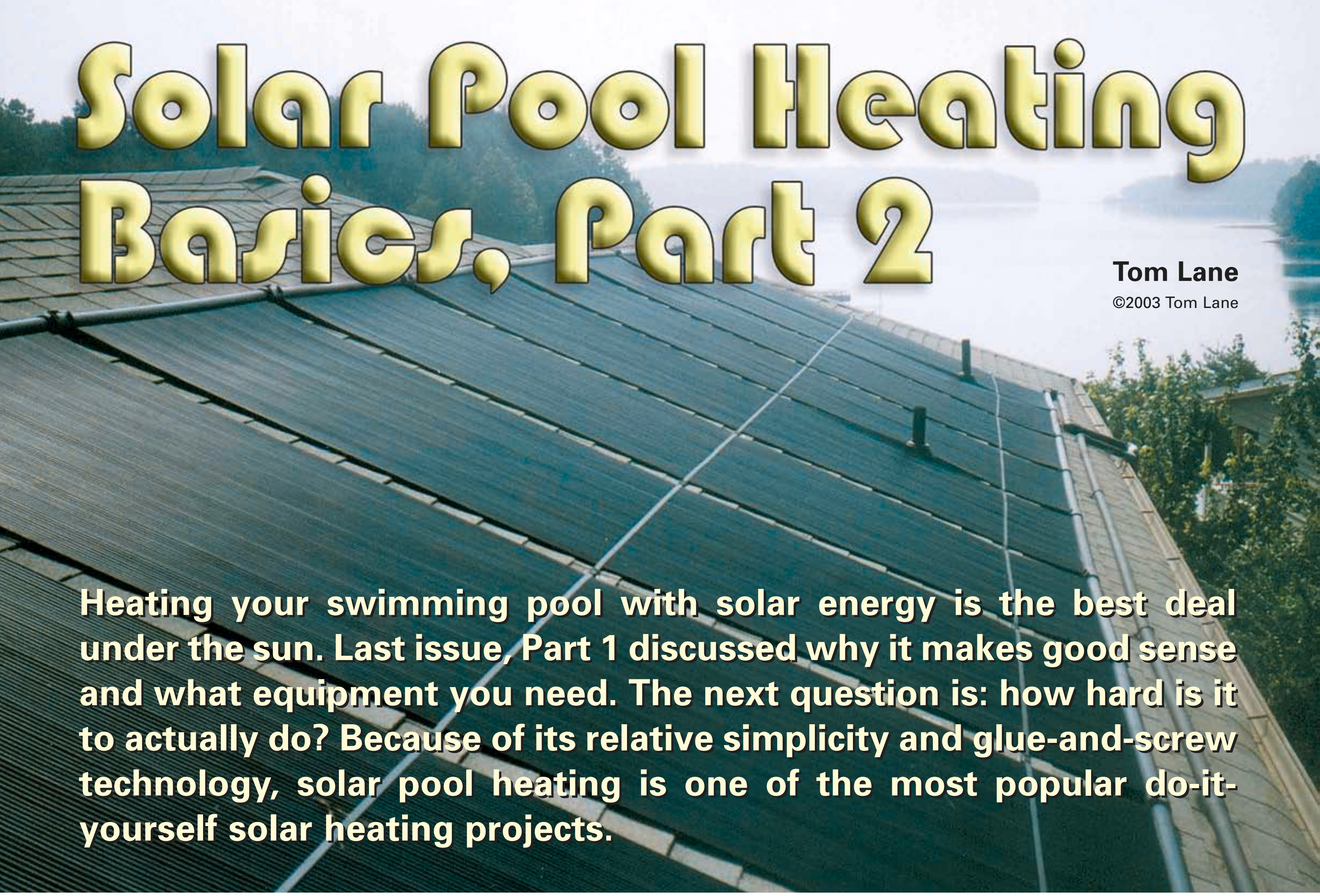
Heating your swimming pool with solar energy is the best deal under the sun. Last issue, Part 1 discussed why it makes good sense and what equipment you need. The next question is: how hard is it to actually do? Because of its relative simplicity and glue-and-screw technology, solar pool heating is one of the most popular do-it-yourself solar heating projects.



Simple solar pool-heating collectors on a roof can provide as much as 1,000 BTU per square foot per day to your pool.

Sizing Collectors

Choosing the number and size of collectors for your pool can be as simple or complex as you like. A simple rule is to have at least half of the pool area in collector surface area. This usually works well for extending your pool season to up to 6 months. If you live in a mild climate and want a 10 to 12 month pool season, you might use the same area of collectors as pool surface. But if doing these quick calculations shows a need for six panels and you only have room for four, you can skip the rest of the math, and figure that the best you can do with solar collectors is two-thirds of the job.

If you want to be more precise, generally speaking, you will get a 3°F (1.7°C) rise over an unheated pool from each 20 percent of the pool surface area you have in solar collectors. For example, if you install 256 square feet (23.8 m^2) of collector to heat a 16 by 32 foot, 512 square foot (4.9 x 9.8 m, 47.6 m^2) pool, that's 50 percent of your surface area. You can anticipate a 7 to 8°F (3.9–4.4°C) rise in pool temperature. If you put in 512 square feet of solar collectors (100 percent of pool surface area), you will get a 15°F (8.3°C) rise in the pool temperature.

The 3°F rise per 20 percent of pool area is based on a Florida Solar Energy Center (FSEC) collector rating of 1,000 BTUs per square foot of collector area at the low temperature rating appropriate for pools. A collector rated at 900 BTUs per square foot would need 11 percent more collector area.

If you measure the temperature of the unheated pool and know how much heat the collectors you have chosen will produce, you can make a more accurate estimate of how many you will need to reach the temperature you want. Ratings for pool collectors are typically in the range of 850 to 1,060 BTUs per square foot per day. You can obtain a rating summary sheet for pool collectors from FSEC (see Access).

See the sidebar to determine temperature increase from your proposed solar collector. Add this temperature increase to the temperature of the unheated pool water. Add 5°F (2.8°C) if you use a pool cover at night, or add 10°F (5.6°C) if you use a pool cover 22 hours per day. Even with all these calculations, this will result in only a rough estimate. Keep in mind that other microclimatic factors, such as wind and low humidity, will affect the accuracy of this estimate. Use of a pool blanket will minimize these factors.

Once you've made your calculations, if you want a higher temperature, you can increase the collector area or use a collector with a higher rating. Pool collector manufacturers generally have the expertise to advise you more specifically on what is necessary, based on your geographic location and collector orientation.

Installing Collectors

The operational theory of a solar pool heating system differs from solar heating for domestic hot water. Flat plate solar pool collectors work more efficiently at lower temperatures. If the water coming back from the collectors into the pool is hot, the system is not working efficiently. If the water returning from the collectors is mildly warm—the system is working great!

This is counterintuitive until you realize that the idea is to collect more BTUs with a higher volume of water and lower temperature rise. Think of it as more heat at a lower temperature. A hot collector loses heat to the ambient surroundings. Cooler collectors lose less heat to ambient surroundings, are more efficient, and collect more BTUs. An adequate flow rate will circulate at least 95 percent of the pool volume through the collectors from 9 AM to 3 PM each day. If the air temperature is 90°F (32°C), the pool collector should also be about 90°F.

Most solar pool heating occurs during the middle 6 hours of the day and 90 percent of that occurs within a 4 hour period, 2 hours on either side of solar noon. (Sound familiar? This is the same time period that gives the lion's share of the output in a solar-electric system too.) Choose a location for your solar collectors that has minimal or no shading during the optimum pool heating period. If you have partial shading or wind, you may need to increase the area of your collectors by 10 to 15 percent. Collectors can be roof mounted, ground mounted on a rack, or even placed flat on the ground.

Collector Orientation

Since solar pool collectors cover large areas, they are usually mounted flat to the slope of east, south, or west-facing roofs. Rack mounts are only used on north roofs or flat roofs to face the collectors south, or for ground mounts.

Collectors on east or west-facing roofs are often combined with collectors on a south-facing roof. For locations north of 35 degrees latitude, collectors on east-facing roofs will require 25 percent more collector area than for south or west-facing roofs. South-southwest is preferred to true south because the collectors will operate more efficiently with higher afternoon ambient temperatures.

Solar collectors on a north roof will work from late spring to early autumn for locations south of 35 degrees latitude, and all year south of 25 degrees latitude. For locations south of 35 degrees latitude, mounting the collectors flat on a flat roof or on a flat ground mount will work well for eight months out of each year. But if you mount the collectors flat, you will need to make sure you can isolate and drain the collectors when freezing weather arrives.

Calculating Increase in Pool Temperature

Here is the basic formula for estimating the temperature increase you can expect from a solar pool heating system:

$$\Delta T = A_{SC} \div A_{PS} \times R \div 1{,}000 \times 15°F \text{ (or } 8.3°C)$$

Where ΔT is the rise in pool temperature in °F (or °C); A_{SC} is the area of the solar collectors; A_{PS} is the area of the pool surface; and **R** is the FSEC BTU rating of your proposed collectors.

For example, a 15 by 30 foot (4.6 x 9.1 m) pool uses 336 square feet (31 m^2) of collectors rated at 950 BTU per square foot, low temperature rating. The average daily temperature of the unheated pool is 70°F (21°C). The estimated temperature increase due to solar heating is calculated as follows:

336 $ft.^2$ collector area ÷ 450 $ft.^2$ (41.8m^2) pool area x 950 FSEC BTU rating ÷ 1,000 BTU x 15°F (8°C) = 12°F (6.7°C) rise in pool temperature.

Add 10°F (5.6°C) if you use a pool cover 22 hours per day. Now, add up the figures:

70°F (avg. daily temp.) + 12°F (rise in pool temp.) + 10°F (pool cover bonus) = 92°F (33°C).

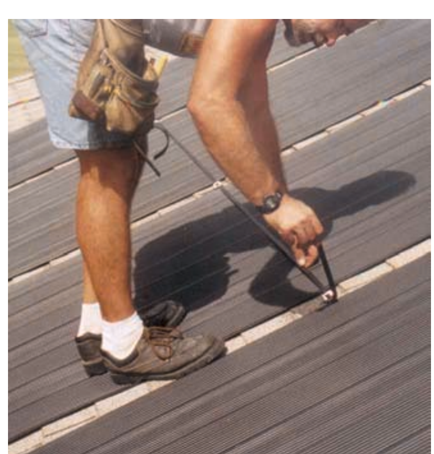
A 92°F pool may seem a bit on the warm side, but remember that you can always use an automatic control to limit the high temperature during the summer. The ambient pool temperature during a seven-month swimming season may vary from 54°F (12°C) in early spring and late fall to 75°F (24°C) in mid-summer. This means that during spring and fall, 336 square feet of collectors might only produce a temperature of 76°F (24°C) at best.

South-facing solar collectors on a north-facing roof.

A well-mounted solar pool collector looks tidy and fits neatly around vents or skylights.

Metal pipe clamps $^{1}/_{2}$ inch larger than the pipe hold PVC pipe and collector headers securely to the roof. A generous amount of quality sealant is used to prevent roof leaks.

Collector risers are held in place during strong winds by rubber-coated stainless steel straps. The straps are threaded through stainless steel butterfly clips that are screwed to the roof.



Roof Mounts

Collector layout on the roof involves taking measurements of the roof, and noting the location of all roof pipe stacks, vents, skylights, etc. You will need to allow for a few inches between the collectors and about a foot above and below the collector array for mounting brackets and piping. Manufacturers of collectors can provide you with all sorts of plumbing parts and adapters to accommodate obstacles like skylights and special installation situations, such as connecting to panels on different roof planes. Contact Aquatherm Industries for information on how to download their excellent, 12 page installation manual, showing parts, installation procedures, and collector layout.

When installing the collectors, make provisions for inlet connections at the bottom header and outlet connections at the top. The collectors should be tilted and sloped for automatic draining and even flow. The tilt should be at least an 8 inch (20 cm) rise from the bottom header to the top header. The slope towards the inlet pipe (bottom header) should be at least 1 inch (2.5 cm) for every six collectors. Snap a chalk line on the roof to determine the placement of the headers.

The mounting system for collectors on a roof should use stainless steel straps and fasteners. The collector headers are attached with brackets at the top, and the rest is held down with two or three horizontal hold-down straps, depending on the length of the collectors and local wind conditions. Lay down a generous amount of a nitrile rubber-based sealant on all roof penetrations to seal against the weather. Consult your collector manufacturer regarding mounting to sheet metal and tile roofs.

After the top headers are attached, put down a generous amount of the sealant where the strap holders will go between the collectors. Put your strap holders down on the sealant, and then use your screw gun to drive the screws through the strap holders to the roof deck. Use 2 inch (5 cm) long, A-tip, stainless steel screws for asphalt roofs.

A ground-mounted collector is subject to plant shading and more wear.

Ground Mounts

You can build lumber or aluminum rack mounts for solar pool collectors. The best orientation for a ground mount is south-southwest, with a tilt angle equal to latitude, or latitude plus or minus 15 degrees, depending on whether you want to heat year-round or seasonally. For structural strength, the front and back support of a lumber rack should use 4 by 4 posts, buried 3 feet (0.9 m) in the ground. The posts should be spread no more than 5 feet (1.5 m) apart in the front and back rows. Use 2 by 6s for spanners, and to tie the front and back posts together at the correct tilt angle.

The top and bottom header of the collector should rest on the middle of a 1 by 6 cross board that runs the entire length of the rack. Between the top and bottom header, additional cross boards should be no more than 2 feet (0.6 m) apart from center to center. The collector strap holders can be screwed down between each collector to the 1 by 6 cross boards. Lattice fencing can be put around the rack for skirting. Use 2 inch pipe on all underground pipe running up to 120 feet (24 m).

For mounting panels flat on the ground, put down agricultural Visqueen or other weed barrier to prevent weed growth. Border the collectors on all four sides with 4 by 6 pressure-treated lumber on top of the Visqueen. Cover 100 percent of the area under the collectors with loose asphalt shingles or pine bark to prevent sunlight from causing the Visqueen to deteriorate.

Basket weave the hold-down straps over and under in an alternating pattern across the collectors. Screw the straps' clamps to the side of the 4 by 6 pressure-treated lumber. Use twice as many straps as used on a roof mount, with one every 2 feet (0.6 m) between the headers. Also use a loose strap running between the top and bottom headers to attach to a strap clamp at each end on the 4 by 6 lumber to hold both headers down. Panels mounted flat on the ground will work well for 6 months of the year at latitudes above 34 degrees, and year-round below 28 degrees latitude. Put boiler drains on each end of the bottom header for draining and for winterizing.

Piping Installation

The most common pool piping configurations use a 1 to 1 1/2 hp pump and filter. The pool pump draws the water from the skimmer or main drain, forces it through the filter, and sends it back to the pool through the return lines. The piping to and from your solar collectors is added after the filter and the chlorinator on the return line to the pool. If there is an existing pool heater, the pipes to and from the solar collectors are connected to the return line before the pool heater.

Use schedule 40 PVC pipe and fittings that are approved for swimming pool filters and pumps. High-quality PVC glue (not multipurpose) should be used for connecting the pipes. For determining the proper pipe sizes, the following guidelines will apply to almost all residential systems having up to 900 square feet (84 m^2) of collector area for a pool up to 800 square feet (74 m^2) of surface area, with a 1 hp pool pump and a total pipe run that is less than 180 feet (55 m).

Use 2 inch piping for all underground pipelines, at the diverter valve, and for added piping around the pump and filter. When you get onto the roof, change to 1 1/2 inch pipe for runs to the collector if the square footage is under 450 square feet (42 m^2) and the total pipe run is less than 120 feet (37 m). Use 2 inch pipe when the collector area is over 450 square feet and less than 900 square feet. Use two 45 degree elbows instead of single 90 degree elbows when the total pipe run, with 1 1/2 or 2 inch pipe, is over 120 feet.

For roof-mounted systems, piping to collectors should be attached securely to the roof. For aesthetic reasons and a slight heat gain, white PVC pipe can be cleaned with pipe

Not on the roof—everything but the collectors.

cleaner and sprayed with a flat black acrylic barbeque paint if you cannot get black PVC pipe. (*Don't* use ABS pipe!) You should put the collector return pipe above the collector bank rather than below. Support all horizontal runs across the roof every 6 feet (1.8 m) with two-hole pipe clamps to prevent sagging. In addition, use 1/2 inch (13 mm) spacers under the pipes to allow rainwater to flow under them.

Pool collectors can expand up to 1 inch (25 mm) in length on hot summer days. So collectors and piping should be mounted to accommodate expansion and contraction. Braided rubber hoses make the best flexible connections from piping to collectors. On asphalt shingle roofs, you can glue 4 by 4 inch (10 x 10 cm) black tiles under the connector hoses to protect the shingles from abrasion.

Pumps

Most likely, your existing pool pump is already adequate for the job of circulating water through your solar collectors in a residential system. But, if you have an old or weak pool pump, it is better to change or upsize the pool pump and upsize the filter rather than adding a booster pump and a differential control that activates this booster pump on the feed line to the collectors.

Unless the pipe size for the pool's feed and return lines is sufficient, adding more horsepower (hp) to pool pumps for a solar pool heating system will not work—bigger is not better. A 1 hp pump will produce the correct flow for residential solar collectors if the feed and return lines are 1 1/2 to 2 inch pipe. Do not use a 1 1/2 hp pump unless the pool's pipe is 2 to 2 1/2 inches.

How to Glue PVC Pipe

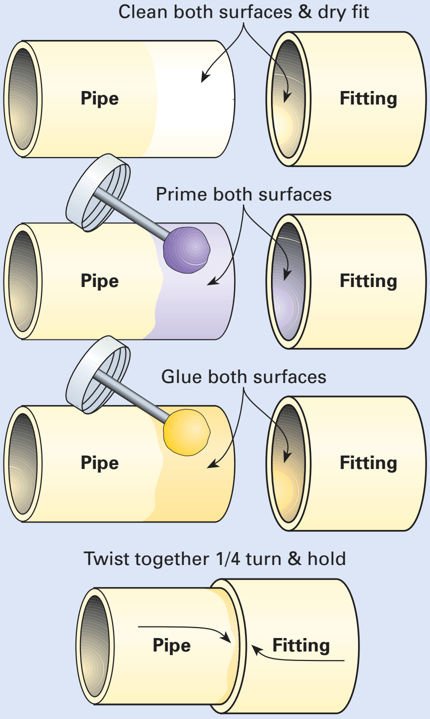
PVC pipe is relatively easy to deal with if you follow a few simple rules.

1. Make sure the PVC pipe and fittings are clean. Clean the outside of the PVC pipe and the inside of the fitting.
2. Dry fit all connections in place to make sure that everything fits and is the correct length.
3. Use a good grade of primer. It is typically bluish purple.
4. Apply the PVC primer to the outside of the pipe and inside of the fitting.
5. Apply the PVC glue (usually gray or clear) to the same places as the primer.
6. Push the pipe firmly all the way into the fitting while turning it a quarter turn, and then hold it in place briefly. The joint must be put together right away—while the glue is wet.
7. Let it set up for 24 hours or the amount of time recommended in the glue instructions. Cure time is dependent on the temperature, humidity, and size of pipe.

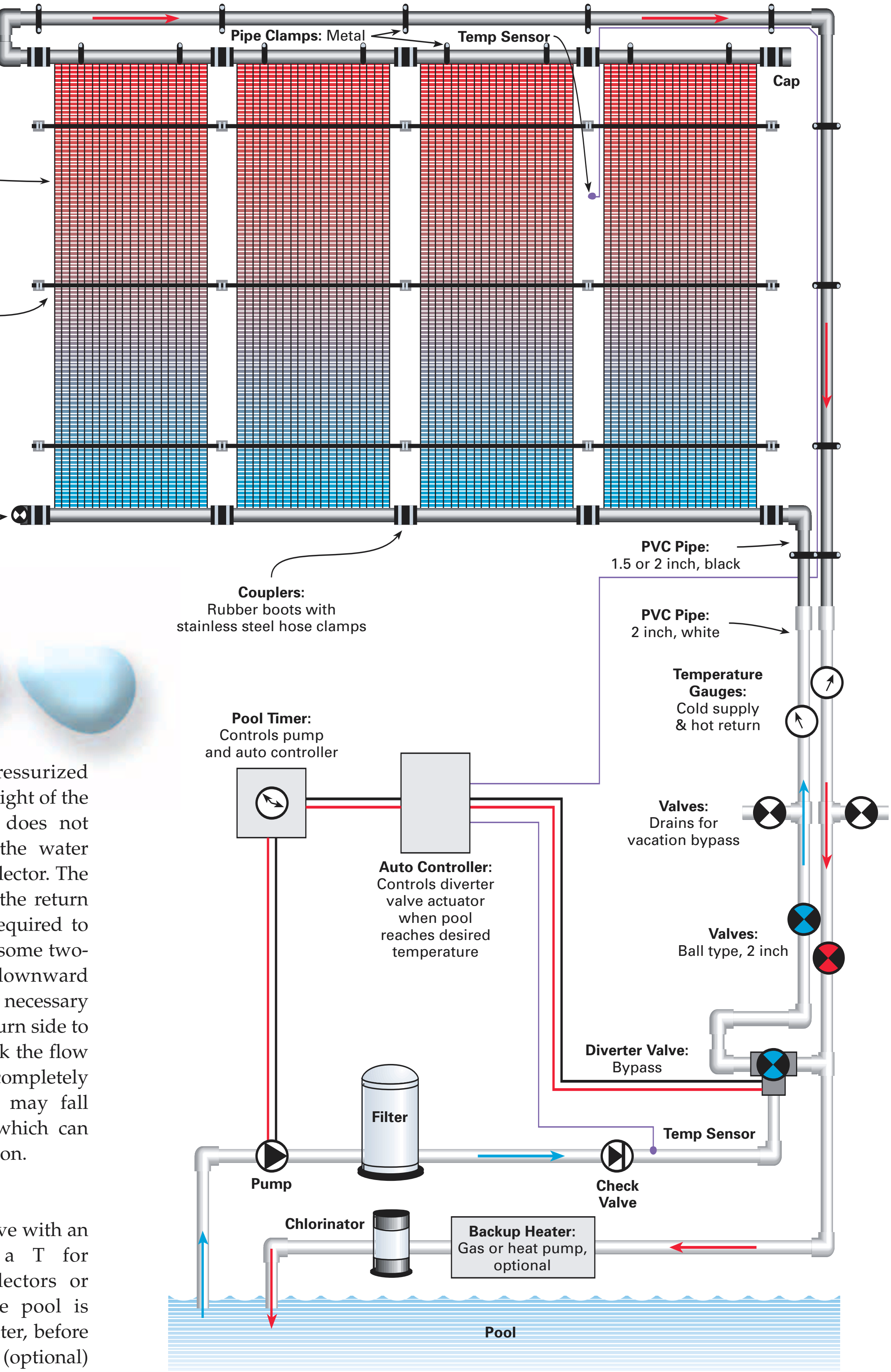
Note: Many inspectors will question a joint if they don't see evidence of primer on the joint.

Caution: Always glue PVC pipe in a well ventilated area and avoid breathing the harmful fumes of the primer and glue.

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



Typical Solar Pool Heating System with Auto Comfort Controller



Pool systems are unpressurized drainback systems, so the height of the collectors above the pool does not affect the flow rate once the water starts returning from the collector. The downward fall of water in the return line counteracts the force required to lift it in the supply line. On some two-story homes, where the downward return line is long, it may be necessary to put a ball valve on the return side to slow the flow down or "back the flow up" so the pipe remains completely full. Otherwise, the water may fall faster than it is pumped, which can create noise and pipe vibration.

Diverter Valve

A three-way diverter valve with an automatic actuator and a T for directing flow to the collectors or bypassing the flow to the pool is always installed after the filter, before any type of backup heater (optional) and before the pool sanitizer

The automatic diverter valve bypasses the solar collector loop when the pool reaches the desired temperature.

(chlorinator, ozonator, etc.). A 2 inch, 1/2 psi check valve is always installed before the diverter valve to prevent backwashing the filter if the collectors are mounted on a roof higher than the pump and filter.

When the pool pump cuts off, all the water in the collectors will drain back through the diverter, and back through the pool's return jets. Determine which side of the diverter valve the automatic actuator (or manual handle) will use to divert the flow to the collectors located on the roof. This decision is based on how you want the feed and return pipes to go on the wall of the house. You do not want the pipes to cross, so you have to know how the collectors are going to be placed on the roof.

The other side of the diverter is connected to a 2 inch T-fitting, the center stem of which is for bypassing the flow to the pool. The other end of the T will be for the collector return through the top of the bypass T to the pool. The feed line should be the shortest line and is arranged so it allows gravity to drain the water that the collector holds back to the pool when the pump cuts off. The return line should be run above the collector array and kept close to its top headers. This makes the piping look like a part of the collector array.

If the pool heating system is sized for early spring and late fall swimming, pipes may overheat during summer, or at other times when the temperature high limit has been reached and the system is not circulating to the collectors. Pipes without water flowing through them may become as hot as 170 to 180°F (77–82°C) during peak summer temperatures. PVC piping has a recommended temperature limit of 140°F (60°C).

At high temperatures, 2 inch and larger PVC pipe begins to soften and lose its pressure rating. Pipe overheating can be avoided by allowing the diverter valve to let 5 percent of the water pass through the collectors to keep the pipes cool. A good solution is to drill 5/16 inch or 3/8 inch holes through the diverter or remove the seal, allowing a little water to bypass when the high limit feature has shut off flow to the collectors.

Vacuum Breakers

When the pool pump turns off, the water in the collectors drains back into the pool, and forms a siphon in the collector loop. A normally-closed vacuum breaker at the end of a collector bank on the roof opens to let air into the collectors. The weight of water falling back into the pool pulls the vacuum breaker open. When the system first starts up the next day and directs the flow to the collectors, the water filling the collectors from the bottom will blow air back out through the pool return lines for 3 to 4 minutes before the water starts returning from the top of the pool collectors.

There is some controversy as to the best location for vacuum breakers, which are prone to creating problems. I prefer placing these normally closed vacuum breakers opposite the inlet, on the far end of the lowest row of collectors on the roof. It is not necessary to put the vacuum breaker on the highest bank in an array. Putting a vacuum breaker on the first collector in a row at the top can result in air being constantly sucked in if the return flow drops too fast off a steep roof.

A differential pool controller senses pool and solar collector temperatures and controls the diverter valve appropriately.

Automatic Comfort Control

Automatic pool controllers can provide your solar pool heating system with more ease of operation and a greater level of temperature control. Differential pool controllers, such as Pentair's Compool LX220 or Goldline Control's GL235, perform two basic functions—comfort control and differential temperature control to assure solar heat gain.

Comfort control limits the pool temperature to a desired setting. The high temperature limit is set to personal preference for the time of day or night that you wish to swim. Pool temperature is dependent on personal preference—some people like pools at 70°F (21°C), while some like it at 88°F (31°C). It's a personal choice, affected by whether you swim during the evening or sunny daytime. People who exercise or swim laps usually like the pool quite a bit cooler than others.

Some rough guidelines are 78 to 84°F (25–29°C) for recreational day swimming and 86 to 92°F (30–33°C) for nighttime swimming. My experience is that most people are comfortable swimming laps at 82°F (28°C), and prefer 86°F (30°C) for nighttime recreational or leisure swimming.

The differential temperature control function is similar to that used in domestic solar hot water systems. The major difference is in the location of the sensors. The pool water sensor is located anywhere before the diverter valve. A hole is drilled into the PVC pipe after the pump or filter, but before the diverter valve. The sensor is set in the hole and clamped to the pipe. It measures the temperature of water coming from the pool.

The other sensor is located in the middle of the collector area—or screwed directly to the roof at least 3 feet below the peak. Its temperature will be affected by solar insolation, air temperature, and wind speed. When the controller sees that the roof sensor is the preset amount warmer than the pool water sensor (typically 4 to 8°F; 2.2–4.4°C warmer), it activates the two-way diverter valve to direct the flow of water through the collectors and then back to the pool.

When the temperature differential is reduced to 3°F (1.7°C), the controller deactivates the diverter valve to block the flow of water to the collectors. Pool water is then circulated only through the filter, as long as the timer activates it.

The pool water sensor also acts as the high limit comfort control. When the pool water exceeds the desired temperature setting, the controller deactivates the valve to stop heating the pool. Goldline's model AG-SOL-LV has a digital display for temperature readings, and its own timer for the pool pump. This control has a selectable solar override to turn on the pump to maximize solar heat gain.

A Solar Opportunity

It is impossible to comprehensively cover all the details of installing a solar pool heating system in these two articles. But you should have gained enough understanding to tackle installing a basic system. If you encounter unusual obstacles or problems at your site, consult with your collector manufacturer or dealer. Solutions and specialized parts to solve problems are available for the asking.

A pool without a solar water heating system is like a day without sun. It's difficult to understand why anyone with a pool would fail to use the energy that is freely distributed on a daily basis. It's no longer a secret why solar pool heating is one of the best opportunities under the sun. For those who have invested in a pool, using the sun is your most economical heating solution and will help you to enjoy your pool even more.

Access

Tom Lane, Energy Conservation Services, 6120 SW 13th St., Gainesville, FL 32608 • 352-377-8866 • Fax: 352-338-0056 • tom@ecs-solar.com • www.ecs-solar.com • Article adapted from Tom's *Solar Hot Water Systems: Lessons Learned, 1977 to Today.*

Florida Solar Energy Center (FSEC), 1679 Clearlake Rd., Cocoa, FL 32922 • 321-638-1000 • Publications: 321-638-1015 • Fax: 321-638-1010 • info@fsec.ucf.edu • www.FSEC.UCF.edu • Pool collector ratings

Goldline Controls, Inc., 42 Ladd St., East Greenwich, RI 02818 • 800-343-0826 or 401-884-6990 • Fax: 800-343-0827 or 401-884-6990 • customerservice@goldlinecontrols.com • www.goldlinecontrols.com • Controllers & diverter valves

Pentair Pool Products, 1620 Hawkins Ave., Sanford, NC 27330 • 800-831-7133 or 919-774-4151 • Fax: 919-776-4571 • pentair@speedymail.com • www.pentairpool.com • Controllers & diverter valves

Aquatherm Industries, Charlie Grignon, 1940 Rutgers University Blvd., Lakewood, NJ 08701 • 800-535-6307 or 732-905-9002 • Fax: 732-905-9899 • aquatherm@aol.com • www.warmwater.com • Installation manual

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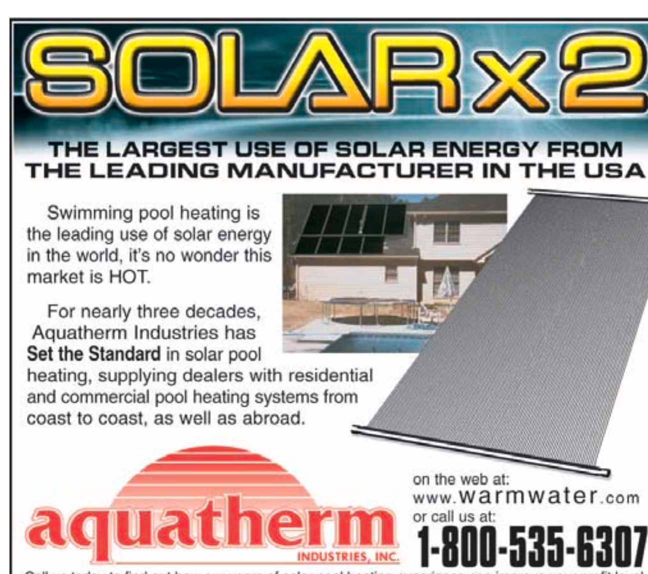

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My Car Runs on Vegetable Oil...

...Straight Vegetable Oil

Gary Liess

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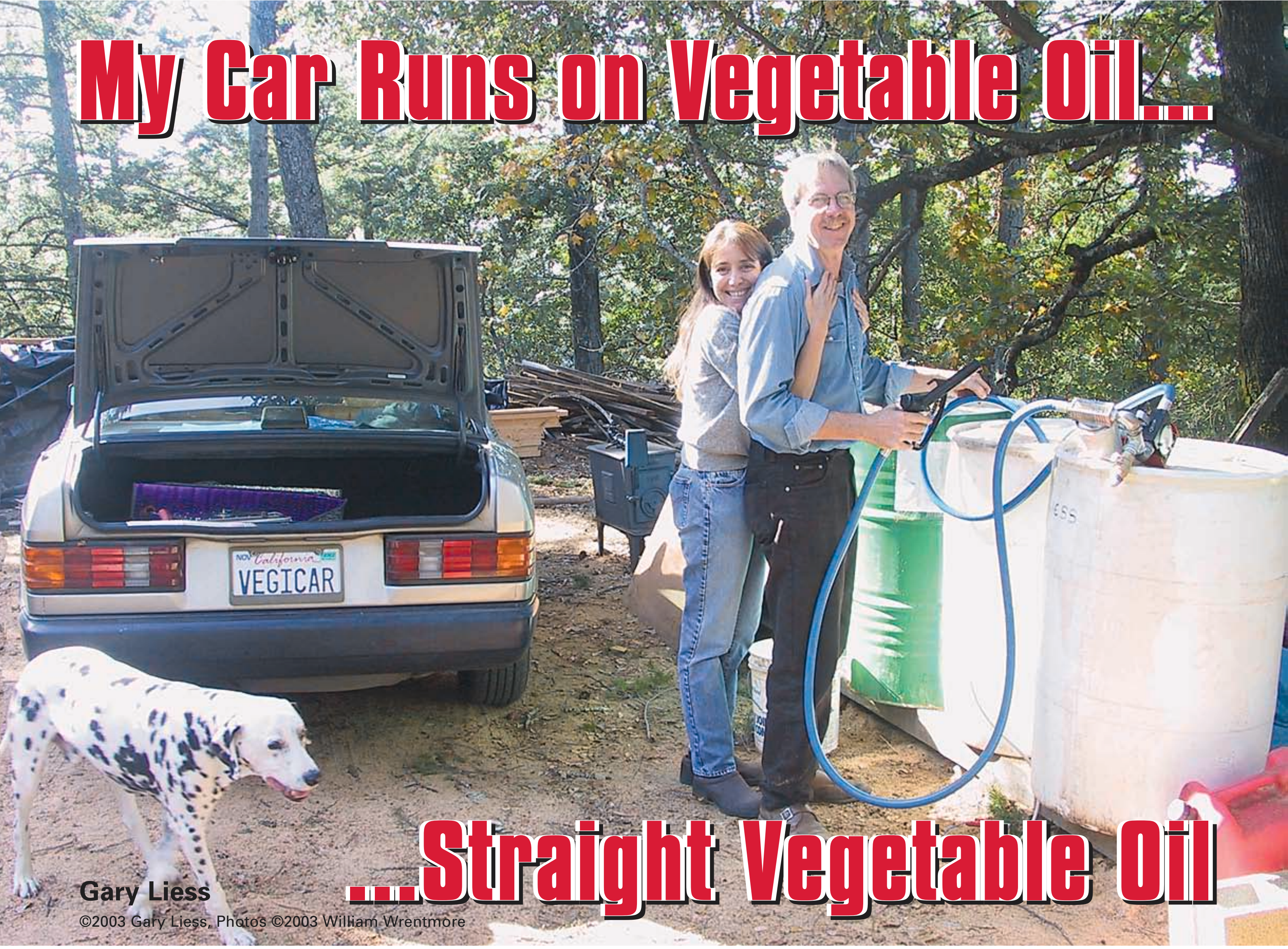


Gary and Carolyn are more than satisfied—they're enthusiastic about running their cars on straight vegetable oil.

Run a car on 100 percent vegetable oil? Sounds crazy! I had driven my Mercedes 300CD diesel engine for a quarter of a million miles before I had even heard about biodiesel. Using straight vegetable oil in my car made even more sense to me.

I learned about biodiesel from Joshua and Kaia Tickell's *From the Fryer to the Fuel Tank.* Biodiesel is made by chemically modifying vegetable oil for use as a fuel in diesel engines by using a mix of lye and methanol. After reading the book, I loved the idea of running on biodiesel, but I personally was hesitant to mix nasty chemicals to create it. I knew that Rudolf Diesel originally designed his engine to run on peanut oil, but somehow it didn't sink in that it was possible to run on 100 percent vegetable oil in this day and age.

Then my partner Carolyn Scott attended the Bioneers Conference in San Rafael, California in October 2001. A young man named Jason Goodman was displaying a diesel VW Vanagon that was running on straight veggie oil. I got in touch with Jason and found that he and Chris Gibson were setting diesel vehicles up to run on veggie oil. This was the start of my straight vegetable oil (SVO) education.

Two Choices

You have two choices when running on biofuels. The first is to make or buy biodiesel, make no modifications to your vehicle's engine, and just drive away. The second choice is to buy or make a conversion kit for running straight vegetable oil. There's no need to process the fuel; you just fill up and go. With biodiesel, you modify the vegetable oil; with SVO, you modify your vehicle.

The conversion to running on straight veggie oil is made by installing an extra fuel tank, tapping into the vehicle's liquid coolant system to heat the oil, and then controlling the flow of the oil by valves and switches. The oil must be heated so it is thin enough to flow through your fuel system. The valves and switches allow you to begin and end your trips on petroleum or biodiesel, so your fuel system will not clog when the SVO cools.

Using SVO in Your Engine

Diesel engines will run on straight vegetable oil if the viscosity of the oil is thinned to the same approximate viscosity as petroleum fuel—the engine doesn't care if it's fed petroleum fuel or vegetable oil. Vegetable oil is about ten times thicker than diesel fuel, and as the temperature decreases, the oil gets thicker still. Heating the oil to around 165°F (74°C) thins it enough for the engine to accept it.

There are two heating methods—one uses an electric fuel preheater and the other uses a heat exchanger. I chose the heat exchanger method. When attempting to run on 100 percent veggie oil using the heat exchanger method, the engine must be cold-started on diesel or biodiesel. After cold-starting and driving for a few minutes, the engine will reach its normal operating temperature.

By then, the veggie oil will have been warmed sufficiently by the hot coolant and the heat transfer system. The driver can switch over to the veggie fuel tank and drive on veggie oil. Before engine shutdown, the veggie oil must be replaced in the fuel lines with the diesel or biodiesel so the vehicle will be ready for the next cold-start.

Conversion Kit

I purchased an SVO conversion kit from Justin Carven of Greasecar Vegetable Fuel Systems (greasecar.com). Jason Goodman and Chris Gibson installed it for me. The kit comes with an additional fuel tank for the veggie oil; a six-way solenoid valve, controlled by a dash-mounted rocker switch for changing between the fuel tanks; and a back-flushing, three-way valve with switch to clear the lines of oil. The kit also has a fuel gauge, a heated 10 micron fuel filter for the veggie oil, hoses, and connectors for connecting into the hot coolant from the heater core to heat the fuel lines. The simplicity of the conversion kit is striking.

The heat exchanger is a hose inside a hose (HIH), and a coil wrapped around the vegetable oil filter. Hot engine coolant is diverted with a tee fitting from the cabin heater-core input and is passed through a copper coil surrounding

The Biofuels Research Co-op

I get the vegetable oil I use from a local company in northern California's Sonoma County that bottles assorted products made from organic oils. A number of people in the area have converted vehicles to run on veggie oil here, so we banded together and formed a vegetable oil co-op that we call the Biofuels Research Co-op. We have 36 members and have spent many hours doing research, developing bylaws, establishing committees, and building and operating two fuel sites.

We have contracted with a local company to haul the oil company's waste oil, which is fresh and uncooked. They save disposal fees, and because they "donate" to us, they get a tax write-off on the oil. We were able to get nonprofit status through a local college, whose curriculum is focused on ecology, community, and activism. The group is highly motivated, building a fueling station with steel tanks and metered fuel pumps.

The primary requirement for membership is to have a converted diesel car, truck, or van. Since membership is limited by the amount of oil allocated to us by the oil production company, one of our committees is dedicated to researching new oil sources, so we can support new conversions in our community. We encourage people to contact us and see how they can form their own cooperatives. One of our more active members, William Wrentmore, has established a Web site that many of our members use—www.veggieavenger.com.

Veggie fleet:
Gary's Mercedes 300CD (front), and Carolyn's Mercedes 190D (rear).
They also have a veggie-powered VW Vanagon camper for weekend fun.

The 15 gallon vegetable oil tank hides in the trunk.

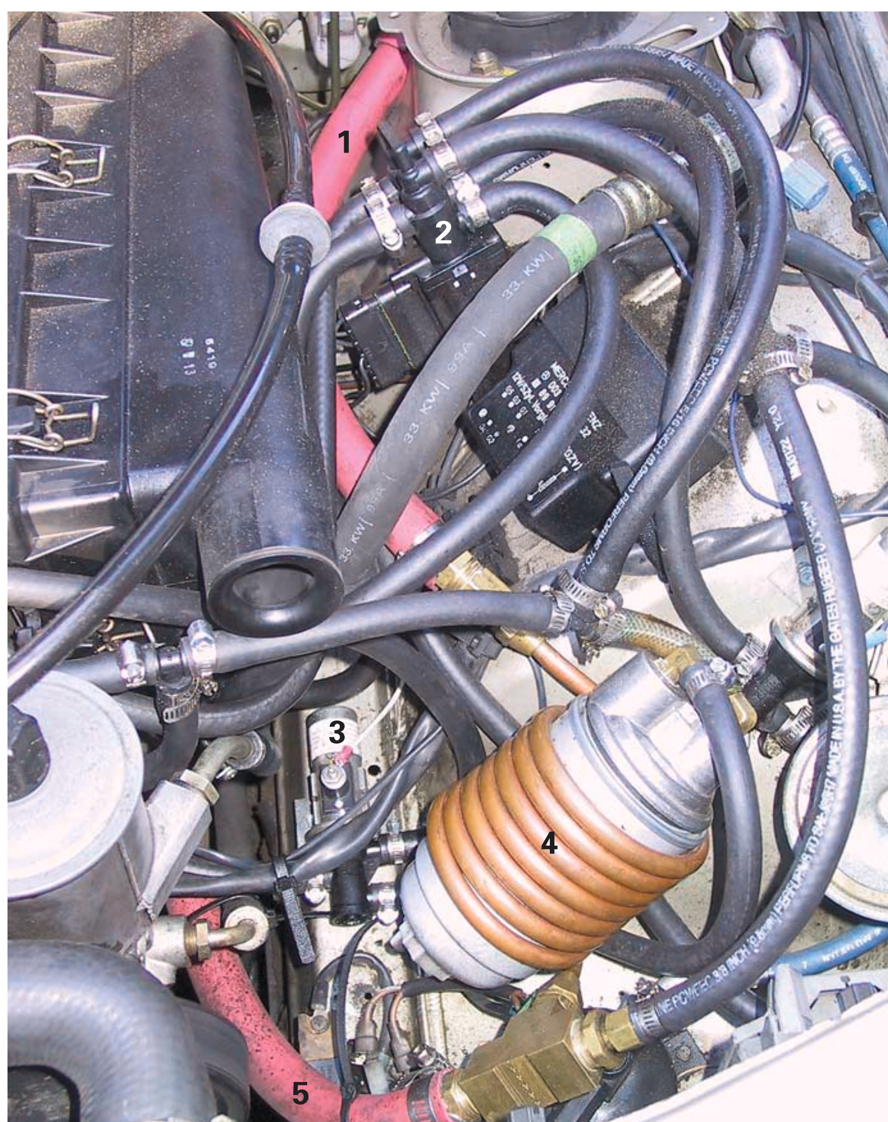
extra fuel tank. My partner Carolyn had a Greasecar kit installed too. Her car is a Mercedes 190D and gets 30 to 35 mpg and her range is 1,000 miles (1,600 km) with both tanks full.

What Works Best

Certain types of diesel engines, injection types, and injector pumps are better suited to running on pure veggie oil than others. Engines with indirect injection are reported to be better than those with direct injection. All newer diesel engines have direct injection. Mechanical injection methods are better than computerized injection methods.

There are three types of injector pumps—inline, rotary, and Lucas/CAV injection pumps. In-line pumps have turned out to be very solid and without problems with veggie oil, and can be found in Mercedes cars (with

Under the 300CD's hood: 1) heater hose from heater-core splice; 2) six-port solenoid fuel switch; 3) three-port solenoid fuel switch; 4) vegetable oil heated filter; 5) HIH back to/from vegetable oil tank.



the vegetable oil filter. From the filter coil, the coolant flows back to the vegetable oil tank via a 1 inch radiator hose, which forms a hot coolant jacket around the vegetable oil line—this is the HIH. The HIH consists of the 1/4 inch (6 mm) veggie fuel oil line that is inside the 1 inch (25 mm) heater hose.

Finally, the coolant is passed through copper coils in the vegetable oil tank, which warms the oil so that it can flow in cold weather. The coolant is then returned to the engine via another 1 inch heater hose that is attached with a tee fitting into the system at the water pump return.

The cost of the deluxe conversion kit from greasecar.com is US$795; an economy kit is US$495. Other companies offer kits with prices starting at US$299, but the deluxe greasecar.com system has a metal fuel tank instead of a plastic one, and uses a 1 minute back-flush method that eliminates switching back to diesel or biodiesel five minutes before shut-down. Installation cost is additional, and was US$525 for my car. For more information on kits, see Access.

With the addition of the kit's 17 gallon (64 l) vegetable oil fuel tank, my car has a range of over 800 miles (1,300 km). The car will run on regular diesel, biodiesel, or straight vegetable oil. The only negative aspect of the conversion is the loss of some trunk space for the

1) the auxiliary veggie fuel gauge, 2) fuel-type switch, and 3) back-flush switch on the dash of the 300CD.

Biofuel Taxes

My partner and I worked on the co-op legal committee to find out what taxes, if any, might be applicable for our use of vegetable oil. Our co-op was alarmed when we heard about the arrest of British drivers who were using vegetable oil. They were fined £500 (US$750) with the threat of seven years imprisonment.

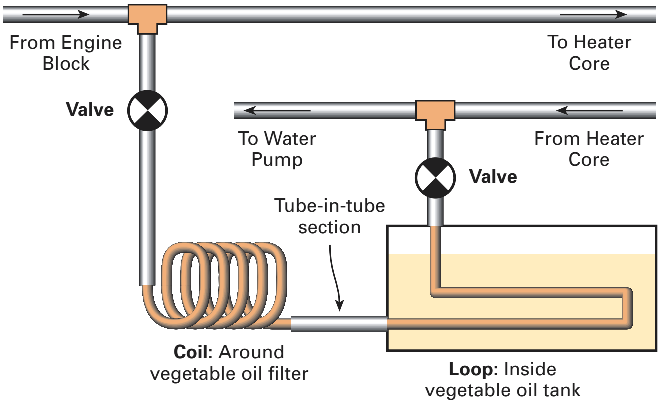
I called several agencies, including the California State Board of Equalization, and found that there are no federal taxes on straight vegetable oil and no taxes on homemade biodiesel if the maker uses or blends less than 400 gallons (1,500 l) per quarter. The state, on the other hand, has informed me that they are formulating rules or laws that will tax any fuel used in diesel engines. They consider food products fuel if they can power a vehicle. The planned road tax will be 18 cents a gallon.

precombustion chambers) and engines such as Cummins, Volvo, and Iveco. Bosch distribution pumps or rotary pumps have shown to be strong enough to cope with veggie oil. But to avoid premature pump failure, you should use fuel with near to diesel-like viscosity. Lucas/CAV pumps are very sensitive to any kind of particles of dirt in the fuel. Use a fine filter and only heated veggie oil.

The type of oil that is used can be important. I am fortunate to have access to high quality (food grade) uncooked oils. Not everybody has this available. Certain oils are better than others. Oils made from plants in the *Brassica* genus (mustard, canola—all containing high-lubricity oils) are among the best. If you live in a colder climate, you want canola, soy, sunflower, or corn oil because they don't solidify as much as others.

Vegetable Oil Preheat

Using Engine Coolant Loop



The Biodiesel Option

For those folks who are driving diesel powered vehicles and don't want to install the extra components to run on straight veggie oil, there is still biodiesel. Using the same waste vegetable oil, you can process the oil into biodiesel and make no modifications to your engine. Because biodiesel is such a great improvement over petroleum diesel (see www.ott.doe.gov/biofuels/environment.html), many people are making biodiesel from waste oil. They are saving money on fuel and helping the environment.

To find out how to make biodiesel, see the URLs in the Access section at the end of this article, and see the how-to article in *HP93.* Because I must use biodiesel for cold-starting, I have decided to join together with local biodiesel lovers and form a co-op group to make biodiesel. The group mixes the nasty methanol and lye together with pumps, which almost eliminates the dangers of handling these potentially hazardous products. The cost of the finished biodiesel is around US$0.60 a gallon.

Pollution

Emissions are greatly reduced with biodiesel and straight vegetable oil, and are far less damaging to the environment than petroleum diesel. There hasn't been as much testing on 100 percent vegetable oil compared to biodiesel, but neither product contains sulfur, so there are no sulfur dioxide emissions. Soot or particulates are reduced by 40 to 60 percent compared to petroleum diesel, while carbon monoxide and hydrocarbon emissions are reduced by between 40 and 60 percent.

Renewable fuels such as biodiesel and veggie oil don't contribute to global warming, since they are carbon neutral. They don't put any more CO_2 into the atmosphere than the crops grown to make more fuel will use. Only nitrogen oxides may be increased, and adjustments to the injection timing and engine operating temperature can result in lower levels than that produced by petroleum diesel. Compared to petroleum diesel, biodiesel and vegetable oil are 80 to 90 percent less hazardous, and SVO is nontoxic, nonhazardous, and biodegradable.

Vehicles running on biodiesel produce the least amount of greenhouse gases compared to those running on any other fuel, including compressed natural gas, hybrid, and all-electric vehicles (charged by the grid), according to a report authored by the Alternative Fuel Vehicle Program, sponsored by Ford Motor Company and Harvard University. It's not hard to see why biodiesel use has grown thirtyfold in two years.

Biodiesel is recognized by both the U.S. Environmental Protection Agency and Department of Energy as an alternative fuel. It qualifies for mandated programs under the Clean Air Act Amendments and the Environmental Protection Act of 1992. In California, biodiesel has been approved for use in remediation of petroleum oil spills.

Advances in Energy Independence

In the year since I installed my conversion kit, there have been some advances in systems. The Elsbett system from Germany uses only the original fuel tank and doesn't require extra switches, hoses, and fuel tank. This company supplies new glow plugs and fuel injectors, which along with an in-line heater allows the vehicle to be cold-started on veggie oil. Several of our co-op members are using this system along with an electric 12/24 volt, VEG-Therm SVO heater from Neoteric, and are having great results.

The veggie fuel movement is becoming known and is rapidly growing. Some people feel that the straight oil conversion kits are still in the experimental state. As with anything new, developments and improvements are happening quickly. But that benefits all of us who are striving for energy independence and trying to improve our lives responsibly.

Access

Gary Liess • 1557 Los Alamos Rd., Santa Rosa, CA 95409 • 707-538-8639• joyluck@sonic.net

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

Greasecar Vegetable Fuel Systems, Justin Carven, PO Box 60508, Florence, MA 01062 • 413-586-2432 • info@greasecar.com • www.greasecar.com • Conversion kit supplier

www.journeytoforever.org/biodiesel_svo.html • Lots of good biodiesel and straight vegetable oil info

www.biodiesel.infopop.net/2/OpenTopic/a/cfrm • Biodiesel and straight veggie oil discussion

Photos by William Wrentmore • william@veggieavenger.com • www.veggieavenger.com

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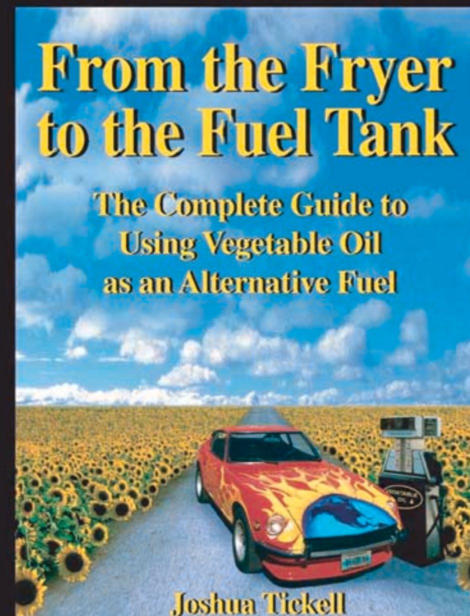

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AJ Rossman & Joe Schwartz

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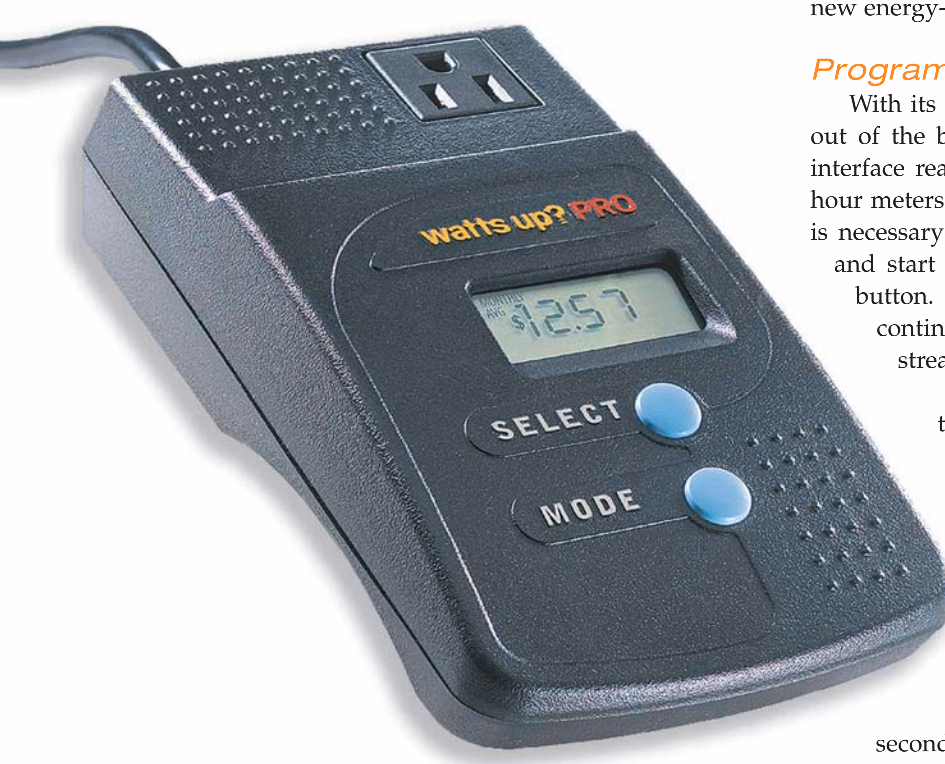


The Watts Up? Pro meter can measure the electrical characteristics and energy consumption of any 120 VAC load up to 15 amps continuous.

Watt-hour meters are necessary tools for anyone interested in analyzing electrical energy consumption. The energy consumed by a variably cycling load, such as a washing machine, is often difficult to predict based solely on run-time. A watt-hour meter can increase accuracy for renewable energy system load analysis.

Most watt-hour meters can tell you the instantaneous power (watts) and the total energy used (watt-hours or kilowatt-hours) by an appliance. But what do you do when you want to see exactly when the energy is being used, and not just the total?

The Watts Up? Pro meter lets you do this with datalogging capabilities and an easy-to-use computer interface. This meter also includes a software calculator that determines the estimated payback period for upgrading to new energy-efficient appliances.

Programming & Software Installation

With its small LCD display, this unit can be used right out of the box as a stand-alone meter. But the computer interface really makes it stand out from most other watt-hour meters. Getting started is easy since no programming is necessary for the metering function. To reset the meter and start a new logging session, just push the "select" button. With some programming, the meter can also continuously output data to a PC as a serial data stream. Details are listed in the software's help files.

One nice feature is that the user does not have to worry about the meter running out of memory. It automatically updates the interval at which data is stored, depending on how long the meter is in use. The meter initially records data into the meter's memory every second. This data storage interval increases automatically as the internal memory starts to fill (the meter has up to 1,023 memory locations). The meter automatically doubles the storage interval (2 seconds, 4 seconds, 8 seconds, etc.), and it drops every other sample of data to make room for more. This doubling of the storage interval is done as many times as needed.

The literature provided with the meter was straightforward and easy to follow. The manual clearly explained the different operational modes (watts, watt-hours, time, cost, volts, and amps) and what displays can be selected within each mode. The on-line help is actually useful! The software installation on a PC went smoothly, with no hitches in the setup wizard.

Using the Meter

The Watts Up? Pro is used in the same way as other watt-hour meters. You simply plug the appliance you want to monitor into the meter and plug the meter into an AC electrical outlet. The Watts Up? Pro will only measure 120 VAC appliances, and the maximum current that can be passed through the meter is 15 amps continuous.

Downloading and graphing the data from the Watts Up? Pro meter is also easy. The meter can be unplugged from the outlet and appliance and be moved without losing data because the data is saved in nonvolatile memory. To download the data, the meter needs to be plugged back into an outlet and then connected to a serial port (RS232) with the meter's serial port cable. An RS232 to USB adapter is available.

The software walks a first-time user through the entire data collection and downloading procedure in easy-to-follow steps. Experienced users can skip these steps by pressing the "one-step logging" button on the computer screen. The meter has no real-time clock, so you need to set a new time and date for either the first or last sample. The meter then automatically time stamps all the individual data points.

The graph generated by the Watts Up? Pro software for a load of laundry is shown on the next page. The data can also be displayed in a table format by clicking on a tab in the software, and can be exported in a comma-delimited format for further analysis in most common spreadsheet programs. In our test, a load of laundry in our large washer, including a prewash cycle, consumed 187.4 WH of electrical energy.

The toolbar to the left of the on-screen graph makes it simple to customize the graph. Users can select which electrical parameters they want to display—watts, volts, amps, watt-hours, cost, power factor, and duty cycle. Zoom in and zoom out buttons and arrows allow you to select which part of the graph you want to view. The graph can be displayed in a 3-D format, with user-selectable depth and rotation. Files can be exported in .bmp, .wmf, or .emf file format.

The Watts Up? Pro software also includes an appliance payback calculator. This cool tool gives an estimated monthly savings and payback period for a new appliance

Features

High Points:

- User-friendly data acquisition
- Simple software setup
- Payback calculator
- Long cord for ease of use with large appliances
- Clever automatic sampling interval update
- Works with modified square wave inverters
- Measures peak power and power factor

Low Points:

- No Mac OS software
- Need to reset time stamp each time data is downloaded
- No real-time monitoring via PC included in software (can be done with user programming though)

List Price: US$130.95

Warranty: One year

Other:

- UL listed
- Serial (RS232) to USB adapter available

Tech Specs

Measures:

- Power (instantaneous/max/min watts)
- Energy consumed (cumulative and average monthly KWH)
- Power factor
- Elapsed time
- Duty cycle
- Cost (cumulative and average monthly, two-tiered KWH cost)
- Voltage (instantaneous/max/min)
- Amperage (instantaneous/max/min).

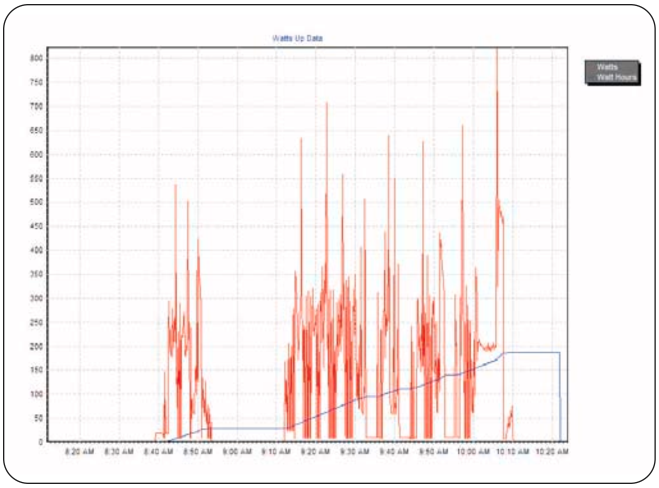
Memory Size: 1,023 samples

Sampling Rate:
Approximately 4,000 samples per second maximum

Physical Size:
4 by 7.25 by 2 inches (10 x 18 x 5 cm)

Weight: 1.25 pounds (0.57 kg)

Construction:
Tough plastic case with LCD display



The graph shows the electrical energy used by a Frigidaire Gallery horizontal-axis washing machine for a single load. Note the distinct prewash cycle on the left side of the graph and the spike with the final spin cycle on the right.

compared to the appliance just measured. We tried this feature using a Vestfrost ConServ refrigerator and found that the ConServ was more efficient than any of the preprogrammed refrigerators.

The calculator can also be used to compare washers, dryers, or any other appliance you may be thinking about upgrading. This is a useful tool for people thinking about buying new energy-efficient appliances, or anyone who specifies appliance upgrades. The software includes 71 refrigerators, 25 washers, and 9 dryers. You can manually add appliances not included in the preprogrammed menu, such as ultra-efficient appliances or new models released after the meter software was released. The meter allows you to enter the average energy the appliance uses (KWH per month) and the appliance price. The meter calculates the payback period of purchasing a new appliance by using this information, the cost of your electricity, and the average energy consumed by the appliance as measured by the meter.

The Watts Up? Pro meter came nicely packaged in a sturdy cardboard box that can be used to neatly store the meter and cords when not in use. The meter comes with a 6 foot (1.8 m) electrical cord, software on a CD, an RS232 interface cable, and two manuals—one for getting started and a user's guide. The software is compatible with Windows 95 and above (98, 2000, XP).

We like the Watts Up? Pro. The meter and software are easy to use. It measures all electrical characteristics of an appliance needed for a common load analysis. The graphs are easily configurable and can be used to teach principles of load analysis. The payback calculator is a useful tool for anyone wanting to see the economic payback of upgrading to energy efficient appliances.

Access

AJ Rossman, Draker Solar Design, PO Box 8346, Burlington, VT 05402 • 802-238-8648 • aj@drakersolar.com • www.drakersolar.com

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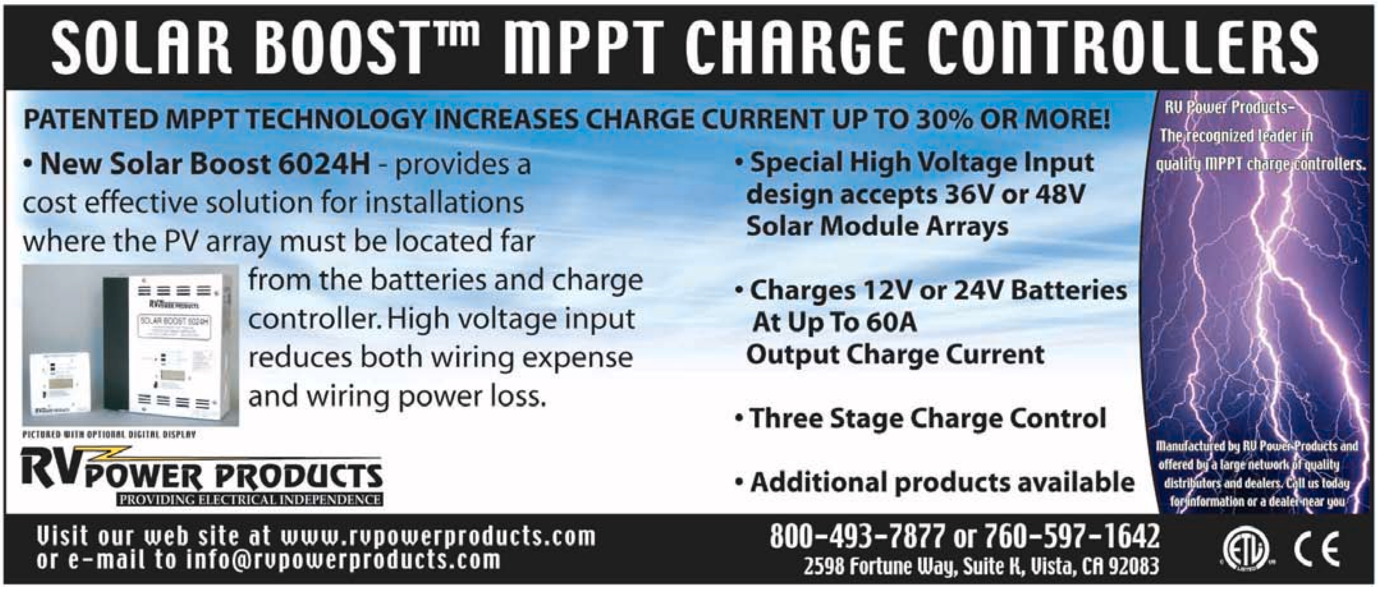

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Cedar Rose Guelberth & Dan Chiras

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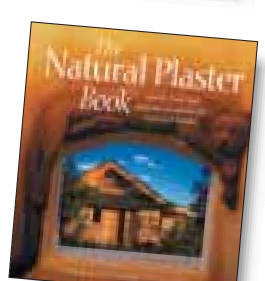

For builders of natural homes, this unique step-by-step guide takes the confusion out of choosing, mixing, and applying natural plasters. From principles to practicalities, and with every stage of the process illustrated, *The Natural Plaster Book* details the entire process of plastering for a long-lasting and durable finish.

Microhydro

Clean Power from Water

Scott Davis

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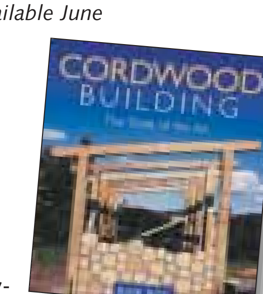
Microhydro features the smallest version of the technology dubbed "the simplest, most reliable and least expensive way to generate power off grid". It is a complete guide to designing and constructing reliable power systems, with a special focus on tiny DC systems available off the shelf. *Available June*

Cordwood Building

The State of the Art

Rob Roy

US$26.95



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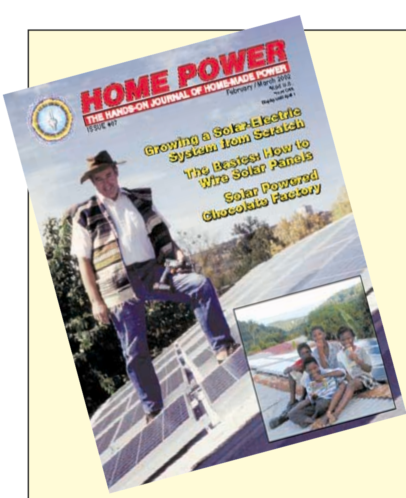

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guerrilla efficiency

washington state

The author smiles knowing that his random act of efficiency will help save the planet—and some money.

The rural Methow Valley of Okanogan County in north central Washington is like nirvana if you like the outdoors and recreation. Awesome activities are abundant in all four seasons, including snowshoeing, cross-country skiing, white water rafting and kayaking, wildlife viewing, mountain and rock climbing, and mountain biking. It seems that more artists live here per capita than anywhere else in the Northwest. Many more off-grid families live here than you would think, and most of them read *Home Power* magazine.

Efficiency Starts Here

Smart things are happening in the Methow; residents are embracing an ecologically sustainable way of life. The area has been challenged by economic changes. Yet, this community continues to progress into the new millennium, all the while restoring fish habitat and growing organic apples and other crops. A fiber optic network helps bring the community into the modern age.

The sense of community here is strong, and transformation is alive in the marketplace. Every hardware store in the valley carries Energy Star compact fluorescent (CF) lightbulbs at good prices. As rural as this area is, it is not unusual to see an occasional hybrid electric vehicle driving down the scenic highways. Even the local Okanogan Electric Co-op has solar-electric modules installed at the utility office.

A Guerrilla Opportunity

The Sun Mountain Lodge near Winthrop, Washington hosts a variety of guests, for both business and pleasure. The lodge is actually quite an international destination. Many organizations retreat here for conferences, and visitors escape the hustle of the cities and bring their families for the inspiration of the environment. Unlike most lodging facilities, the guest rooms are TV free!

On a recent stay at the lodge, I noticed that the family game room had lampshades with "toast" marks—incandescent burn spots. 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 CF that fit the random act. I replaced the 75 watt bulb, and then anonymously informed the front desk of my good deed.

Money Isn't All You're Saving

I recommend picking up CFs whenever you see them on special buys, and having them handy for your next GEO. Each time I visit the lodge, I try to perform a guerrilla action in the area. I am up to five CF, GE actions in the Methow Valley now.

Incandescent bulbs lose up to 95 percent of the energy they use as heat. When using an incandescent bulb to light a room, we are basically resorting to a technology that goes back beyond Thomas Edison to the caveman days of using a wood torch to see. But the smoke produced today is at a distant power plant, adding to global climate disruption.

The manager of the local electric co-op mentioned to me recently that the Bonneville Power Administration, which sells electricity to the co-op, will be increasing wholesale rates this October by another 25 percent, and still more cost increases are scheduled to follow in 2005. A GE action done now just gets more valuable over time! Every day, month, and year means more energy and dollars saved, and less pollution from the power plant smokestack.

Many of the local business owners bought and installed LED holiday lights this season. If rural Washington communities like Mazama, Winthrop, and Twisp can adopt smart technologies, then any place can!

Access

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Guerrilla Efficiency Defined

Energy efficiency is the most effective action for moving the planet toward a sane energy future. Education is the first step in increasing public awareness of energy efficiency. Installing compact fluorescent lightbulbs and implementing other efficiency measures in your community is fun, and it helps increase the use of energy efficient technologies. Practice random acts of efficiency and sensible acts of conservation!

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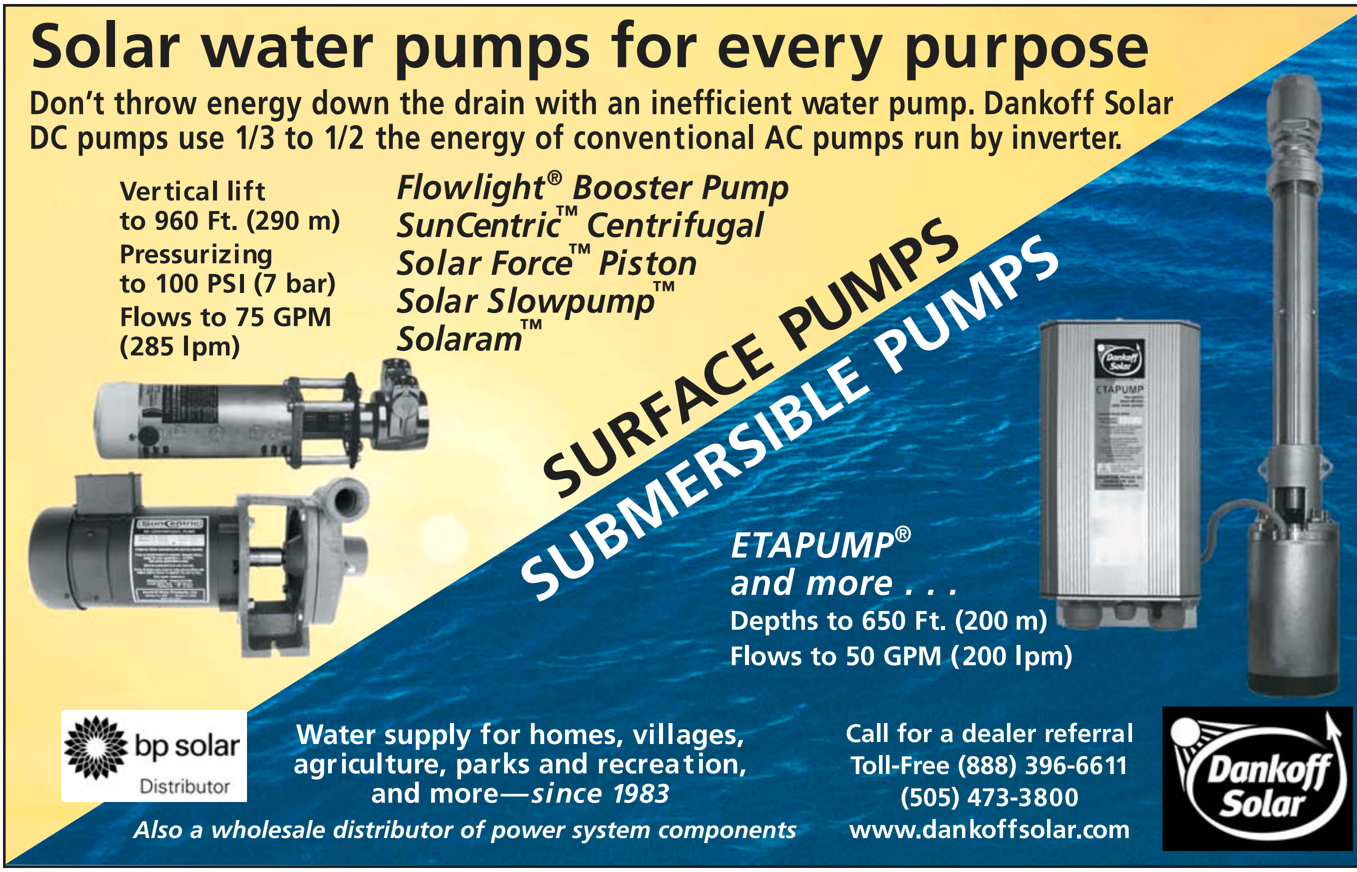

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It's Your Choice:

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The flex-fuel Ford Taurus can run on gasoline or ethanol.

Shari Prange

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When Henry Ford introduced the Model T, he told the public, "You can have it in any color you want, as long as it's black." For most of the past century, automakers have been telling us, "You can have any engine you want, as long as it burns petroleum."

With the periodic gas "crises" that began in the 1970s, and increasing air quality problems, people have started to question this dictum. Automakers often unveil concept cars and prototypes that promise 100 mpg or the ability to "run on water," but somehow, these don't seem to make it into production. They promise us the sun, but what they give us is…gas.

But wait! Is that a glimmer of light breaking through? Are there *really* some alternatives that are available to the average human? In the last issue of *HP*, we looked at some of the electric-based options, including pure electric cars, hybrids, and fuel cell cars. This time, we'll look at some nongasoline-combustion options.

Our objective here is not to talk about the "cars of the future," but the cars of *today.* This is not intended to be a comprehensive discussion of these fuels or vehicles, but an overview and introduction to some of the options available to consumers now, or in the very near future. If you want to pursue any of these in more detail, see Access.

Fuel & Vehicle Sources

Before we get into specifics, let's cover a problem common to all alternative fuels—availability. Because these fuels are still so new in vehicle use, you cannot find filling stations on just any street corner. Alternative fuels tend to make their appearance in fleets first, so that is also where the fuel supplies show up first. For any of these fuels, you should count on doing a little research to find just where they are available in your area. This kind of information is often available on the Internet. In some cases, home fueling may be an option.

The vehicles themselves are also not as readily available. These types of vehicles are marketed primarily to fleets, and your local dealer probably won't have one in the showroom. However, you can usually order one, although some are restricted to fleet purchasers only.

If you are looking for a compressed natural gas (CNG) vehicle, you will have to go to a dealership with CNG certification. Special training is required, and special shop ventilation, for a dealer to be able to order these vehicles.

Comparison of Automotive Fuel Characteristics

Item	Biodiesel or Straight Veg. Oil (SVO)	Natural Gas (CNG)	Ethanol (E85)	Propane
BTUs (thousands per gal.)[a]	121.00	29.00	80.46	84.00
Fuel cost compared to gasoline	+20–40%	-10–30%	+20–70%	-10–20%
Vehicle conversion cost	$0–800	$2,700–6,000	$0–1,000	$1,000–2,500
Added vehicle purchase cost	None	$4,000–6,000	None	$3,000–5,000
Maintenance & engine life issues	Longer engine life	Longer engine life; less maintenance	Special lubricants needed; more frequent overhauls	Longer engine life
Carbon monoxide[b]	B20:[c] -12.6% B100: -43.2%	-90.97%	-0.40%	-30.35%
Hydrocarbons[b]	B20: -11.0% B100: -56.3%	-50.75%	-0.15%[d]	-20.40%
Nitrogen oxides[b]	B20: +1.2% B100: +5.8%	-35.60%	-0.10%	-15.99%
Particulate matter[b]	B20: -15.0% B100: -70.0%	-90.97%	-0.20%	-80.95%

[a] For comparison, reformulated gas has 111.8 BTUs per gal., & diesel has 135.
[b] Emissions reductions or increases as percentages of typical gas car emissions.
[c] Bx = the percentage of biodiesel in the overall mix, combined with diesel; B20 = 20% biodiesel & 80% petroleum diesel.
[d] VOCs (volatile organic compounds)

Biofuels

One alternative fuel is vegetable oil-based and is used in diesel engines. This fuel can be a pure vegetable fuel, or a vegetable oil processed with methanol or ethanol and lye, known as biodiesel. Biodiesel is sometimes mixed with regular diesel. "B20" indicates 20 percent biodiesel and 80 percent petroleum diesel. "B100" identifies pure biodiesel, and is also called neat biodiesel.

Diesel engines began to move from big rig trucks into the consumer market in the mid-1970s. Their advantages were higher mileage, lower fuel costs, and less maintenance. As air quality requirements tightened, they were also exempted from smog checks, since they were naturally low in the types of emissions tested (although they did have other emission issues, including particulates).

At first, many people wrinkled their noses at diesels as too strange. One early hardship was that diesel fuel was only available at truck stops. So to fuel up your diesel Mercedes, you had to wiggle in between huge rumbling behemoths at the kind of filling station where Mercedes drivers don't normally venture. Diesels never did take over more than a small part of the vehicle mix, but they did become mainstream enough that ordinary gas stations began to offer one diesel pump next to the regular and super.

Research on biodiesel also picked up in the mid '70s. (Funny what a little gas crisis can do to get your attention,

The Ford F-150 pickup comes as either a dedicated or bi-fuel compressed natural gas vehicle.

Ford's Mike McCabe (left) and Brad Deacon from the governor's office open Michigan's first ethanol fueling facility.

isn't it?) Is the biodiesel option available to the average person today? Absolutely. At this point, major auto manufacturers have yet to show any interest in biodiesel. However, there is a substantial grassroots movement toward it, and a great deal of information available to those who want to jump in. A number of biodiesel suppliers can be found in North America and beyond if you look for them.

Biofuels have substantially lower emissions than petroleum diesel, including reduced unburned hydrocarbons, carbon monoxide, and particulates. They're nontoxic and biodegradable, and do not produce explosive vapors, making them safer to handle and store than gasoline or diesel.

There are two ways to get into biofuels. One is to get an ordinary diesel vehicle, locate a source of biodiesel fuel, and start using it. That second part is trickier than it sounds, though. If you scout out your town, you may locate a source, or find a biodiesel cooperative you can join. You can also manufacture your own. For more information on how to do this, see *HP93*.

You should be aware of one other issue with biodiesel. Because one component of it is alcohol (ethanol or methanol), it can deteriorate rubber hoses, seals, and fittings. The higher the concentration of biodiesel in your fuel mix, the greater the problem. B100 will cause more deterioration than B20. You will need to think about the grade of biodiesel you intend to use, and determine whether the fittings in your car are appropriate. Alcohol-resistant fittings are available, and may already be in place on your vehicle.

The other option is to modify your vehicle to run on straight veggie oil (SVO). You will have to find a source for large quantities of new or used vegetable oil, which may mean cutting a deal with a local restaurant, but you won't have to deal with any messy or dangerous processing on an ongoing basis. Once your car is modified, you're done with the hard part. There are kits available for this purpose. For more information on how to do this, see the article in this issue by Gary Liess.

SVO is a kind of guerrilla alternative fuel. It is not officially recognized by the Department of Energy, simply because of economics. No big profit can be made promoting veggie oil as fuel, so no one with deep pockets has had any interest or incentive to do the necessary testing to get it officially sanctioned. This could shut an SVO vehicle out of eligibility for some alternative fuel incentives, although there aren't many of those for conversions anyway. But no law prohibits using it in the U.S., and it *does* work.

Can you buy a veggie-oil-ready vehicle at the dealer, and fuel it at the corner filling station? Not in most communities, though a few fuel stations have drive-up biodiesel pumps. But you *can* buy a straight diesel that can burn biodiesel, and the straight veggie oil option is within reach, with a little effort on your part.

Double Your Fun!

Before we move on to other fuels, the discussion above gives us a chance to clarify a couple of tricky terms that arise when you talk about alternative fuels. Some fuels, such as biodiesel, can be used in the same tanks and fuel systems as petroleum diesel. You can fill up with a petroleum fuel one time, and fill with the alternative fuel the next time, actually letting them mix in the tank. This type of option is called a "flex-fuel vehicle."

Other fuels, however, are incompatible with each other. For example, while an engine might be able to burn either gasoline or compressed natural gas, the two require separate fuel tanks and delivery systems to the engine. They cannot be mixed. This type of vehicle is called a "bi-fuel vehicle."

You may also hear the term "dual-fuel vehicle." Sometimes this is used interchangeably with bi-fuel, and sometimes it is used to encompass both bi-fuel and flex-fuel, which can be a little confusing. As we get into other fuels, we'll spotlight ones that may be used in bi-fuel or flex-fuel vehicles, as well as dedicated alternative fuel vehicles.

Natural Gas

Natural gas comes from natural gas wells, or as a byproduct of oil wells, and can be produced from landfills. Since natural gas is gaseous, it must be converted into a more dense form, such as compressed natural gas (CNG) or liquid natural gas (LNG) to be used as a vehicle fuel. CNG is what you are most likely to encounter.

Natural gas has several advantages over gasoline. First, it is cleaner burning, being low in carbon monoxide and organic volatiles. It is lighter than air, so it will not pool on the ground, and does not contaminate ground water. Those are environmental benefits. Economic and supply issues are also important. Natural gas is substantially cheaper than gasoline. Most natural gas is domestically produced in North America, and there is already an infrastructure for distributing it throughout the U.S. Commercial CNG stations provide a fast fill, much like filling with gasoline. For a thousand dollars or so, you can also install a home compressor for overnight slow filling.

In regard to safety issues, CNG is noncorrosive, and poses less of a combustion hazard than gasoline. We mentioned earlier that it is lighter than air. This means that, in an enclosed space, it could pose a hazard by pooling near the ceiling. This is why special training and ventilation are needed for shops that work on CNG vehicles. However, it has a distinct odor to warn of its presence well before it reaches hazardous concentrations. The main disadvantage to CNG is that the necessary tanks are bulky, and take up a great deal of trunk or truck bed space, reducing cargo capacity.

The Honda Civic GX is the dedicated compressed natural gas version of the popular sedan model.

CNG is one of the more popular alternative fuel options with vehicle manufacturers, but it is often available only in trucks and minivans, rather than passenger cars. There may also be an extra cost of several thousand dollars to get the CNG version of the vehicle, although this can be largely offset by various alternative fuel incentives.

Honda has marketed the Civic GX, a dedicated CNG version of the Civic sedan, for a couple of years now. GM offers the Chevy Cavalier sedan as well as the GMC Sierra/Chevy Silverado pickups as CNG/gasoline bi-fuel vehicles. Chrysler offers the Dodge Ram van as a dedicated CNG vehicle. Ford offers its F-150 pickup in either dedicated CNG or CNG/gasoline bi-fuel versions, and the Crown Victoria as a dedicated CNG sedan. (Sorry, civilians can't order the tricked out police version.) Conversion kits are also available.

Alcohol

There are two types of alcohol fuel. Methanol is usually produced from natural gas. Although ethanol can be produced from various types of biomass, it is usually derived from corn. Ethanol is the type of alcohol vehicle fuel you are most likely to encounter, since none of the major manufacturers are pursuing methanol vehicles. The last was the 1999 Ford Taurus. Methanol was abandoned because its energy density is too low. It takes 1.65 gallons of M85 (85% methanol and 15% gasoline) to equal one gallon of gasoline. Also, the political lobby for ethanol is much stronger than that for methanol. When the ten-year leases for one hundred methanol fueling stations in California ran out, they became gasoline stations.

Ethanol is usually in the form of E85, which is an 85 percent ethanol, 15 percent gasoline mixture. E85 has lower energy density than gasoline, but better than methanol. It takes 1.4 gallons of E85 to equal one gallon of gasoline. Fuel with a lower percentage of ethanol is also sometimes referred to as "gasohol." In very low percentages, ethanol is added to gasoline as an oxygenator, making cleaner burning "reformulated gasoline."

Ethanol is clean burning and nontoxic. It is also domestically produced. Speed, acceleration, and fueling are all comparable to gasoline. Mileage per gallon is a little less. Cost is comparable to gasoline, as the result of government subsidies.

In 2001, a widely quoted study stated that ethanol was horribly energy inefficient, requiring 70 percent more energy to make than the resulting fuel contained. However, several studies have since been published rebutting this argument, and showing that ethanol is energy efficient to produce. This is an example of the problem in identifying one fuel as better than another. It may be better in some respects and worse in others, or you may have to sort through conflicting evidence to reach a decision.

E85 is corrosive, so all tanks, lines, hoses, and seals that will come into contact with the fuel must be made of appropriate materials that will not react with ethanol. Because ethanol is less volatile than gasoline, there can also be cold-start and misfiring problems while the vehicle warms up.

Again, like CNG vehicles, ethanol vehicles are available primarily as trucks, SUVs, and vans. Unlike CNG, there is often no extra cost for the ethanol version. GM currently offers the Chevy Suburban, Tahoe, and GMC Yukon SUVs, and the GMC Sierra/Chevy Silverado pickups as flex-fuel E85/gasoline.

Chrysler offers any Dodge or Chrysler minivan with a 3.3 liter engine in a flex-fuel E85/gasoline version for the current model year. In 2004, the minivans will be phased out and replaced with the Dodge Ram pickup as a flex-fuel E85/gasoline vehicle. The Dodge Stratus and Chrysler Sebring sedans are currently available in flex-fuel E85/gasoline versions only to fleets, but are expected to be available to the public at some point in the future, although no date has yet been announced. Ford offers the Taurus sedan, the Mercury Sable wagon, and the Ford Explorer, Explorer Sport, and Mercury Mountaineer SUVs as flex-fuel E85/gasoline vehicles.

In fact, you may already own a flex-fuel ethanol vehicle and not know it. As reformulated gasoline became more widespread, many manufacturers switched the hoses and fittings on their standard models to alcohol-resistant materials. However, they are not marketing the vehicles as flex-fuel ready. If you have a late model car or truck, check the fine print in your owner's manual. You may be in for a pleasant surprise.

Propane

Liquefied petroleum gas (LPG), commonly known as propane, is a by-product of natural gas or petroleum refining. It has been widely used for many years for heating, cooking, and other applications. For this reason, it is probably the most commonly available of the alternative fuels. Surprisingly, however, it is not as popular with vehicle manufacturers as CNG or ethanol.

Propane is almost completely domestically produced. Power, acceleration, and speed for propane vehicles are comparable to gasoline, but mileage is slightly lower. Propane fueling is only a little more complicated and time consuming than filling a gas tank. Although it *is* in liquid form, it must be kept pressurized to keep it that way. For that reason, there is a locking fitting instead of a simple nozzle, and some vents and drains to be dealt with. Also, the tank must not be filled to more than 80 percent, to leave room for expansion with temperature changes.

Propane produces lower levels of reactive hydrocarbons, carbon monoxide, and nitrogen oxides than gasoline. It is heavier than air, colorless, and extremely flammable. Leaks or spills can be hazardous, since it can pool and flow along the ground, possibly reaching an ignition source. It can also enter water systems.

Thousands of propane vehicles have been on the roads for years, primarily in fleets. Currently, however, the only offering is Ford's F-150 pickup in a bi-fuel propane/gasoline version. As with CNG, conversion kits are also available. Most of the propane vehicles on the road are conversions, both commercially built and privately converted.

The Choice Is Yours

So some alternatives to petroleum fuels *are* out there. They are not actively marketed at the consumer level, but they are there if you are willing to put out a little effort to find them. In some cases, you will have to weigh the pros and cons for yourself to decide what best suits your priorities, whether they are reduced emissions, energy efficiency, domestic supply, or other issues. If enough people lead with their wheels, perhaps eventually the leaders will follow.

Access

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Ford Motor Company • 800-343-5338 • www.fleet.ford.com

Energy information division of McGraw-Hill Companies, with information on a wide variety of energy types • www.platts.com

The Alternative Fuels Data Center, a project of the Department of Energy • www.afdc.nrel.gov/altfuels.html

Office of Energy Efficiency and Renewable Energy, biofuels Web site • www.ott.doe.gov/biofuels/renewable_diesel.html

Straight veggie oil info • info@journeytoforever.org • www.journeytoforever.org/biodiesel_svo.html

Greasecar Vegetable Fuel Systems, Justin Carven, PO Box 60508, Florence, MA 01062 • 413-586-2432 • info@greasecar.com • www.greasecar.com • SVO conversion kit supplier

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What the Heck? 6

Charge Controller

Used in: Battery systems

AKA: Controller, regulator, CC

What It Is: A device for regulating and optimizing battery charging

What It Ain't: The quarter-ton monster your spouse hired to control your credit card spending

Any device that charges batteries should use electronics to limit charging once the batteries approach full. The charge-limiting electronics can be stand-alone or included as part of the device. Your car alternator/regulator, cell phone charger, and laptop charger are all examples of devices that use electronics to control charging. Overcharging batteries can lead to decreased life, and even fire and explosions in some cases. That may sound exciting, but believe me, only on TV.

Charge controllers limit the amount of energy that charging sources deliver to the batteries as they get full.

Charge controllers are a common component in battery-based RE systems. There are two basic types of charge controllers—series and shunt. Series controllers basically disconnect the charging source from the batteries when they're fully charged. Shunt or load controllers divert excess energy to secondary, nonpriority appliances or "dump loads," such as electric water heaters or air heaters, once the batteries are full.

Solar-electric panels can be partially or fully disconnected from the batteries and not be damaged. In fact, this is the most common form of regulation in battery-based solar-electric systems. As the batteries reach a full state of charge, the controller gradually turns off the array, tapering off the charge rate. Many modern solar charge controllers include maximum power point tracking (MPPT) circuitry that also optimizes the amount of energy that goes into the battery.

Most wind generators and hydroelectric turbines will be damaged if disconnected from the batteries while running. The batteries electrically load the turbine and help limit how fast it spins. In these systems, a shunt-type charge controller is used to divert excess energy to a dump load when the batteries are fully charged.

For more information on charge controller basics, check out "What is a Charge Controller?" by Windy Dankoff in *HP72*, page 68.

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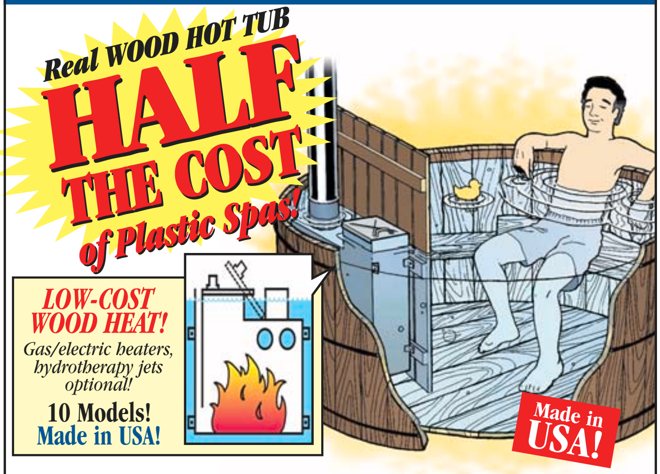

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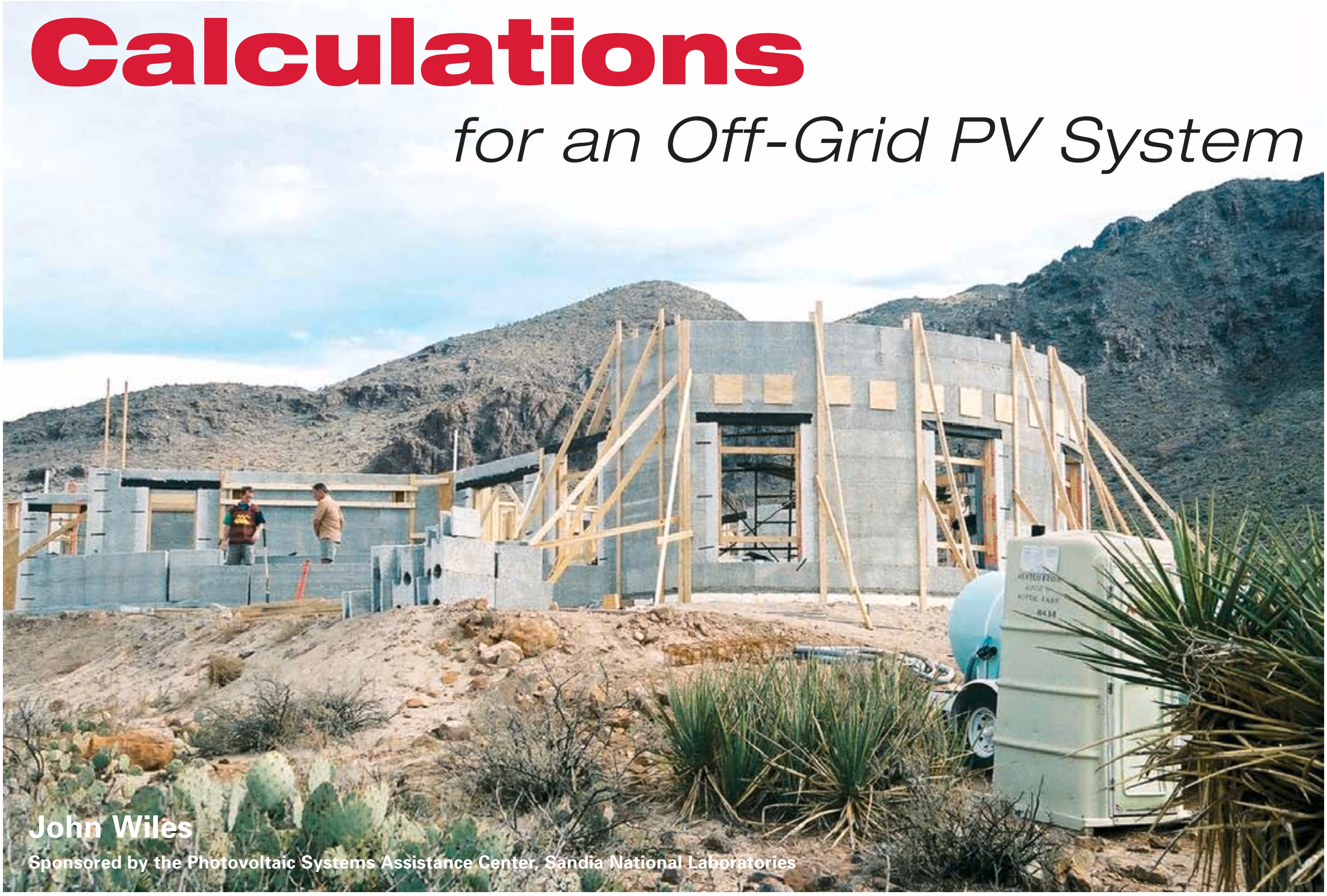
Code Calculations

for an Off-Grid PV System



John Wiles

Sponsored by the Photovoltaic Systems Assistance Center, Sandia National Laboratories

Judy LaPointe's home is on its way to becoming a finished, off-grid home.

The walls are up and the PV system is being assembled for the off-grid home described in *Code Corner* in *HP94.* This article presents most of the calculations required to design the photovoltaic (PV) system within the requirements of the *National Electrical Code (NEC).*

These calculations may not be all that are needed in the total design of every PV system. Local electrical codes may impose other requirements, and building codes may require calculations involving the mechanical installation. The calculations shown here are typical for a stand-alone PV system. But PV design is very system specific, and the calculations will be different for other PV systems.

The PV system detailed in this article will provide electricity for a residence located about 0.5 miles (0.8 km) from the utility grid in rural New Mexico. The PV array consists of twenty, 165 watt PV modules—3,300 watts DC at standard test conditions (STC) of 1,000 watts per square meter of irradiance and a module temperature of 25°C (77°F). See *Code Corner* in *HP94* for a description of the loads and system. References to the *NEC* are presented in brackets.

PV Source Circuit Calculations

The PV source circuits consist of the wiring from the modules to the combiner box.

Overcurrent Protection—Step 1. Overcurrent protection is required for each ungrounded conductor. The first overcurrent device is a fuse installed in series with each string of two modules. The fuse size for each of the ten PV source circuits was determined by meeting several requirements. The first requirement is to allow PV output to flow unimpeded to the charge controller. By multiplying the module short circuit current (Isc) of 5.46 amps by two adjustment factors of 1.25, we get a design current of 8.52 amps (5.46 x 1.25 x 1.25 = 8.52).

One of the 1.25 adjustment factors is due to expected and normal module current outputs above the rated value around solar noon. The other 1.25 factor is related to the *NEC* requirement to keep overcurrent devices and conductors from operating above 80 percent of rating (1 ÷ 1.25 = 0.80).

Although a 9 amp fuse is the next highest standard value above the design current of 8.52 amps and is available by special order, a 10 amp fuse is more commonly available and will meet all requirements for conductor ampacity and overcurrent protection discussed below. The above calculation determines the basic minimum fuse rating and conductor ampacity required by the *NEC* [690.8-9].

Module Conductors. The Sharp 165 modules we chose have #14 (2 mm^2) pigtail leads and no junction box. The ampacity of a #14 USE-2 conductor in free air is 35 amps at 30°C (86°F) [310.17]. The ampacity temperature correction factor for an estimated maximum 75°C (167°F) module operating temperature is 0.41 [310.17]. See the table on page 97.

The ampacity of conductors and temperature correction factors can be found in the *NEC* [310.15 and Tables 310.16 (conduit installations), 310.17 (free air installations)]. The correction factor is multiplied by the conductor ampacity at 30°C (86°F) to determine the corrected ampacity at the elevated operating temperature. The temperature-corrected ampacity of the #14 conductor at 75°C is 14.35 amps. (0.41 x 35 = 14.35).

We will splice #10 (5 mm^2) USE-2 conductors to the #14 pigtails. Their ampacity in free air is 55 amps at 30°C [310.17]. Some of these conductors will touch the backs of the PV modules and are therefore exposed to 75°C module operating temperatures. The temperature correction factor for an estimated maximum 75°C module operating temperature is 0.41. The temperature-corrected ampacity of the #10 conductor at 75°C is 22.55 amps (0.41 x 55 = 22.55).

Overcurrent Protection—Step 2. Ten, 10 amp fuses protect the module conductors from excess currents from the battery or from parallel strings of modules. The fuse rating is equal to the maximum module series fuse of 10 amps (marked on the back of the module), which protects the internal connections of the module. It cannot be more than this marked value. It is less than the cable ampacity of 14 amps (#14) or 23 amps (#10), and protects both conductor sizes used in the module wiring in this system.

The fuse rating is above the required rating of 8.52 amps needed to carry the current from each module. These fuses are installed in the DC combiner boxes that combine the outputs of the ten modules in each subarray to the two circuits running to the charge controllers. RV Power Products MPPT PV charge controllers are being used with a 48 volt input and a 24 volt output.

Voltage Drop Calculations. Although voltage drop calculations are not an *NEC* requirement, the length of your wire runs should be a factor that you consider in system design. In our design, each PV module has a 50 inch (127 cm) length of #14 (2 mm^2) conductor connected to a length of #10 (5 mm^2) conductor to reach the combiner box. The maximum length (for both the positive and negative conductors) in any of the source circuits totals about 20 feet (6 m).

Just meeting code ampacity requirements may not always yield an efficient system.

Wire resistance is specified in ohms per 1,000 feet (305 m) of conductor length. [Ch. 9, Table 8]. To determine the total resistance for a wire run, the wire resistance in ohms per 1,000 feet is multiplied by the number of feet and then divided by 1,000. If we considered (for simplicity) that the entire run of cable is #14 (with a resistance of 3.14 ohms per 1,000 ft.), the resistance would be 0.0628 ohms (20 x 3.14 ÷ 1,000 = 0.0628).

Using the formula, voltage = amperage x resistance (V = I x R), we can determine the voltage drop. At a peak power current of 4.77 amps (Imp), the conductors attached to each set of two modules have a voltage drop of 0.3 volts (4.77 x 0.0628 = 0.299). To figure out the percentage of voltage drop as a result of resistance, you divide the voltage drop by the nominal system voltage and multiply by 100 percent. On a 48 volt system, this is a 0.625 percent loss on the longest circuit (0.3 ÷ 48 x 100 = 0.625).

With a portion of the circuit consisting of a #10 (5 mm^2) conductor, and on circuits where the circuit length is less than 20 feet (6 m), the voltage drop and power loss (which is expressed as the same percentage because P = V x I) are even less. It is not practical to use a larger size cable at this point because the combiner box accepts no conductors larger than a #10 conductor.

PV Output Circuit Calculations

The PV output circuits include all the wiring from the combiner box to the charge controller.

Conductor Sizing. The next step in the system design is to calculate the size of the conductors between the PV combiner boxes and the DC power center. Pairs of modules are series-connected in sets of two for a 48 volt nominal output. Five strings (sets of two) of modules are paralleled in each combiner box.

The continuous output current from each of the combiner boxes (for conductor ampacity calculations) is determined by multiplying the number of paralleled strings of modules (five) by the short-circuit current (5.46 amps) of each string, and then by a current adjustment factor of 1.25 to yield an expected current of 34.125 amps (5 x 5.46 x 1.25 = 34.125) [UL Standard 1703, 690.9]. An additional 1.25 factor is then applied to get a current of 42.65 amps, and this is the current on which the conductor size and the overcurrent device must be based (34.125 x 1.25 = 42.65) [690.9].

Ambient temperatures for this system are 45°C (113°F) around the exposed portions of the metal conduits running from the combiner box to the DC power center. But the conductor ampacity tables [310.16] are based on 30°C (86°F) ambient temperatures, so we must use temperature correction factors to select a properly sized conductor.

For 90°C (194°F) insulated conductors (RHW-2 or THWN-2) in conduit, the temperature correction factor is 0.87 at an ambient temperature of 45°C (113°F) [310.16]. To determine the required ampacity for the conductor at 30°C (86°F), divide the 42.65 amps by the temperature correction factor to get 49 amps (42.65 ÷ 0.87 = 49). Use this number to find the proper wire size on the 30°C ampacity tables in the *NEC* [310.16].

This ampacity value of 49 amps dictates that a #8 (8 mm^2) conductor be used. We can verify our selection by working the calculation backward. A #8 conductor in conduit has a 30°C ampacity of 55 amps [310.16]. At 45°C, the ampacity is corrected to 47.9 amps (55 x 0.87 = 47.9), which exceeds the requirement of 42.65 amps.

Voltage Drop Calculations. (Not an *NEC* requirement) From the combiner boxes located across the driveway from the house to the DC power center, the total conductor distance (positive and negative conductors) is 300 feet (90 m). The resistance of a #8 (8 mm^2) conductor is 0.778 ohms per 1,000 feet and for the 300 foot length, the resistance is 0.233 ohms (300 x 0.778 ÷ 1,000 = 0.233) [Ch. 9, Table 8].

At the maximum power point for the PV array, the five strings of modules with a current of 4.77 amps each generate 23.85 amps when connected in parallel in the combiner box (5 x 4.77 = 23.85). The voltage drop in each of the PV output circuits is calculated by multiplying the current by the resistance, and is 5.56 volts (23.85 x 0.233 = 5.56). In a 48 volt system, this represents an 11.6 percent voltage drop, which also represents an 11.6 percent power loss (5.56 ÷ 48 x 100 = 11.58).

Just meeting code ampacity requirements may not always yield an efficient system. A design goal (not a code requirement) was to keep the voltage drop and power loss below 2 percent. This required increasing the size of the PV output circuit conductors.

A 2 percent voltage drop can be translated into a drop of 0.96 volts on a 48 volt system (48 x 0.02 = 0.96). The allowable maximum conductor resistance can be calculated by dividing the maximum voltage drop (0.96 volts) by the current (23.85 amps). This yields 0.04 ohms for the entire 300 feet of conductor (0.96 ÷ 23.85 = 0.04). The resistance per 1,000 feet would need to be 0.133 ohms (0.04 ÷ 300 x 1,000 = 0.133) or less. This indicates that a #1/0 (5 mm^2) conductor should be used, which has a resistance of 0.122 ohms per 1,000 feet [Ch. 9, Table 8].

Using this #1/0 (53 mm^2) conductor with a resistance of 0.122 ohms per 1,000 feet yields a voltage drop of 1.82 percent when carrying 23.85 amps (0.122 x 300 ÷ 1,000 x 23.85 ÷ 48 x 100 = 1.82). A larger conductor could be used to reduce the voltage drop and power loss even further. Using a #2/0 (67 mm^2) conductor, for example, would reduce the voltage drop to 1.44 percent (0.0967 x 300 ÷ 1,000 x 23.85 ÷ 48 x 100 = 1.44). This is not a very significant decrease in the voltage drop or power loss. Also, #2/0 is larger than the terminals on some of the equipment will accept.

The one-time expense of the larger wire should be weighed against the loss in energy over the life of the system. It usually pays to install the largest conductor that can be easily connected to the devices at each end. Stand-alone PV energy has been estimated to cost as much as US$2 per kilowatt-hour over the 20 to 30 year life of a system! Why go to the trouble of eliminating hidden loads and increasing the efficiency of all other loads, or choosing a more efficient inverter and charge controller when you don't address a constant (forever) loss of PV energy (and power) due to smaller than maximum (although code compliant) conductor sizes.

Overcurrent Protection. The DC circuit breakers used in the power center for PV output circuit overcurrent protection are rated at 100 percent duty in their listed enclosures and do not require an *NEC* 80 percent derating [690.8(B)(1)EX]. These circuit breakers are mounted in the power center and protect the PV output conductors from overcurrent from possible backfed current from the batteries or the inverter. These circuit breakers must be rated to carry the continuous short-circuit current of 34 amps, determined previously when making calculations for conductor sizing (5 x 5.46 x 1.25 = 34.125). The second 1.25 factor is not used in this calculation because the circuit breakers do not have to be derated to 80 percent of rating.

Circuit breakers rated as low as 35 amps could have been used. We are using circuit breakers rated at 75 amps. They were ordered when the PV modules were going to be connected

Laying out the energy conversion equipment.

Copper Conductor Temperature Correction Factors

Conductor Temp. Rating	Conductor Types	Ambient Temperature; °C & (°F) 21–25 (70–77)	26–30 (78–86)	31–35 (87–95)	36–40 (96–104)	41–45 (105–113)	46–50 (114–122)	51–55 (123–131)	56–60 (132–140)	61–70 (141–158)	71–80 (159–176)
75°C (167°F)	RHW THHW THW THWN XHHW	1.05	1.00	0.94	0.88	0.82	0.75	0.67	0.58	0.33	None
90°C (194°F)	RHH RHW-2 THHN THHW THW-2 THWN-2 USE-2 XHH XHHW XHHW-2	1.04	1.00	0.96	0.91	0.87	0.82	0.76	0.71	0.58	0.41

For ambient temperatures other than 30°C (86°F), multiply the 30°C ampacities [310.16, 310.17] by the appropriate factor.
Source: *NEC* 2002

for 24 volts rather than the present 48 volts. These breakers protect the #1/0 (53 mm^2) conductors, which have a temperature-corrected ampacity of 148 amps—170 amps at 30°C times 0.87 correction factor for 45°C operating temperature (170 x 0.87 = 148).

The two, 75 amp circuit breakers are connected to a single, 175 amp circuit breaker mounted in the same enclosure as the battery disconnect. This 175 amp circuit breaker serves as the main PV disconnect, and is connected to the conductors going to the battery. Conductors sized at #1/0 are used to connect this breaker to the main battery circuits and to the 75 amp breakers.

Equipment-Grounding Conductor Size. For this ground-mounted PV system, *NEC* 690.45 requires that the PV array equipment-grounding conductor be able to carry a current equal to the continuous current from the modules (each set of ten), which is calculated by multiplying the short circuit current (Isc) of 27.3 amps (5 x 5.46 = 27.3) by an *NEC* factor of 1.25, which in this case yields 34.1 amps (27.3 x 1.25 = 34.1). This requires a #10 (5 mm^2) equipment-grounding conductor.

NEC 250.122(B) requires that this conductor be increased in size if the circuit conductors are increased in size for voltage drop. Circuit conductors were increased from #8 (8.4 mm^2) to #1/0 (53.5 mm^2), a ratio of 6.4 to 1. Applying this ratio to the #10 (5 mm^2) conductor indicates that the equipment-grounding conductor should be increased to about a #2 (33 mm^2) conductor. A #2 black, insulated conductor is marked on both ends with green tape and routed in each conduit containing the #1/0 circuit conductors.

Conduit Fill. "Conduit fill" refers to the number of wires of a particular size and type allowed in a particular size of conduit. There are no short-cuts or easy explanations about conduit fill. The code and all electricians handle it with numerous tables (more than 50) that are a function of the exact conductor type, exact conductor size, and the conduit material, type, and size. The *NEC* tables must be used.

We chose a 2.5 inch (64 mm) conduit to use from the PV array location to the DC power center, and it carries the four, #1/0 (53 mm^2) circuit conductors and the #2 (33 mm^2) equipment-grounding conductor. There is additional room in this conduit for using larger conductors if additional modules are ever added to the array. The conduits are run underground and beneath the concrete slab of the house from the array to the DC disconnect. The house is built on a pad made of sand so the trenching was easy.

A T will be installed near the combiner boxes at the PV array. The single, #2 (33 mm^2) equipment-grounding conductor will be spliced into two (one to each combiner box). Separate 1.5 inch (38 mm) conduits will run from the T to each combiner box.

Battery to Inverter Circuit

Conductors. The inverter has a 24 VDC nominal input and a rated AC output of 4,000 watts at 120 VAC. At the lowest battery voltage of 22 volts, the inverter efficiency is 85 percent. A maximum continuous DC input current for the inverter is calculated using the AC power output divided by the inverter DC-to-AC efficiency to get a DC power input. This DC power input is then divided by the lowest input battery voltage to get a continuous DC input current of 214 amps (4,000 ÷ 0.85 ÷ 22 = 214). An additional factor of 1.25 is used to allow for the 80 percent conductor derating required by the *NEC*. The resulting ampacity requirement is 267 amps (1.25 x 214 = 267) for the conductors between the inverter and the batteries [690.8(A)(4)].

A 90°C (194°F), 300 kcmil (152 mm^2) conductor has an ampacity of 291 amps when used in conduit and corrected for an operating temperature of 40°C (104°F) (320 x 0.91 = 291). We chose to use two, #2/0 (67 mm^2) conductors connected in parallel (four in conduit). Each of these #2/0 conductors has an ampacity of 195 amps when used in conduit at 30°C. Using these two conductors instead of the one above required that a conduit fill correction factor of 0.8 and a temperature correction factor of 0.91 be used to calculate their combined ampacity of 284 amps (2 x 195 x 0.8 x 0.91 = 284).

Conductors #1/0 (53 mm^2) and larger may be connected in parallel to increase the ampacity if they are exactly the same length and connected at each end in exactly the same manner to the same point. When large conductors are required, paralleling smaller conductors to achieve the required ampacity is common practice. Besides, the Heinemann GJ 250 circuit breaker that we used will accept no conductor larger than 250 kcmil (127 mm^2). Nearly all electricians start paralleling conductors above #4/0 (107 mm^2) because the ampacity does not go up as fast as the conductor size increases.

Terminal Temperature. Most overcurrent devices have upper limits on the temperature at which their terminals are allowed to operate. If these temperatures are exceeded, the device may be subject to nuisance trips and premature failures.

We must estimate the actual temperature of the 90°C insulated conductor when carrying actual currents to ensure that the conductor temperature is not higher than the terminal to which it is connected. This estimation is made by taking the same size conductor (2 x #2/0 in this case) and finding the temperature derated ampacity when these conductors are insulated with an insulation having the same temperature rating as the terminal (in this case 75°C).

We can look up the 30°C ampacity of the paralleled #2/0 conductors in the 75°C insulation column in Table 310-16, apply the new (75°C insulation/45°C ambient) temperature correction factor and the conduit fill factor (0.8) to get the ampacity of the cable. If the actual currents in the cable are lower than this ampacity, then we can be assured that the cable will operate below 75°C.

The actual maximum continuous current of 214 amps is less than the conduit fill and temperature-corrected ampacity of a pair of 75°C (167°F) insulated #2/0 (67 mm^2) conductors (2 x 175 x 0.8 x 0.88 = 246), so the terminals on the batteries and circuit breakers always operate below their temperature rating of 75°C.

Battery Disconnect. The battery disconnect is a 250 amp circuit breaker rated for 100 percent duty in its listed enclosure. This breaker serves as overcurrent protection for the battery cables and as a disconnect for the batteries. This circuit breaker can carry the continuous current of 214 amps and also protects the paralleled #2/0 (67 mm^2) conductors between the disconnect and the inverter. A 2 inch (51 mm) conduit is used between the inverter and the battery disconnect and between the disconnect and the first battery enclosure.

Battery String Circuits. The four, 6 volt batteries in each string are connected in series using 1/8 by 1 inch (3 x 25 mm) copper bus bars in free air that have an equivalent area of #2/0 conductors (ampacity is greater than 300 amps). The four strings of batteries (four batteries per string) are connected in parallel using high current terminal blocks with #2/0 conductors running from the common terminal block (one positive, one negative) to the ends of each battery string. The ampacity of each of these conductors at 30°C (86°F) is 265 amps in free air, which is significantly more than the 54 amps (one-fourth of the 214 amps continuous current) that they may be expected to carry.

This oversizing allows for battery aging, where one of the four battery strings may have to carry higher current than the other three strings. In fact, with an ampacity of 265 amps, the conductors in a single string of batteries could carry the entire 214 amps maximum expected continuous current.

DC Circuit Equipment-Grounding Conductors. The battery enclosures are nonconductive, so no equipment-grounding conductors are required between the battery enclosures and the battery disconnect. The battery disconnect is in a metal enclosure and is connected to the inverter with metal conduit, providing the equipment-grounding conductor. A #6 (13 mm^2) bare equipment-grounding conductor is also used between the inverter and the disconnect to provide additional insurance of good bonding.

A #6 bare conductor is used as an equipment-grounding conductor between the generator and the enclosure containing the 175 amp battery starting circuit breaker. This enclosure is also bonded to the main battery/inverter disconnect with a #6 bare copper conductor [Table 250.122].

The pump circuit uses a #8 (8 mm^2) equipment-grounding conductor—oversized from the #14 (2 mm^2) minimum requirement by *NEC* 250.122. The DC lighting circuit uses a #14 equipment-grounding conductor.

AC Circuits

Generator to Inverter. The rated continuous AC output current of the generator is 54.2 amps at 120 volts (6,500 watts) up to an elevation of 3,000 feet (915 m). At an estimated elevation of 4,500 feet (1,370 m), the output current is reduced to about 51 amps because of lower air pressure. The generator manual gives the correction factor of 0.9475 (54.2 x 0.9475 = 51).

Increasing the output current of 51 amps by a factor of 1.25 to meet code requirements yields a required cable ampacity of 64 amps (1.25 x 51 = 63.75). A #4 (21 mm^2), 90°C (194°F) conductor in conduit at 40°C (104°F) has a temperature-corrected ampacity of 86 amps (95 x 0.9 = 85.5).

Checking Terminal Temperatures. The actual generator current of 51 amps is less than the temperature-corrected ampacity of a #4, 75°C insulated conductor, which is calculated, using the *NEC* tables, to be 75 amps (85 x 0.88 = 75). So the circuit breakers protecting these conductors operate with terminal temperatures of less than their rating of 75°C.

A 70 amp circuit breaker is used at the generator to serve both as overcurrent protection for this circuit and as a disconnect located outside at the generator. The 70 amp overcurrent protection dictates a #8 (8 mm^2) equipment-grounding conductor for this circuit [250.122].

A 1 inch conduit is used between the generator and the inverter bypass switch to carry the two, #4 (21 mm^2) conductors and the #8 equipment-grounding conductor [Ch. 9, Table C-10].

Inverter Output. The continuous output of the inverter in the inverting mode is about 33 amps. That is calculated by dividing the rated inverter power of 4,000 watts by the AC output voltage of 120 volts (4,000 ÷ 120 = 33.3). In the battery charging mode, the inverter may draw up to 51 amps from the generator and send it to the house AC load center. The *NEC* 1.25 factor increases the needed conductor ampacity to 64 amps (51 x 1.25 = 63.75). A #4 (21 mm^2) conductor in conduit at 40°C (104°F) has a temperature-corrected ampacity of 86 amps (95 x 0.91 = 86).

A second 70 amp circuit breaker (part of the inverter bypass switch) is mounted near the inverter in the AC output circuit of the inverter and provides overcurrent protection and a disconnect for the AC circuit to the house AC load center. Once again, the 70 amp overcurrent protection requires the use of a #8 (8 mm^2) equipment-grounding conductor [250.122].

Calculation Process

This calculation process is lengthy, but it is necessary to achieve a safe, code-compliant, reliable, and durable system. If you have questions about the *NEC*, or the implementation of PV systems that follow the requirements of the *NEC*, feel free to call, fax, e-mail, or write. See the SWTDI Web site for technical notes and articles on installing code-compliant PV systems and frequently asked questions (and answers—of course).

Sandia National Laboratories sponsors my activities in this area as a support function to the PV industry. This work was supported by the United States Department of Energy under Contract DE-FC04-00AL66794. Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy.

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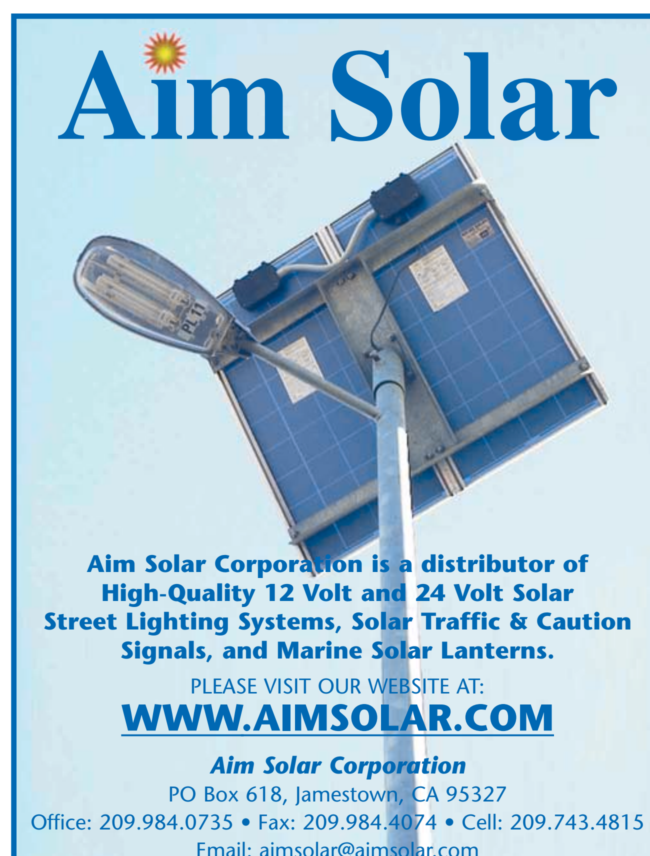

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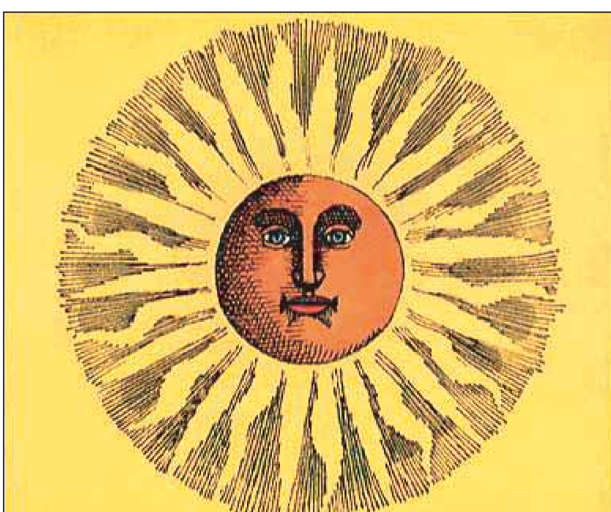

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A Cliff Hanger

Don Loweburg
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In my last column, I discussed exit fees, ownership of renewable energy credits (green tags), and interconnection fees confronting California utility customers who install solar-electric systems (net metered and not). The solar energy industry's position was presented, but as we went to press, there was no definitive outcome to report. Like a Saturday matinee serial, we closed with the solar good guys hanging over a cliff, assaulted from all directions by the evil forces of utilities in collusion with elements of state government.

One of the arguments made by CALSEIA's legal council against exit fees, as proposed in the utility advice letters mentioned last issue, was that the whole question of exit fees was being handled in the formal proceeding underway at the CPUC (Rulemaking 02-01-011). It was felt that solar generation would fare well with the commissioners since they had ruled favorably in earlier proceedings regarding solar generation (ICE-T).

Shortly after *IPP94* went to press, the CPUC issued a proposed decision (Pulsifer, 1/28/03) that was totally unfavorable to solar generation. Basically, PV was treated like any other form of distributed generation (DG), and an "exit fee," estimated to be from 2 to 5 cents per KWH, was proposed. Administrative Law Judge Pulsifer applied a fairness argument asserting that all distributed generation created a "departing load," and customers installing independent generation at their sites must cover their fair share of the state of California's financial burden. This burden was created last year when the state purchased future power contracts at prices far above current market prices. The state is attempting to recover lost revenue via utility billings. In essence, the state is colluding with the utilities in this.

Fortunately, Pulsifer's decision was not to be voted on by the PUC until February 27, 2003. Immediately following the public release of the proposed decision, an organized response was initiated. A diverse network of interests, ranging from environmental groups, solar manufacturers, solar trade organizations, installers, solar users, and the public at large began a letter and e-mail campaign opposing the imposition of exit fees on solar generation. In the public's mind, the decision on this "solar tax," as the issue came to be known, was very simple—it was unfair. How can the utilities charge for what customers do not use? My partner Cynthia made this analogy. "Imagine putting in a garden, only to later receive a bill from the local grocer for his lost profit arising from unsold groceries."

Solar Tax

Local radio stations began reporting on the issue of the "solar tax." Newspapers up and down the state ran articles such as: "PUC Proposal to Tax Solar Power Could Chill Climate for Fuel Savings" (*San Francisco Chronicle*, February 16, 2003); "Two Proposals Could Darken Solar Industry" (*Silicon Valley Business Journal*, February 17, 2003). Our business office began getting calls asking about the "bogus solar tax." Many callers, correctly or not, attributed the solar tax to Governor Davis. During a recent home show, at least half the folks who stopped asked about the solar tax. This high volume of publicity had both positive and negative effects.

The immediate negative result of the publicity was that many potential customers reconsidered the wisdom of installing PVs on their homes if they were to be taxed for doing so. Many commented on the schizophrenic behavior of state government, simultaneously giving incentives and punishing the installation of solar generation. Though the California emerging renewables program rebate resumed March 3, 2003, many people said that they will remain on the sidelines until the exit fee issue is resolved.

On the other hand, the publicity had a very positive effect. It generated thousands of letters and e-mail messages directed to the governor and the commissioners on the Public Utilities Commission. In addition, official comments rejecting the Pulsifer proposal were filed with the commission by organizations such as CALSEIA and the Union of Concerned Scientists. Also, during the month between the initial filing of the Pulsifer decision and the date scheduled to vote on it, two alternate decisions authored by commissioners Lynch and Peevey were submitted. The Lynch proposal exempted net-metered PV systems, but maintained exit fees for non-net-metered solar generation. The Peevey proposal exempted all PV systems 1 MW or smaller from exit fees, and was endorsed by CALSEIA and the solar community.

Strong Showing

On February 27, the day of the scheduled vote, over 100 people attended the meeting. Following about twenty short comments supporting the abolition of all exit fees on solar generation, the commissioners made some comments to the effect that they had never seen such a strong showing of support on any issue. At this point in the meeting, they postponed the vote and rescheduled it for their next meeting, March 13, 2003.

Regretfully, at the March 13th meeting the decision was postponed again to April 3. *Late breaking news: The vote is in; customer-owned RE systems are exempt from exit fees.*

In addition to the public and industry letter writing and media campaign for the abolition of exit fees on solar generation, backup legislation was initiated. California assemblyperson Leno introduced AB1684, which in the final section states: "Notwithstanding any other law, the commission shall not impose any cost responsibility surcharge for customer solar generation."

Though I believe we will continue to prevail in issues regarding solar distributed generation, I want to point out that inadequacies in recent legislation are the sources of these challenges. This is in no way a criticism of the hard work done by our solar lobbyist and advocates in the legislature. To get anything done, considerable dealing is required. The familiar comment regarding legislation and sausage comes to mind—you don't want to see either being made.

Lessons to Learn

However, there is value in understanding and learning from each experience. Each of the challenges discussed last issue—exit fees, interconnection fees, and ownership of renewable energy credits—were set, like land mines, within last year's "successful" solar legislation enacted in California. For example, AB58 (1 MW net metering) contained the seeds for exit fees and interconnection fees while SB1078 (renewable portfolio standard) was unclear regarding ownership of green tags. In each case, considerable cleanup activity is required later down the line.

Clearly, the road to a renewable energy future is going to be a long one. Because distributed, customer-owned renewable generation erodes utility revenue (both from generation and distribution), it should be clear that we will encounter persistent opposition from investor-owned and municipal utilities. For example, in California, our 1 MW net metering law caps new intertie installations at 0.5 percent of the state's total system capacity. Now if we are serious about renewables, we must realize that this is a crippling limitation to a true renewable future. Personally, I believe at least 20 percent of system load could be served by distributed solar energy systems (including solar thermal) in California.

In other words, we have a long way to go, and judging from the cost and effort to get this far, it will be tough. So the solar energy industry needs to be tough. We need to be tough competitors. We need to be tough politically. Those who assert that energy and politics should not mix must be on another planet—and thank god I am hearing less and less of the "win-win, let's partner with the utilities" pabulum.

Shift to a Renewable DG Consciousness

A significant shift is occurring in California. Because incentive programs are now developing a real market here, we are attracting the resources to continue expanding. This year, some major manufacturing companies have formed a subcommittee within CALSEIA. Members of the new policy committee include Kyocera, SMA, Powerlight, Shell Solar, BP Solar, Sharp Electronics Solar Division, AstroPower, Schott, Solar Depot, and SMUD. The purpose of the policy committee is to significantly increase the effectiveness of our lobbying activities at the California State Capitol and Legislature. These companies have contributed to a special fund for this purpose.

Finally we are seeing a shift in perspective at many levels of governmental bureaucracy. At the federal level, the national energy labs are conversant in the language of renewable distributed generation. State energy commissions and utility commissions are beginning to understand that they must shift their understanding away from the old paradigms of monolithic utility franchise and adopt policies fostering renewable distributed generation.

Access

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Other Stuff

Besides War

Michael Welch

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U.S. leaders have sent our country to war. Who knows, we may be at war for quite awhile. While obtaining peace should be a major objective, I don't think we can afford to ignore other important issues that are facing us.

Lots of things have been marching forward that the Bush administration helped put into action before concentrating on the war. Things have been set in motion that perhaps the public does not want. But the war has blasted these issues from media coverage, camouflaged them from the public eye, and engaged activists in a quest for peace.

ANWR

We dodged a bullet on this one in March. Members of the Senate voted 52 to 48 in favor of a bill to remove language from the Senate budget resolution that would have allowed drilling in the sensitive Arctic National Wildlife Refuge (ANWR) on Alaska's North Slope. Senator Barbara Boxer (D-CA) and Senator Lincoln Chaffee (R-RI) introduced the bill. While most votes were along party lines, four Democrats voted for drilling and eight moderate Republicans and the Independent member voted against drilling.

Please be sure to thank or spank your Senators—see Access for a link to the Senate vote record for this issue. While you are communicating with your Senators, be sure to ask them and your representative in the House to support the Morris K. Udall Arctic Wilderness Protection Act, which would finally give wilderness status to ANWR.

We are not done with the ANWR issue yet. This issue will continue to be used as a diversionary tactic so that mainstream environmental forces won't muster to defend other targets of the Bush administration. In fact, exploring in ANWR has cropped up yet again in new House energy legislation. Until we can finally take the ANWR hill by making it a wilderness area, the problem will keep cropping up.

Energy Bill Is Back

Buried way back on page 8 of section C in of your local paper, where only a bunker buster could get to it, was an announcement that the first vote on the Bush energy plan for 2003 was to take place on April 1st—no joke. The House Energy and Commerce Committee was the first to consider the Energy and Policy Act of 2003. It is expected to sail through this committee, and reach the House floor soon thereafter. Our best chance of defeating this bill will come in the Senate again this year, where the members don't seem quite as willing to give our world away to corporate exploitation.

This new bill contains a lot of bad provisions in it, just like the 2001–2002 House bill. The current bill includes funding to resurrect programs for reprocessing nuclear waste into weapons-grade plutonium. Reprocessing had been abandoned in the past because it is so difficult to do without releasing radioactive contamination into the environment, and it goes against previous administrations' goals of nuclear nonproliferation. Really, this is a bailout for the nuclear industry, which has not been able to build more nuclear power plants in the U.S. for many years. It's also a means to keep the nuclear weapons industry funded, even though we do not need more plutonium for nuke weapons.

All the critters in ANWR are safe from oil exploits—for now.

The energy bill would form a new partnership between the U.S. government and the nuclear industry by using taxpayer money in not just R&D, but in the building of new nuclear power plants for utilities and other potential plant owners. This Bush administration Nuclear Power 2010 program has the goal of at least some nuke power plants by 2010, and a total of 50 (!) new reactors by the year 2050. The bill also would reauthorize the Price-Anderson Act, which removes nearly all liabilities from plant owners in the case of a major nuclear accident.

As you might imagine, the energy bill's proposed government spending for renewables, efficiency, and conservation are a drop in the bucket compared to the corporate-friendly technologies of nuclear and fossil fuels. Though things are likely to change by the time it gets through committee and gets a final vote on the house floor, the committee version of the Energy Policy Act of 2003 can be downloaded from the Promised Files section of the Downloads area of *Home Power's* Web site.

FERC Admission—Too Little, Too Late

Yet another significant event happened recently that received little notice because of the Iraq conflict. Remember that pesky energy "crisis" that California had in 2001 and 2002? That was the one where energy companies withheld electricity and otherwise manipulated the market to gouge excessive profits from ratepayers and the state. State regulators and politicians have been trying ever since to get reimbursements from the energy companies that created these problems. It was up to the Federal Energy Regulatory Commission to determine if and how much should be refunded. Well, more than two years later, FERC finally admitted that Californians were gouged by several energy corporations, including Enron and five other firms.

California was hoping to get around US$9 billion refunded to it as a result of the overcharges. FERC ordered the companies to refund about US$3.3 billion. Unfortunately, ratepayers will not see any of that money in decreased rates, because in a related setback, FERC ruled that California owes energy companies US$3 billion for unpaid energy contracts.

FERC would not allow California to renegotiate around US$20 billion in long-term energy contracts that the state entered into while it tried to keep energy flowing and prices down, even though the state claimed that those contracts were over-inflated by the very same market manipulation that caused the overcharges. FERC maintains that if there had been ample supply, the energy companies would not have been able to take advantage of the flaws inherent in California's restructured system.

FERC is once again bowing to the corporations that have been allowed to control it. The agency feels the pressure to call for more investment in non-RE generation, so there is no way they could do anything but claim that the California problem was one of not enough supply.

And things could get worse at FERC. The Senate is expected to approve two new Bush appointments to the commission, Joseph Kelliher and Suedeen Kelly. Both are proponents of federal deregulation plans that would favor energy corporations, and remove much control from the states. Hold onto your wallets, ratepayers. Time to invest in RE.

Peace and justice.

Access

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March ANWR Senate vote record, see www.redwoodalliance.org/anwr.htm

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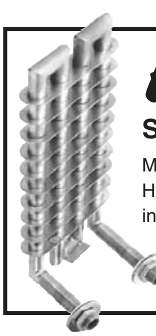

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Derivation: From Latin *semi*, half, and from Middle English *conducten*, from Latin *conducere*, to bring or lead together, to induce, to employ.

Electrical energy is transported by charged atomic particles—charges. Materials with moveable charges are called conductors. Materials that lack moveable charges are called insulators. Semiconductors can have qualities of both conductors and insulators.

The charges in conductors are very loosely bound. They behave like a "sea" of moveable charges that will flow easily. The charges in insulators are very tightly bound. It's tough to make them move.

Metals are generally good conductors, while plastic, rubber, glass, and other materials tend to be good insulators. This is why electrical wires are copper that is covered with plastic insulation, not plastic that is covered with copper. The copper lets the charges—and the energy—move, while the rubber or plastic insulation around the copper keeps the charges from flowing out and causing trouble.

Structurally, conductors have only a few electrons in the outer shell of their atoms, and they give them up easily. Insulators have atomic shells that are full or almost full, and they don't give the electrons up easily. Semiconductors are in the middle, with half-filled outer shells. Pure semiconductors are insulators (if poor ones). But with doping, and by applying some energy, their electrons can be freed, making them into conductors.

Common semiconductor materials are silicon (the most prevalent), gallium, germanium, and selenium. By adding minute quantities of other materials (called dopants) to these materials, their semiconducting qualities can be enhanced, modified, and varied.

These enhanced semiconductors can be used in a variety of ways. Applying light, heat, radiation, voltage, or other forces to a semiconductor can make it act like an insulator, a conductor, or something in between.

When they were first discovered, semiconductor materials were just a scientific curiosity. But soon many applications were found, and today these materials are critical for the operation of millions of electronic devices. Using these materials has made electronic devices faster, smaller, more reliable, and more efficient. Semiconductor devices include transistors, integrated circuits, and various types of diodes, including light emitting diodes (LEDs).

A semiconductor device in its simplest form is like a switch or faucet. External stimuli can turn this switch on, off, or somewhere in between. Before semiconductors, this function was handled by vacuum tubes. Tubes typically work at very high voltages, generate a lot of waste heat (which causes them to wear out), and are more fragile than semiconductors. A semiconductor device does the same job using less energy, and is much more durable, even though it is hundreds of times smaller. A single microprocessor chip does the job that a large building full of vacuum tubes did before the discovery of semiconductors.

Computers and other electronic devices rely on components turning on and off. This switching is essential to the logic operations that make a computer function. Semiconductors allow an enormous amount of electronic functionality to be built into a very small package. Transistors, one of the most common applications, use a tiny amount of energy to control a large amount. This is the basic principle of amplifiers and inverters.

In the renewable energy realm, semiconductor materials and devices are used in inverters, charge controllers, diodes, and PV modules. Modern inverters would be impossible without huge (large current) field effect transistors (FETs). The inverter is perhaps where transistors have most changed our industry. PVs are semiconductor devices—photo-diodes. Meters, efficient lighting, and other electronic devices rely on semiconductor materials too.

Semiconductors are basic electronic building blocks. Without them, our modern world would look very different. They have the ability to act as insulators or as conductors, and can be switched in simple and complex ways to make our toys and tools work.

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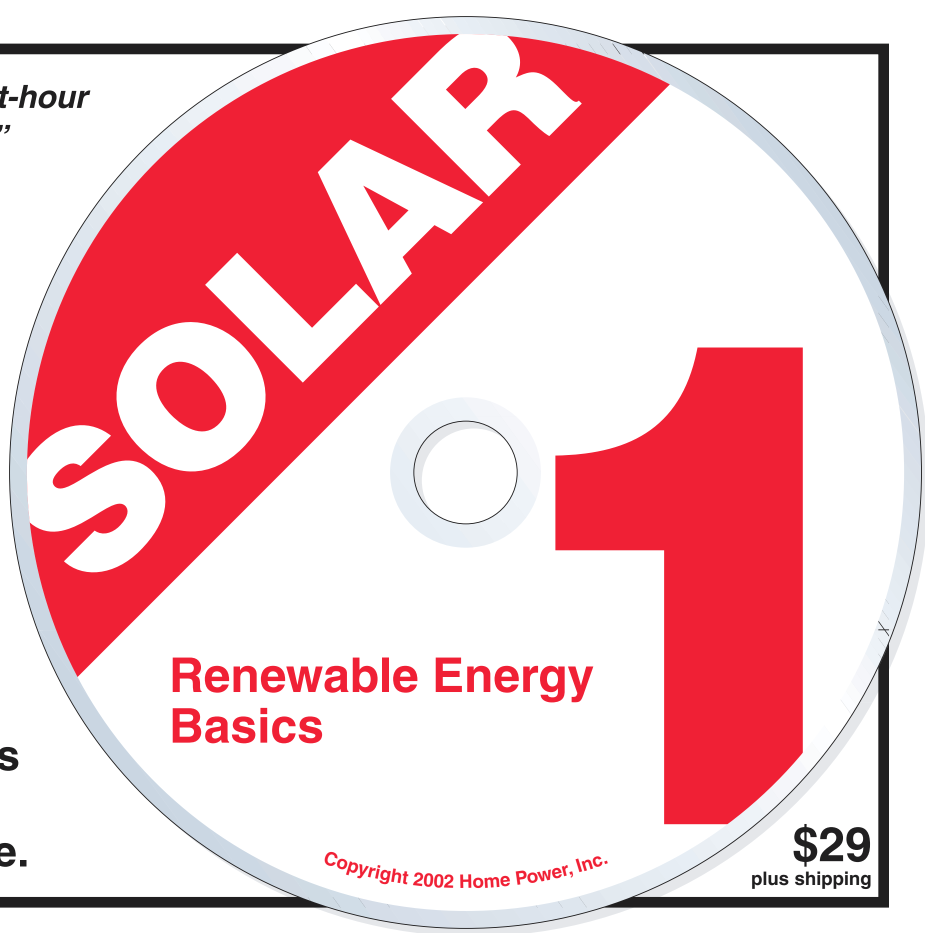

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River Writings

Kathleen Jarschke-Schultze

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By moving to the Salmon River in California in 1985, I became part of a very small, close community. After initial introductions, I was readily accepted as Bob-O's mail-order mate (see *HP22*). Everyone had heard of me. They all wanted to meet me to form an opinion, which would then be eagerly discussed with everyone else.

On the River

Bob-O lived at the Starveout Mine, halfway between Forks of Salmon and Cecilville on the South Fork of the Salmon River. Not too far from our mailbox was the 25 mile marker of the river road. To get to our cabin, you had to go across a small suspension bridge, three planks wide and ninety feet (27.5 m) long, that Bob-O had built. It was like San Francisco's Golden Gate Bridge, only smaller.

My first week at Starveout, it snowed. After I crossed over the river the first time, a foot of snow fell on the bridge. I would not cross back until the snow was gone, shoveled off by Bob-O. The bridge would sway and bounce with each person's passage. At first, whenever I did cross, I made everyone else go first so that I was the only one on the bridge. I would cross very slowly, hanging onto the waist-high suspension lines the whole way.

I became used to the bridge very quickly. Soon I could carry a full trashcan while Allen, Bob-O's young son, ran across in front of me. It's all a matter of rhythm.

Forks

Eight miles down river from Starveout was Forks of Salmon, where the north and south forks of the Salmon River combine. Located there was the post office, arguably the smallest in the U.S.; the Forks store; the Forks school; the Forest Service compound; a small, lovely, old graveyard, which is still used; and the Community Hall (the old school) with a teacherage attached. In the days of the old school, the teacher's living quarters were attached to the school. The teacherage consisted of a small bedroom, a tiny bathroom, and a living room/kitchen. Now the school board rents it out.

The suspension bridge over the Salmon River, with Kathleen and Bob-O's cabin in the background.

The postmaster of Forks was Glady. She was born in Sawyers Bar on the North Fork and had been postmaster since the year I was born, 1953. She was very curious to meet me because she had a hand in my romance with Bob-O by processing our letters for mailing and delivery. We became good friends and always shared a new joke or two whenever I was in Forks.

The Forks store held equal importance with the Postie, as the post office was called. You always went into the store to see people and talk about the latest news, even if you didn't buy anything. In the winter, there was a woodstove you could back up to for warmth before you hit the river road again.

In the summer, the Forks store had an unofficial extension at the Beer Tree. The Beer Tree was about 30 feet (9 m) high and spread its branches over a one-piece wooden picnic table and benches. The Beer Tree was across the road from the Postie and the store, at the edge of a small meadow.

In early spring, this same meadow would bloom with thousands of sun yellow daffodils. When the weather was fine, you could always find a group of locals there drinking beer or pop, or eating ice cream bars, while exchanging gossip, political opinions, gardening and automotive advice, or recipes. There was always lively conversation under the Beer Tree.

Forks School

While the Community Hall, or old school, had only one room, the new school had two. Grades K through 8 were divided between the two rooms. Kindergarten through 4th grade students were in one room, and were known as the Youngers; 5th through 8th grade students were in the other, and were known as the Olders.

The school was the heart of the Forks community. Any doings at the school became community social events, not to be missed by anybody, whether or not they had children. Halloween fairs, Christmas plays, bingo nights, music recitals, and sports events all brought the locals together. At the Halloween fairs, I was known as Madam Yarschka, gypsy fortuneteller—"Knows all. Sees all. Tells a little."

Before each school event, there would be the de rigueur bake sale. The women of the community would bring pies, cakes, breads, cookies, and such to the school where Betty Ann and Bobbie would have the difficult task of figuring

Kathleen in front of the Forks of Salmon Post Office.

out what prices to charge. This pricing dilemma was not made easier by the bachelor miners. They would be milling close to the bake sale tables so as not to miss any opportunity. As soon as the sale started, these lone men would move in and buy whole pies, whole cakes, and all the loaves of bread. Not having a woman to bake for them and not possessing the knowledge or inclination to bake for themselves, they would make the most of local talent whenever they could.

All the money from bake sales and bingo went towards the kids' annual field trips. The Youngers usually went out to the coast for the day. The Olders would travel farther and spend a day or two off the river and out in the big world.

Graduation

The Forks school graduation night was huge in terms of our social life. Anywhere from one to four Olders would graduate from eighth grade. The celebration was always held in the Community Hall, which had a small stage that the ceremony could be held on. It really was a coming of age for Forks kids. The community members had known most of these kids since they were born.

Once the kids graduated from eighth grade in Forks, they would have to leave the river and live somewhere else to go to high school. Some people had relatives out in Scott Valley or on the coast where the kids could live for their high school years. Sometimes the whole family would move off the river to keep their family intact. Sometimes they returned; sometimes they didn't. It was wrenching to everyone, in any case.

Wedding Party

When Bob-O and I got married, it was in the Forks Community Hall. Everyone from Forks, Cecilville, and Sawyers Bar came. There were even people from Somes Bar. It was a big potluck, down-home celebration. Some of our friends put on a little play, akin to a three-penny opera. Bob-O's band, the Hills Brothers, played dance music, with Petey stepping in to play bass for Bob-O. Petey, whose CB name was Ragamuffin, was a talented local musician who jammed with the band on occasion. The kids from the school sang "Watching the River Run" to us, accompanied by their teacher, Suzanne, on guitar.

I had two wedding cakes, one chocolate and the other made by my little sister, Tamra. My favorite picture of our wedding is of Edna, peeking into the door of the community hall. Edna was a buddy of Bob-O's from the old ENT tree planting co-operative (they told me it stood for "extra nice trees"), who now teaches grade school in Somes Bar. In the wedding photo, it just looks to me like she is seeing wonderful things, like Howard Carter peering into King Tut's tomb.

Our friends and family from the river are treasures beyond value.

Access

Kathleen Jarschke-Schultze is recovering from colon cancer at her home in Northernmost California. Her advice: "Get a colonoscopy." c/o *Home Power* magazine, PO Box 520, Ashland, OR • kathleen.jarschke-schultze@homepower.com

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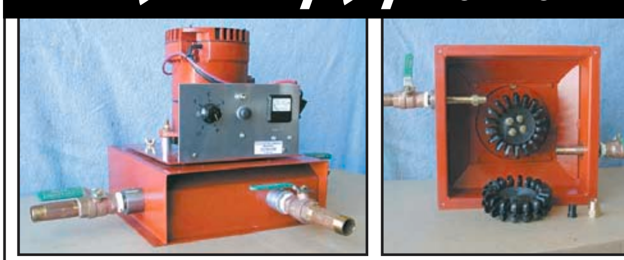

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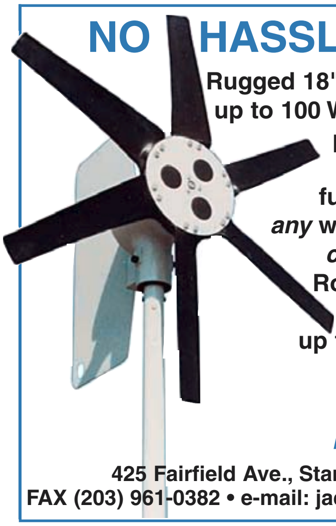

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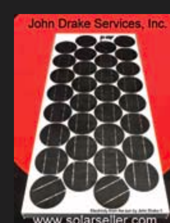

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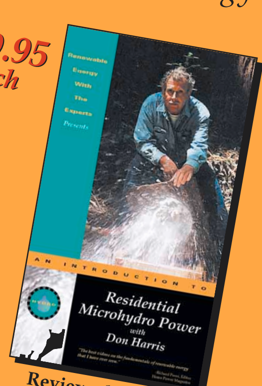

Reviewed in HP56

Residential Solar Electricity with Johnny Weiss, 48 min. Johnny Weiss is one of the founders and teachers at Solar Energy International, in Carbondale, CO.

Residential Wind Power with Mick Sagrillo, 63 min. Mick Sagrillo has installed and repaired over 1,000 wind turbines.

Residential Microhydro Power with Don Harris, 44 min. Don Harris has designed and manufactured over 1,000 microhydro power plants.

Batteries with Richard Perez, Editor in Chief and founder of *Home Power* magazine.

Solar Water Pumping with Windy Dankoff, 59 min. Windy Dankoff has been designing and installing solar-powered water pumping systems for 15 years.

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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; Hands-On PV System Installation; Solar Homes; Healthy Buildings; & Solar Energy for International Development. SóL, PO Box 217, Carbondale, CO 81623 • 720-489-3798 • info@solenergy.org • www.solenergy.org

Solar Energy International online courses: PV Design & Solar Home Design. Info: see SEI in COLORADO listings.

CANADA

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

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

Aug. 18–20, '03; SESCI 2003: 28th Annual Conf. of the Solar Energy Society of Canada; Queen's University, Kingston, ON. Info: SESCI 2003, Solar Calorimetry Lab, McLaughlin Hall, Queen's Univ., Kingston, ON, K7L 3N6 • 613-533-2591 • sesci03@me.queensu.ca • www.solarenergysociety.ca/sesci03

Alberta Sustainable House; guided tours last Sat. every month 1–4 pm, private tours available. Cold-climate features, environment, conservation, RE, recycling, efficiency, self-sufficiency, appropriate technology, autonomous & sustainable housing. 9211 Scurfield Dr. NW, Calgary, AB T3L 1V9 Canada • 403-239-1882 • jdo@ecobuildings.net • www.ecobuildings.net

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

GERMANY

Jun. 27–29, '03; RENEXPO 2003; Augsburg. International trade fair & conference on RE, energy-efficient construction. Info: Erneuerbare Energien Kommunikations und Informationsservice GmbH • Unter den Linden 15, 72762 Reutlingen, Germany • 0049-7121-3016-0 • redaktion@energie-server.de • www.energie-server.de

Oct. 9–11, '03; Hydrogen Expo, Hamburg. Exhibits, technology, & commercialization. Info: Hamburg Messe, + 49-211-687858-11 • info@h2expo.de • www.h2expo.de

NICARAGUA

Aug. 5–15, '03 (again Jan. 6–16, '04); Solar/Cultural Course. Managua. Lectures, field experience, & eco-tourism. Taught in English by Richard Komp & Susan Kinne. Info: Barbara Atkinson • 215-942-0184 • lightstream@igc.org • www.grupofenix-solar.org

SINGAPORE

Nov. 18–19, '03; Sustainable Energy Asia, & Energy Efficiency Asia. Conference. Info: Christina English • (65) 6227 6252 • cenglish@iirx.com.sg

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 • ises2003@gbg.congrex.se • www.congrex.com/ises2003

UNITED KINGDOM

Jul. 7–11, '03; Wind Power Technology Summer School; Loughborough Univ. Info: Allison White, CREST, AMREL, Loughborough Univ., Leicestershire, LE11 3TU, UK • +44 1509 223466 • A.J.White1@Lboro.ac.uk • www.crestuk.org

Jul. 11–13, '03; Self-Build Solar Hot Water workshop. Redfield Community, Buckinghamshire. Build your own & learn to install a SDHW system. Info: Low-Impact Living Initiative, Redfield Community, Buckingham Road, Winslow, Bucks, MK18 3LZ UK • (01296) 714184 • www.lowimpact.org

U.S.A.

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.

Videos. Appalachia: Science in the Public Interest; 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 • aspi@a-spi.org • www.a-spi.org

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 • www.dsireusa.org

Energy Efficiency & Renewable Energy Clearinghouse (EREC): Insulation Basics (FS142), Financing an Energy Efficient or RE Home (FS104), PV: Basic Design Principles & Components (FS231), Cooling Your Home Naturally (FS186), & 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

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 • 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. Florida Solar Energy Center • 321-638-1017 • www.fsec.ucf.edu/Ed/sw

ARIZONA

Aug. 8–10, '03; SW RE Fair. Flagstaff, AZ. Exhibitors, workshops, & speakers on solar, wind, biomass; green building, & alternative vehicles. Greater Flagstaff Economic Council • 928-526-9317 or 800-925-0583 • swref@gfec.org • www.gfec.org/swref

Tax credits for solar in AZ. ARI SEIA • 602-258-3422 • www.azsolarindustry.org

Scottsdale, AZ. Living with the Sun; free energy lectures, 3rd Thurs. each month, 7–9 PM, City of Scottsdale Urban Design Studio. Dan Aiello • 602-952-8192; or AZ Solar Center • www.azsolarcenter.org

CALIFORNIA

Aug. 23–24, '03; Solfest RE & Sustainability Fair; Exhibits, workshops, music, speakers; Hopland, CA. 707-744-2017 • www.solfest.org

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

Nov. 15–19, '03; EVS 20, International EV Symposium & Expo; Long Beach. Info: www.evs20.org

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.state.ca.us • www.consumerenergycenter.org/erprebate

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

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COLORADO

June 27–29, '03; RE Now!, 6th Annual Colorado RE Conf.; Montrose, CO. Workshops, energy policy, rural power, building, education, guest speakers. Info: Colorado RE Society, 303-806-5317 • info@cres-energy.org • www.cres-energy.org

Sep. 13–14, '03; Rocky Mountain Sustainable Living Fair; Ft. Collins, CO. RE & other sustainable living topics. Workshops, keynotes, demos, vendors, music, kids' activities, food, more. Info: Rocky Mountain Sustainable Living Assoc. • 9860 Poudre Canyon Rd., Bellvue, CO 80512 • 970-224-2209 • kellie@poudre.com • www.sustainablelivingfair.org

Aug. 4–8, '03; RE Youth Camp; Paonia, CO. Ages 15–19. See below for SEI contact info.

Carbondale, CO. SEI hands-on workshops & online distance courses. PV Design & Installation, Advanced PV, Solar Water Pumping, Wind Power, Micro-hydro, Solar Hot Water, Biodiesel, Alternative Fuels, Solar Home & Natural House Building, Advanced Straw Bale Construction, RE for the Developing World, Politics of Energy, Utility Interactive PV, Women's PV Design & Installation, Women's Wind Power, Women's Carpentry, PV Distance course, & Solar Home Design distance course. Solar Energy International (SEI), PO Box 715, Carbondale, CO 81623 • 970-963-8855 • sei@solarenergy.org • www.solarenergy.org

ILLINOIS

Aug. 9–10, '03; 2nd Illinois RE Fair; Ogle County Fairgrounds, Oregon, IL. Info: 815-732-7332 • sonia@essex1.com www.illinoisrenew.org

IOWA

Sept. 6–7,'03; Iowa Energy Expo, Prairiewoods Franciscan Center, Hiawatha, IA. Info: IRENEW, 563-875-8772 • www.irenew.org

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

KENTUCKY

Mt. Vernon, KY. Appalachia: Science in the Public Interest. Projects & demos in solar electric, solar hot water, gardening, sustainable forestry, more. ASPI • 50 Lair St., Mt. Vernon, KY 40456 • 606-256-0077 • solar@a-spi.org • www.a-spi.org

MASSACHUSETTS

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

MICHIGAN

Urban Enviro workshop, Ferndale, MI. Third Wed. 7–9 PM. Sustainability, energy efficiency, RE, & consumer issues. Free. Mike Cohn, 22757 Woodward #210, Ferndale, MI 48220 • 313-218-1628 • ECadvocate@aol.com • www.hometown.aol.com/ecadvocate

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

MINNESOTA

'03 St. Paul MREA Workshops. Basic PV & Site Audit: Sep. 18–19, Intermediate PV: Sep. 20–21, PV Install: Oct. 14–18. Info: see MREA listing in WISCONSIN

MONTANA

Jul. 12, '03; Sustainability Fair 2003; Depot Rotary Park, Livingston. Exhibitors, workshops, on-site "sustainable office," RE, music, kids' programs, & green products. Info: Corporation for the Northern Rockies • 406-222-0730 • info@northrock.org • www.northrock.org/fair.html

Aug. 18–22, '03; Biodiesel Fuel; Missoula, MT. Make biodiesel & a biodiesel processor. Vehicle conversion & straight vegetable oil covered. Info: see SEI in COLORADO listings. Local Coordinator: David Max • zenfuel@yahoo.com

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 • www.sagemountain.org

NEW MEXICO

Aug. 17–Oct. 25, '03; Certificate for Earth-based Vocations. Santa Fe, NM. 10 wk. internship for professionals about systems approaches for designing human environments, including RE. Ecoversity, 2639 Agua Fria, Santa Fe, NM 87501 • 505-424-9797 • apilling@ecoversity.org • www.ecoversity.org

Sep. 29–Oct. 3, '03; Natural House Building workshop; Kingston, NM. Build with earth & straw. Hands-on sessions: straw bale, adobe, pressed block, rammed earth, cob, & natural plaster. Info: see SEI in COLORADO listings.

NEW YORK

Sep. 12–13, '03; ReCharge Energy Expo & Conf.; Bear Mt., NY. Displays, demos, & discussions on RE & efficiency. Info: Pace Energy Project • 914-422-4415 • mgolden@law.pace.edu • www.rechargeexpo.com

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

NORTH CAROLINA

Saxapahaw, NC. How to Get Your Solar-Powered Home. Call for dates. Solar Village Institute • PO Box 14, Saxapahaw, NC 27340 • 336-376-9530 • info@solarvillage.com • www.solarvillage.com

OKLAHOMA

Jun. 19, '03; 2003 Oklahoma Wind Power & Bioenergy Conf.; Norman, OK. Utility scale wind, small wind, bioenergy, & business. Info: OK Wind Power Initiative • 405-447-8412 • windgirl@ou.edu • www.seic.okstate.edu/owpi

OREGON

Jul. 21–24, '03; Pre-SolWest hands-on solar installation class, John Day. See below for EORenew info.

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., 10 weeks, 14 interns per quarter. Aprovecho Research Center, 80574 Haxelton Rd., Cottage Grove, OR 97424 • 541-942-0302 • apro@efn.org • www.efn.org/~apro

PENNSYLVANIA

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

Jun. 7, '03; RI Sustainable Living Festival & RE Expo; Coventry, RI. Exhibits, workshops, music, kids' activities, vendors. Apeiron Inst. • 451 Hammet Rd., Conventry, RI 02816 • 401-397-3430 • info@apeiron.org • www.apeiron.org

Coventry, RI. Apeiron Institute for Environmental Living. Ongoing workshops & demos on sustainable living. Apeiron Inst. • 451 Hammet Rd., Conventry, RI 02816 • 401-397-3430 • info@apeiron.org • www.apeiron.org

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

TENNESSEE

Summertown, TN. Kids to the Country: nature study program for at-risk urban TN children. Sponsors & volunteers welcome. KTC • PO Box 51, Summertown, TN 38483 • plenty1@usit.net • www.plenty.org/KTC.htm

TEXAS

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 • ases@ases.org • www.ases.org

Sept. 26–28, '03; RE Roundup & Green Living Fair, Fredericksburg, TX. Info: 877-3ROUNDUP • www.theroundup.org

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

Houston Renewable Energy Group: Call for meetings: HREG • hreg@txses.org • www.txses.org/hreg/

VERMONT

Jul. 12–13, '03; SolarFest RE festival; Green Mt. College, Poultney, VT. Solar stages, workshops, vendors. Info: 802-235-2866 • www.solarfest.org

Aug. 9, '03; RE for Your Home; Fairfield, VT. Hands-on workshop, incl. off-grid solar, wind & hydro. Tour a PV system, theory, & practical help. Info: Flack Family Farm • 5455 Duffy Hill Rd., Enosburg Falls, Vermont 05450 • 802-933-6965 • sarahf@globalnetisp.net • www.flackfamilyfarm.com

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

Sep. 18–21, '03; NW RE Festival; Whitman College, Walla Walla, WA. Keynote Christopher Flavin, tours of Stateline Wind Energy Center, & RE & efficient homes. Sessions, workshops, kids' activities, exhibits, & music. Info: PO Box 1501, Walla Walla, WA 99362 • 509-525-8479 • info@nwrefest.org • www.nwrefest.org

Oct.11, '03; Intro to RE, Guemes Island, WA. Solar, wind, & microhydro for homeowners. Info: see SEI in COLORADO listings. Local coordinator: Ian Woofenden • 360-293-7448 • ian.woofenden@homepower.com

Oct. 13–18, '03; PV Design & Install Workshop, Guemes Island, WA. System design, components, site analysis, system sizing, & a hands-on installation. Info: see SEI in COLORADO listings. Local coordinator: Ian Woofenden • 360-293-7448 • ian.woofenden@homepower.com

Oct. 20–25, '03; Wind Power Workshop with Mick Sagrillo, Guemes Island, WA. Design, system sizing, site analysis, safety issues, hardware specs, & a hands-on installation. 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 workshops: Women's Wind Power: Jun. 8–14 in Custer; Advanced PV Installation: Jun. 11–17 in Central WI; Straw Bale Construction: Sep. 5–7 or 12–14 in Sarona; Intro to RE Sep. 13 in LaCrosse; Community Micro-Grid Wind Install Sep. 14–20 in Amherst; Solar Space Heating, Wind System Install, PV Installs, Straw Bale, Masonry Heaters, Sustainable Living. MREA, 7558 Deer Rd., Custer, WI 54423 • 715-592-6595 • mreainfo@wi-net.com • www.the-mrea.org

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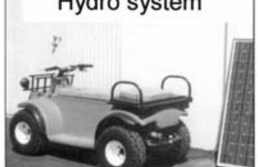

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So it all boils down to a very simple choice. Pay the piper now or pay the piper later. I would suggest that paying now is the wiser choice. It will, in the long run, prevent much chaos and hardship. Society and the planet will benefit. Make the right choice.

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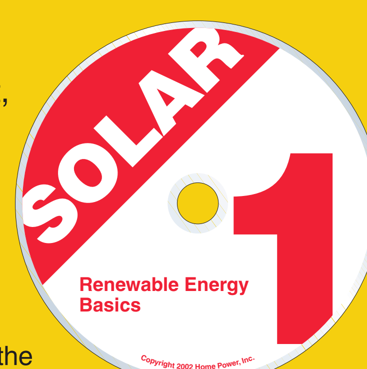

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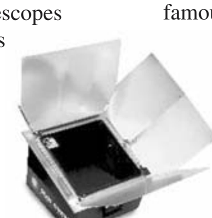

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The Next Generation of Solar Bozos

Dear *HP* magazine, It was just over two years ago when I constructed a micro-sized solar and wind energy system that has successfully and reliably provided basement lighting in our home (see *HP82*, page 32). The purpose of this investment was primarily education—for me to learn about the technology and for my family to learn to use it properly. It's been fun for everyone—fuses and meters for me, lighting for all of us, and a switch-and-light toy for the kids.

As we prepare to relocate to a new home, the planning has begun for establishing a more permanent solution. And with this comes a surprise—a young volunteer who has asked to help install the new system when it is time. To prove her point, she asks for her own turn to practice whenever the toolbox appears. The picture should speak for itself. Four years old now, she does not remember a time in her life without a solar panel, a wind generator, and battery care.

For me, making the step into renewable energy has taken a lot of careful thought and consideration. For her, she doesn't understand why the neighbors don't have a solar panel. The implication has vast, if not longer term potential. What if several of her friends feel the same way when they are the ones making the decisions?

Call me naïve, but only now have I realized that we have the responsibility to share our enthusiasm beyond just the comfortable circles. While it may prove difficult to overcome many of the barriers facing renewable energy today, we all know what seeds do over time. Mike Lew • thelewfam@earthlink.net

Mike's daughter is handy with a soldering iron, and wants to have her own RE system one day.

Impact

Dear Mr. Perez, I donated a one-year subscription of your publication to several libraries a couple of years ago. One of those libraries is located in an outlying rural area in Washington. I had a chance to visit the library this week, and found out that they had renewed the subscription on their own, without any contact from me, for a second year after the initial donated subscription ran out.

Also, I noticed a set of solar-electric panels on a house near the library that were not there on my prior visit. I do not know how many homes located on the remote side roads may have started using renewable energy or found ways to conserve energy, after the owners read your publication at the library. So your publication seems to be having an impact.

Several years ago, I donated an anonymous subscription to a distant relative who was planning to build a remote cabin. He was going to use diesel generators for power. I found out from another relative that he is now using solar power for the generation of electricity. I believe that the donated subscription helped change his mind about using solar energy. A small investment of donating your publication can generate large returns. Best wishes, Anonymous

Solar Hot Water Retrofit

I am planning to install a solar hot water system on our two-story, two-unit building in urban Burlington, Vermont. The solar hot water panels are likely to be free from a friend. The plumbing is not. The big question in my mind is how to plumb the hot and cold lines through the roof (it is a standard asphalt roof that was stripped and redone last year) and then through the second floor apartment to plumbing chases from the second floor to the basement. The water heaters are in the basement. We live on the first floor. Is there an *HP* article that describes this kind of thing? Are there nationwide standards about where plumbing pipes can go and where they can't? Obviously, I don't want to plumb them through an exterior wall. What about a chimney chase or a waste pipe chase? Do I need to build another plumbing chase in the second floor to achieve my goal? Thanks for your help, Ben Gordesky, Burlington, Vermont • turtleisle@pshift.com

Hi Ben, Your question is very timely. In HP94 *and in this issue, you'll find an article on SDHW installation basics. Many of your questions are answered there, particularly with respect to roof penetrations. Use a roof jack to penetrate the roof with the pipe. Available at most home centers, it has a sheet metal base with an EPDM or neoprene jacket on top. The sheet metal base slides under the shingles above, and over the shingles below. Screw it into the roof and cover the screw heads with plastic roof cement. The pipe passes through the neoprene jacket and makes a weather-tight seal.*

Supply and return pipes definitely do not belong in exterior walls, as you know. Getting them into interior walls is tricky to impossible unless it is new construction. It is usually easiest to pass them through a closet or some other inconspicuous place. Build a chase around the pipes where there are aesthetic considerations.

Since you will be insulating the pipes, you should keep them well away from chimney flues. If you have access and sufficient room in a chase containing a waste pipe, that may be a good option. You should check with a local mechanical/plumbing contractor or inspector to see if any local codes apply. Ken Olson • sol@solenergy.org

World Trade Center Suggestion

To the engineers and designers of the new World Trade Center structures, As I look at the two final selections for the World Trade Center replacement, I think back to Bush's comment about development of a fuel efficient automobile, and I wonder about America's need and goal of achieving a vision of eliminating our dependence on foreign oil and air-damaging fuels.

Here we see two huge spires pointing toward and into the sky, and there is no display of what an incredible opportunity the advancement of solar energy is! My suggestion, if anyone is *really* serious about reducing our dependence on oil, would be to cover those towers with PV panels. Top the roof with wind generators! Generate enough electricity to reduce NYC's dependence on foreign oil and environmentally damaging fossil fuels! Power as much of NYC with the sun and the wind as possible, and make a statement to: the world, our President, the terrorists who hold America hostage, and the citizens of America that solar energy can power our country! Thank you! Cliff Taylor • Finergysys@aol.com

Solar Panels

Dear Editor, I need some clarification on the following. Are solar panels and photovoltaics the same? If so, how is each used and what are their functions? If not, how do they differ and which one is more beneficial (cost vs. output). I am a newbie to all of this, and I am educating myself to find the ideal "home power" for my need. Thanks! Paul Sertic, Stoney Creek, Ontario, Canada • wildfowlhunting@sympatico.ca

Hi Paul, The term "solar panels" is confusing and inexact, in my opinion. It's hard to know just what the speaker means. There are two very different solar energy technologies that fall under that general phrase—solar heating panels and solar-electric panels.

Solar heating panels include various kinds of collectors that heat water or air using the heat from the sun. They can be used for space heating or domestic water heating. It would be clearer if we called these "solar thermal panels." They are also often called "solar collectors."

Solar-electric panels include crystalline and film technologies that make electricity from sunlight (not heat—they actually work better when they are cool). These are semiconductor devices with no moving parts. They are technically called "photovoltaic modules," and abbreviated as "PV." Calling them "solar-electric panels" leaves no confusion.

Solar thermal panels are generally thought to be more cost effective than solar-electric panels. But of course, the two technologies have very different functions—one captures the sun's heat and the other uses the sun's light to generate electricity. Regards, Ian Woofenden • ian.woofenden@homepower.com

What the Heck!

I really appreciate all the effort you have put into your magazine. I especially appreciate the guerrilla solar and homebrew articles. The letters to the editor give us an insight to others' thoughts and problems. The new *What the Heck?* feature seems to be a good idea. Although I've had a small PV setup since the great NE ice storm of 1998 (no utility electricity for 26 days), there are still some terms I'm not familiar with, such as the non-islanding inverter. Thanks for all you hard work Richard, and the rest of the gang too. 73 de Tim Yeatman, VA2TPY • tyeatman@aei.ca

SDHVO

Since my interest in biodiesel started, I never liked the fact that a lot of people making biodiesel were using grid electricity to heat the vegetable oil. I wondered if the environment was getting a net benefit from this. Regardless of the actual answer, I decided to try to heat my waste vegetable oil using solar means. I managed to pick up two 3 by 8 foot Novan solar collectors for US$55 each, which I thought was pretty good. I am using only one of the collectors in my system. I constructed my solar loop using the design in *HP89* (Solar Hydronic Space Heating), without a lot of the bells and whistles.

Once I finally got the system together, I tested it and it seemed that the pipes weren't getting that hot. I could easily put my hands around them. I know a temperature gauge would be a lot more accurate than my hands, but I am already way over budget with this contraption. I am using a March cast iron circulation pump, which I was told pumps at about 4 gpm. Is this too fast? My heat exchanger is a single wall immersion in the oil. It is actually two, 3 foot sections of baseboard for hot water heat. I am testing it right now with 25 gallons of water and there seems to be very little temperature gain in the water.

Am I being unrealistic with this system? Do I need to use both panels? And here's a wild question... Can I run straight vegetable oil through the panel to heat the oil or am I likely to start a fire? Any help you could give on this setup would be greatly appreciated! Thank you. Dan Kostenbader, Denver, Colorado • dan@wellrooted.com

Dan, Not knowing the actual starting and finishing temperatures of the 25 gallons of water, I am going to enter the realm of speculation. Since you almost have a 1:1 ratio, 1 gallon of water to 1 square foot of panel, a clear sunny day in Denver should raise the water temperature by about 80 degrees. I'll spare you the math. If this is not happening, the heat is not getting out of the panel.

Possible causes are a physical blockage of flow, air in the collector loop making the pump cavitate, creating a no-flow situation, and a delaminated absorber plate (detached from the small riser tubes Novan used). If this latter happened, the absorber would get hot but would not conduct the heat to the fluid. Novan made a good product and this would be rare, but still possible. All three of these problems would put the panel under stagnation and the glass glazing will get very, very hot. If that is the case, it won't take you long to check. Your 4 gpm is not contributing to this problem.

Pumping the oil directly into the panel will improve performance by getting rid of the heat exchanger. The problem is the oil may attack the rubber seals in the pump or flange gaskets, if they exist, and it may not. Just a heads up on that. Give some thought to setting it up so that the oil thermosyphons. I don't know the flash point of this oil, but I seriously doubt that fire is a concern. Good luck. I need some fries—gotta go. Smitty, AAA Solar Supply • smitty@aaasolar.com

Easy Energy

Thanks for a great magazine! It's a great source for planning our future fully RE home. More DIY for those of us with limited technical know-how is always appreciated! Renewable energy should also be marketed as a patriotic duty to make our country free and independent from foreign energy sources. Until we adopt these technologies, we cannot accomplish this. Individual freedom from "tyranny" will not be achieved until we are free from the utility companies' grasp. We should be able to adopt RE without having to become "minimalist" or losing the comforts we enjoy in a technologically advanced society. Don't forget that one of the purposes of advancements has always been to ease and enhance our lifestyles, not detract. Go *Home Power!* Bernie Cook, La Center, Washington

Energy for Food

Dear *Home Power*, When we think of the terms renewable energy and energy conservation we usually think of solar electricity, wind power, and electric and biofueled vehicles. How about the energy of food? On average, the food that Americans eat travels 1,300 miles before it reaches our mouths. The industrialized food production system in the United States uses 10 to 20 times the amount of energy as locally produced small scale farming (conservative estimate). Inefficient use of water, production and distribution of synthetic fertilizers, pesticides and herbicides, growing crops not suitable to local environments, as well as processing, packaging, and transporting foods all contribute to the massive energy consumption of our current eating habits.

A great way to save energy and reduce the amount of fossil fuels each of us require is to eat local, organically grown, whole foods as frequently as possible. Grow a garden, shop at farmers markets, ask your local grocery store to carry local foods, or join a CSA (community supported agriculture) group. By eating closer to home, we can all make use of our local renewable sun, wind, and water; decrease the fossil fuels required to get our food on the table; and make sure our dollars stay within our communities.

For more information:

Local Harvest • www.localharvest.org • Nonprofit organization publishing a nationwide directory of small farms and farm products, food cooperatives, and CSAs.

Backyard Organic Gardening • www.backyardorganic gardening.com • Comprehensive guide to backyard organic gardening; including information on composting, planting, and maintaining your garden. Mark Colby, Paonia, Colorado

Biofuel Generator?

I am very interested in renewable energy, but I don't have the resources to run a photovoltaic system. But I was reading an article on biofuels in your latest issue. Is it feasible to use biofuel and a diesel generator? Would it be a worthwhile path to pursue? Terance Brown, Memphis, Tennessee

Hello Terance, A biofuel, such as 100 percent biodiesel, is a viable form of renewable energy. While you would still be putting carbon dioxide into the atmosphere, at least the carbon cycle is short—a year instead of hundreds of thousands of years.

Most of us who moved off-grid decades ago rapidly discovered that, as a prime mover for an independent system, generators have some major problems. They are expensive, high maintenance items, and they are noisy. Over the life cycle of a generator, it will produce energy at between US$0.75 and US$1.25 per KWH. This price is very high—the most expensive form of pure RE is PV power and it comes in at less than US$0.25 per KWH. Maintenance is a cost/time issue—100 hour oil change intervals and an engine lifetime of around 15,000 hours before a major rebuild will eat up both money and time. The noise issue can be moderated with a liquid-cooled generator (the water jacket reduces engine noise), a good muffler, and a generator shed designed to trap the sound inside.

Having said all this, biodiesel can be burned in any conventional diesel generator. The only possible modification is the fuel lines, but on newer generators, these will withstand biodiesel, since they are now made of nylon or plastic and not the rubber that was used in the past. Richard Perez • richard.perez@homepower.com

A Ton of CO_2

I'm glad Mick Sagrillo asked, "How much is a ton of CO_2?" It's one of those ethereal concepts that tend to be only useful in comparisons. Dan Ihara's response was educational in that it pointed us toward the importance of the carbon cycle in the fossil fuel burning equation. But Dan didn't answer Mick's question. It's been my question too for some time, and Dan's response enabled me to research an answer.

The density of dry ice is 1.56 (water = 1). The weight of a cubic foot of water is 62.5 pounds. A cubic foot of dry ice weighs 1.56 x 62.5 = 97.5 pounds. The number of cubic feet in a ton of dry ice is 2,000 ÷ 97.5 = 20.5 cubic feet, about a 4 x 5 x 1 foot block. That's what a ton of frozen carbon dioxide looks like. Of course, it's not frozen when it leaves our exhaust pipes. The expansion ratio of frozen carbon dioxide to gaseous carbon dioxide is 845. Thus, a ton of carbon dioxide gas is 845 x 20.5 = 17,323.5 cubic feet, about a 46 x 46 x 8 foot space—the equivalent of the first floor of a 2,100 square foot ranch house in the suburbs, or the insides of 962, eighteen cubic foot Maytag refrigerators, or the passenger compartments of 195 Toyota Priuses, or... Dan Menzel, Stevens Point, Wisconsin • djandpj@wctc.net

Big Array!

Dear *Home Power*, Have you heard of this? On the property just to the south of where I live in Prescott, Arizona, Arizona Public Service Co. is building the largest solar-electric farm in the world. The pictured array is one of thirteen to be built. The rest are panels mounted on horizontal racks that rotate from east to west. Sincerely, Henry Schrieber • henrysch@mac.com

Questioning Biodiesel

Dear *Home Power*, I generally believe that the technologies promoted in *Home Power* are sustainable and good for the planet. A good test of sustainability is to ask, "If large numbers of people switch to using this technology, will it improve our environment?" I think biodiesel fails this test and is just a plain bad idea. People who promote small-scale home production of biodiesel are no doubt sincere and well intentioned. But I fear we will be worse off than we are in our current petroleum-based fuel economy if biodiesel becomes our primary motor fuel.

On the surface, biodiesel looks like a good way of making use of a waste product, restaurant fryer fat. However, according to a USDA report on biodiesel and Department of Energy figures on diesel fuel use, we could only meet less than one percent of current U.S. diesel fuel demand for transportation if we turned the country's entire waste fryer fat into biodiesel. A serious transition to biodiesel would depend on large-scale increases in production of soybeans and other oil crops. And I mean large scale. If we diverted all the current oil plant production in the U.S. to biodiesel, it would only meet 13 percent of our diesel fuel demand.

The scenario of a biodiesel future really scares me, as the widely predicted shortages of arable land and fresh water in this century do not even take biodiesel production into account. A world where most of our transportation energy comes from crops will make our existing petroleum-based system look downright utopian. When Americans' cars and poor nations' children compete for the same corn crop, guess who wins? And agribiz farmers who are already sucking our rivers dry will wield even more clout when we Americans depend on their crops to fill our fuel tanks.

Even the small-scale use of restaurant fat as a biodiesel feedstock is a flawed idea. Nearly all of this "waste" is already being recovered to make products such as soap and animal feed. If these industries get pre-empted by biodiesel, they'll just turn to petroleum or "virgin" agricultural sources, so there's no net gain in terms of waste diversion or resource conservation.

Biodiesel also worries me for its genetic engineering implications. The giants of biotech love biodiesel, because it potentially means a huge new market for soybeans, the leader in genetically engineered cash crops. Biodiesel has already been largely co-opted out of the hands of the small-time entrepreneurs who dreamed of breaking the oil companies' monopoly on transportation fuel.

Home production of biodiesel looks to me like an environmentalist's nightmare. I'm sure that folks like *Home Power* contributor Scott Durkee are competent and responsible, but the homebrewing process Scott describes in *HP93* is not something I'd like to see happening in garages across America. As he makes clear, methanol and lye are dangerous chemicals, even more so when combined. Frankly, I don't trust most people to handle these materials safely. Widespread do-it-yourself biodiesel production would be like having a meth lab in every home—yuck!

I also question biodiesel advocates' claim that their fuel beats the competition on emissions. A study by University of California Riverside researchers published in *Environmental Science and Technology* (Vol. 34, No. 3) found that biodiesel as compared with conventional diesel was substantially higher in particulates and about the same or only slightly better in other pollutant levels. And of course conventional diesel is much worse than gasoline (our current fuel choice for most personal transportation) in particulates. Biodiesel means dirtier air.

We environmentalists need to keep pushing government and industry (and ourselves as consumers) for more efficient cars, better public transit, community designs that don't require cars to get around, and renewable energy development. But I'm convinced that biodiesel is not a road we should drive down. Sincerely, Richard Engel • chard_e@yahoo.com

Hi Richard, I think that you have some very good points in your letter and I would like to thank you for taking the time to share your thoughts with Home Power *readers. The field of renewable energy is so new, and growing so quickly that we need all the input and perspectives we can get!*

I should start by saying that I don't believe there is a panacea for the global energy problem. I believe that the *solutions to the world's growing energy needs and the increasing problems of pollution and global climate change are many and varied and include using the energy of the sun, the wind, falling water, biomass, geothermal, and yes, vegetable oil, among others.*

Unlike petroleum oil, vegetable oil is renewable—and therefore sustainable. I disagree with your statement that ''a good test of sustainability is to ask: if large numbers of people switch to using this technology, will it improve our environment." As I said, there are many solutions to our energy needs. Depending on where you are, what you need, what you have, and what you're willing to do, there is probably a sustainable energy source.

One thing I know for sure: petroleum oil will run out. And until it does, it will cause pollution when burned, disaster on the beach when spilled, and war when it's ''under their desert." For these reasons, I believe that we need to move away from fossil fuels to cleaner and more sustainable alternatives.

You also wrote about arable land and water shortages as we try to produce more and more vegetable oil to satisfy our needs. You are right again. That's one of my concerns, too. Long before oil runs out, we humans will experience a serious water shortage. The next big war may well be fought over fresh water.

But as with energy use, our water use practices must evolve. With increasing populations and climate changes that cause droughts and floods in odd corners of the globe, we need to examine our water use very carefully.

Fortunately, soybeans are not the only source of usable oil. In his book From the Fryer to the Fuel Tank, *Josh Tickell describes algae that produces oil. He writes, ''According to research funded by the DOE, algae could produce more than enough oil to fulfill U.S. diesel fuel needs." There is much information in his book about oil production. Remember, vegetable oil—or algae oil—can be produced in one season on a farm, whereas petroleum oil requires millions of years underground!*

This is another example of the many small solutions to the one big problem of energy production and consumption. By using our ingenuity and our inventiveness, we can and will come up with new ideas, new technologies and products—like photovoltaic panels!—that all help to solve our energy needs.

As far as your claim that biodiesel pollutes more than petroleum diesel, I haven't read the study you cite, but everything that I have ever read on the subject supports the idea that the pollution levels at the tail pipe drop dramatically once biodiesel is introduced.

I've been burning biodiesel for the past 9 months and personally I prefer the smell—and the sensation—of biodiesel much more than petroleum diesel. To me, it feels like my car doesn't pollute at all, though I know that it does produce some pollutants, like nitrous oxide, for example.

About the danger involved in making your own fuel, well, again, you have a very good point. I don't like the way you connect it to meth labs, but there are certainly some hazards involved in handling methanol and lye—and even vegetable oil. (Oily rags can spontaneously combust if not handled properly.)

But does that mean that we should categorically dismiss homemade biodiesel? When caution is exercised and care taken at every stage, anyone can make biodiesel safely—and I would encourage them to do so. Because every gallon of fuel—energy—that we make from renewable sources is one gallon that we don't have to pump out of the ground halfway around the world, ship, refine, truck, store, and burn.

I like your vision of a sustainable community: "more efficient cars, better public transit [electric?], community designs that don't require cars to get around, and renewable energy development." But in the meantime, every little bit helps. Let's keep up the good work! Scott Durkee • Vashon Island, WA

Happy with Exeltech

I wanted to let all of the readers of *Home Power* know of my great experience with the folks at Exeltech. I purchased an XP1100-12 sine wave inverter from one of your advertisers way back in 1999. I didn't really get it installed until the summer of 2000. At that time, I noted that the output voltage was varying enough that all of the lights running on the inverter were flickering somewhat. Being the lazy soul that I am, I pretty much ignored it other than to ask others about theirs, and of course, theirs didn't do this. In the summer of 2002, the inverter failed due to shorted output MOSFETs. I finally got around to replacing them in November and decided to e-mail Exeltech to see what the repair would cost and if they had seen any units with fluctuating output. I also gave them this history (including the 1998 manufacturing date code). Derek Frank in tech support replied:

> *There is a flat rate of $100, to repair your unit. You stated that the inverter has not been working properly from the start, so I will gladly be happy to waive the repair charges and repair your inverter at no charge to you. I need some information to start the process on my end, if you decide to let us repair it.*

Of course it took me another two months to follow up on this astounding offer, but sure enough, it's back and installed with a $0 invoice to show for it—with rock solid output now, I should add. It's been running for two weeks now with only one outage yesterday (my Square-D, 120 amp input breaker tripped when my daughter added an iron to the load.) I flipped the breaker back on, reduced the overload, and am now reporting on how great folks exceed our greatest expectations. Sincerely, Mike Nash • mikenash@mindspring.com

Sensible Housing

Dear *Home Power*, I liked your piece about looking down the barrel (*HP93*). Being self-sufficient works for me. Back in about 1981, a college paper did an article on building a small holdover spot for trapping. It had a foot of insulation. You could heat it with body heat and a candle. We should make our houses with that much insulation. Or what about building more in-earth homes? I talked to one guy who built one, and his heating bill was US$34 for the whole year.

I think there are too many regulations and restrictions. There's a lot of government discrimination keeping the poor, poor by not allowing the size of house they want to build. Thank you, David Graham, Milwaukee, Wisconsin

Hydrogen Production

With your inspiration, I have decided to build a hydrogen production plant. I think it is one of the fuels of the future. I have found it difficult to locate electrolyzers at a reasonable cost (US$1,000 to $5,000) that can optimize a 1 KW PV system. I would also like to read more about hydrogen storage (safety and most cost effective technologies). Do you know of any good technical books? Thanks for your help! Jeff Bays, Raleigh, North Carolina

Hello Jeff, Your question is becoming more and more common as people start to realize the vast potential of hydrogen as a clean and limitless energy storage device. Notice that I did not say it was a fuel. Since you must first put energy in to split the water into its component parts of hydrogen and oxygen, you are essentially doing the same thing as charging a battery, but with some advantages, as well as disadvantages, based on end use of the energy. I also did not mention reforming fossil fuels into hydrogen, since I see no real sense in this process.

Many people think of hydrogen as a direct substitute for propane or natural gas. Although it can be done, converting wind or solar power to hydrogen and then using it for cooking, hot water, or heating is simply not practical and in fact is quite silly when you look at the energy losses and the capital equipment expenses. Cook electrically if possible, heat your water with a thermal solar collector, and use solar energy in many forms for heating. A 1 KW array is just barely large enough to justify using an electrolyzer as a dump load, and it has little value if used for a primary source. Propane contains 98,000 BTUs per gallon and it takes 1.4 kilowatt-hours to produce 3,512 BTUs of hydrogen. Say it's 60 percent efficient—you can do the math, and I think you may be disappointed with the results.

It is my opinion that the most practical way of using renewable hydrogen in the future will be as a backup power source in fuel cells and for powering fuel cell or ICE (internal combustion engine) vehicles. But I think you are on the right track, since most experienced experts in the energy field have concluded that hydrogen will ultimately be the "end game" in terms of its total contribution to the renewable energy mix. This is primarily due to its ability to substitute as an almost universal fuel and its ability to be produced almost anywhere on the planet.

As to hydrogen safety, I have more concerns when using propane, natural gas, or gasoline than I do with hydrogen. That does not mean that hydrogen is inherently safe. Search out the many free downloads on hydrogen codes available from the NFPA or contact companies who deal with it on a daily basis. There are some fairly simple and cost effective methods for using and storing hydrogen. Just proceed with caution and a good dose of practicality. I hope this has been helpful. Larry Elliott, senior science editor, H2Nation Magazine

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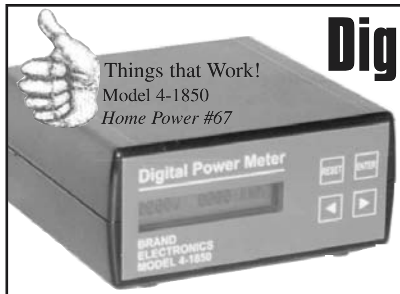

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When Karen and I were living with kerosene lamps, we went to our local public library to find out if there was a better way to light up our nights. We found nothing about small scale renewable energy.

One of the first things we did when we started publishing this magazine many years ago was to give a subscription to our local public library.

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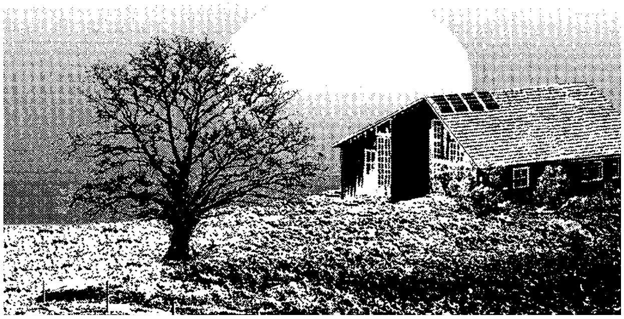

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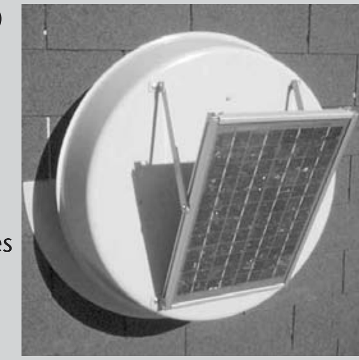

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The *Home Power* Crew

Richard Perez
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Home Power is the work of many people. Long gone are the days when Karen and I published this magazine from our kitchen table with just a little help from our friends. Just as the use of independent, clean energy sources has grown over the years, so has the *Home Power* crew. These days, it takes a big crew working long hours to keep the information flowing to you.

The magazine has become fatter, more detailed, and of higher quality, and its production has grown more complicated. We've added our CD-ROMs, a few books, and a very extensive Web site to our offerings—and to our workload. We're doing all we can to provide you with current, accurate, and realistic RE information.

As we've grown, the crew has become more specialized. While we all still wear many hats, it takes the individual talents of the whole crew to keep the business and our mission on track. My hats are off to every one of our dedicated people. We're publishing photos and a short bio written by each crew member and regular contributor, so you can see the whole top-notch, deranged crew that puts together *Home Power.*

And we can't do it without our readers, who write most of the articles, help pay the bills, and give us the inspiration we need to keep doing what we're doing. Your mail, calls, visits at fairs, and good energy keep us flying. We consider you family—please do the same with us!

Richard Perez
Publisher & Digital Janitor

While I facilitate the work of *Home Power's* editorial, art, advertising, production, sales, Web, and CD-ROM crews, my primary job is Digital Janitor. I maintain and upgrade *Home Power's* extensive computer systems, a monumental task. I also write articles and editorials. I've been living and working off-grid since 1970 with a photovoltaic/wind RE system. When I'm not working, I like tinkering with Macintosh computers, amateur radio (N7BCR) and electronics, and watching movies with my sweetheart, Karen. My goal is to change the way people make electricity. Small-scale renewable energy can solve many of our environmental and human problems. • richard.perez@homepower.com

Karen Perez
Publisher & Business Manager

My duties at *Home Power* include managing the money, paying the bills, keeping business ducks in their proper rows, being a database grunt, doing weird business research (paper, trademarks, UPCs, distributors, etc.), cooking for the crew, and acting as mediator and den mother. My love and joys are critters (currently three dogs and eight cats), gardening, playing with string (knitting, needlepoint, etc.) while listening to audio books or watching movies, loving my bear, and reading. • karen.perez@homepower.com

Joe Schwartz
CEO & Technical Editor

My work life with *Home Power* is happily schizophrenic. In the office, I help organize the magazine's direction, projects, and crew. I write articles and equipment reviews, shoot photos, and edit text and graphics for technical accuracy. In the field, I install renewable energy hardware for testing, and collect performance data. I'm finishing up my licensing requirements for Oregon's Renewable Energy Technician program. Further afield, I'm busy homesteading an off-grid piece of land east of Ashland, Oregon. I drive a biodiesel pickup, and I don't use petrol fuels for cooking, heating, or electric backup. In my spare time, I play guitar and ramble about in the backcountry. • joe.schwartz@homepower.com

Benjamin Root

Art Director

My degree in graphic design prepared me for the workplace, but not for the shock of our ethic-less economy. I often found myself designing pieces to promote the very aspects of society that I think are its largest problems. Graphic design is about communication, and I didn't believe in what I was being paid to communicate. After selling everything but the VW van, and spending a magical summer in Colorado studying at Solar Energy International, I had a mission. By doing design, layout, and illustration at *HP*, I now have something of value to communicate—information that interests me and benefits humanity and the planet. • ben.root@homepower.com

Linda Pinkham

Managing Editor

My job is to make sure the editorial and advertising components of the magazine are brought together into a finished and quality product. I am an editor, the keeper of the style guide, and the ring mistress of proofing. I focus on the details and keep track of corrections and suggestions from our editors, authors, and advertisers, without losing sight of our goal. I live and garden on four acres amongst the pear orchards outside of Medford, Oregon with my husband, three dogs, numerous cats, and a horse. We recently installed a 2.1 KW (rated) grid-intertie PV system. When I'm not watching the meter spin backwards, I like to go backpacking in the Siskiyous and Cascades. • linda.pinkham@homepower.com

Connie Said

Advertising Manager

I joined the *HP* staff in 1999 after finishing my degree in anthropology. My primary job is to manage all aspects of *HP*'s advertising accounts, beginning with ad sales all the way through to final publication and billing. I am continually inspired by the passion our advertisers have about changing the way the world makes energy. I live with my 16-year-old daughter, who tells me to breathe as she jumps off mountains to go paragliding. My son is a grad student in engineering at Stanford University and likes to ski, very fast. My children are my joy, and they keep life interesting! My current hobby is collecting and growing heirloom seeds, and being part of a seed exchange to help preserve our plant biodiversity. • connie.said@homepower.com

Rick Germany

Chief Information Officer

I'm responsible for all aspects of information technology (IT) and systems, including *HP's* Web site. I have more than ten years experience in Internet technologies and database integration. My goals include re-engineering *Home Power's* business processes and IT infrastructure to make them more productive and efficient for the end user and the *HP* crew. My job allows me to work with technology while supporting the growth of energy technologies that benefit our planet. Yes, I'm a geek with a conscience, and a dabbling activist. When I'm not plugging away at the computer, I enjoy exploring the outdoors with my wife near our home in beautiful Ashland, Oregon. • rick.germany@homepower.com

Ian Woofenden

Senior Editor & Word Power Columnist

My primary job with *Home Power* is to edit the articles and columns. I take the rough text and try to make it clear and readable for you. I really enjoy working with the authors. Later I proofread the articles, columns, and other text to find the bugs we missed in edit. I write *Word Power*, do an occasional interview, answer reader inquiries, put together the *Letters* and *Q&A* sections, and evaluate articles. And I try (in vain) to keep up with the rest of my over-full life, which includes putting up wind generators, coordinating SEI workshops, trimming trees, singing, and trying to keep my large, off-grid family busy, fed, and laughing. • ian.woofenden@homepower.com

Eric Grisen

Graphic Designer & Article Submissions Coordinator

I work with images, words, and tools at *Home Power.* I split my time coordinating and soliciting new articles for the magazine, and working on the magazine's layouts, illustrations, and ads. I also write and work on progressive construction and RE projects. My publishing background includes reporting for newspapers, writing for whitewater paddling magazines, and managing editorial projects at a large publishing house. I enjoy traveling with my partner Tiffany, making our own biodiesel from waste vegetable oil, kayaking, mountain biking, Macintosh computers, recycling everything, stinky dogs, and staying active in local environmental and political arenas. I live with renewable energy and telecommute from the Siskiyou Mountains in Williams, Oregon. • eric.grisen@homepower.com

Michael Welch

Senior Research Editor & Power Politics Columnist

My jobs at *Home Power* include editorial researcher and political commentator. I also answer most of the e-mail from our readers, and assist the editorial staff with indexing, editing, proofing, and other assignments as they come up. In 2003, I celebrated my fourteenth year of involvement with *Home Power.* My other work is a volunteer position with Redwood Alliance, a nonprofit that works strictly on energy issues. I do most of my work from Arcata, California. The rest of my life is well filled, including enjoying my wonderful daughter, Emilly, a future solar bozo. • michael.welch@homepower.com

Marika Rose Kempa

Customer Service/Circulation

My duties at *Home Power* include sales of subscriptions and products, database management, and general office work. Being raised in the country, I was shown by my parents how to respect nature. My five siblings and I learned how to make our environment a playground. Away from work, my husband and I enjoy taking our three dogs camping and hiking. I am proud to be part of a company that makes a difference in our world. • marika.kempa@homepower.com

Shannon Ryan

Customer Service/Circulation

I'm a relative newcomer to *Home Power* and love working for a company whose mission is to help preserve the planet and its resources. I help in our office doing circulation-related tasks, such as answering calls about subscriptions and other customer service matters. I pack orders for our products, back issues, and miscellany. After hours, I love gardening, walking in Oregon's beauty, learning to play the guitar, and spending time with my two rascally parrots. I'm passionate about animals, wildlife, and protecting our dwindling resources. I support various environmental groups attempting to constructively change the present course. • shannon.ryan@homepower.com

Scott Russell

Marketing Director

The newest crew member, I'm devoted full time to expanding *Home Power's* reach and making sure that we keep up with the diverse needs of a rapidly evolving readership. This means analyzing survey data, managing distributor relationships, creating marketing materials, juggling logistics for energy fair exhibitions, etc. I come from a broad background in business administration, information management, RE retail sales, and system installation. Recently back from a six-month stint doing PV work in Nepal, these days I'm busy nursing my very first crop of Oregon veggies, sussing out the local bike routes, and trying to remember the names of the crew's myriad dogs. • scott.russell@homepower.com

AJ Rossman

Data Acquisition Specialist

I am excited to have just joined the *Home Power* crew to help with data acquisition and product reviews. My academic background is in electrical engineering, geology, and environmental engineering. I teach a renewable energy design course at the University of Vermont, where I am a Ph.D. candidate researching the applications of renewable energy for groundwater remediation. I am also the president of Draker Solar Design, LLC, an electrical and ecological engineering firm that specializes in environmental data acquisition and display. My wife Kathy and I live in Burlington, Vermont and are eagerly awaiting the birth of our first child. • aj@drakersolar.com

Ken Olson

Solar Thermal Editor

I edit and author solar thermal articles for *Home Power*. Practical training in solar energy has been my full-time occupation since 1981. At Solar On-Line (SõL), I teach practical workshops and on-line distance courses. I co-founded Solar Energy International in 1991, and have trained PV technicians for the World Health Organization since 1989. In 1999, I took my family (Barb, Kristin, Sander, and Kaitlyn) to Oaxaca, Mexico for a school year and a change in perspective. We discovered a new way of looking at things and have yet to find our way home to Colorado. My goal is to help more people use solar energy for a cleaner, safer, more prosperous, and peaceful world. • sol@solenergy.org

Chuck Marken

Solar Thermal Technical Reviewer

I am a licensed electrician, plumber/gasfitter, and HVAC contractor, and I review selected *HP* articles for technical accuracy. I started installing solar heating systems in 1979 and PV in 1983. New Mexico's multiple climate zones gave our business the opportunity to install and service virtually every kind of solar energy system. My wife Juanita and I have been married for 31 years, and our house and water are heated with solar energy. Our shop is also solar heated, and we use PV to offset utility electricity usage. Whitewater rafting, photography, video editing, cantina ambiance evaluation, and fooling with computers round out my life. • chuck@aaasolar.com

Smitty

Solar Thermal Technical Reviewer

I assist Ian and Linda by reviewing solar space and water heating articles for technical errors and clarity. I also contribute to *What the Heck?* features, *Tips from the Pros* sidebars, and *Q&A* answers. I actually wanted the *HP* janitorial position, but that was already taken. So they said, "Why don't you clean up articles instead of bathrooms?" I figured I've got to start somewhere, and said OK. When not adding to my 26 years in the industry, I put on my starving artist hat and add to my scar collection by playing with lava (blowing glass). • smitty@aaasolar.com

Shari Prange

Transportation Editor & Author

I grew up in Illinois, and moved to the San Francisco Bay area in 1978. In 1982, my VW was towed into Brown's Auto Service, home of Electro Automotive. By 1983, Mike Brown and I had joined both our personal and business lives. My auto education was on-the-job. In 1988, I put my background as a writer to use as Mike and I coauthored *Convert It*. My niche is taking technical information and turning it into simple language that a nontechnical person can understand. We live and work in the Santa Cruz mountains, with our two cats and a boa constrictor. We solicit and consult on alternative transportation articles for *HP*. • shari.prange@homepower.com

Mike Brown

Transportation Editor & Author

I'm a Nebraska native, and I studied engineering briefly at the University of Wyoming before settling in the San Francisco Bay area in 1965. I worked as a mechanic at various auto dealerships, but my specialty was Volkswagens. In 1975, I opened my own auto repair shop and gas station. During the gas crisis of 1979, a customer asked me to build an electric car. I discovered a dearth of conversion parts suppliers. So I founded Electro Automotive, and eventually closed my gas car repair business to work full time on electric cars. I now live in the Santa Cruz, California area, and run Electro Automotive with my wife, Shari Prange. • mike.brown@homepower.com

Kathleen Jarschke-Schultze

Home & Heart *Columnist*

I had a great childhood in a large family in California's Napa Valley. Checkered past: Psychiatric Technician, EMT, Owner/Rider of a BMW R90/6, Restaurateur, and On-Grid Consumer. Now: Mail-Order Bride, Homesteader, Bee Wrangler, Organic Gardener, Vermi-Composter, Rose Rustler, Garlic Grower, Haus Frau, Cookbook Collector, Solar Cook, Basket Weaver, Self-Proclaimed Vidiot, Raconteur, Avid Reader, International Author, Workshop Presenter, RE Appliance Queen, Tai Chi Student, Trekker, Devoted Dog Mom, Tarot Reader, Fairy Sister—Energy Park Electric Co. at OCF, Ham—KB6MPI, Sainted Wife of Bob-O, *Home Power's* First Hired & Retired, Renaissance Woman, Optimist, Survivor. • kathleen.jarschke-schultze@homepower.com

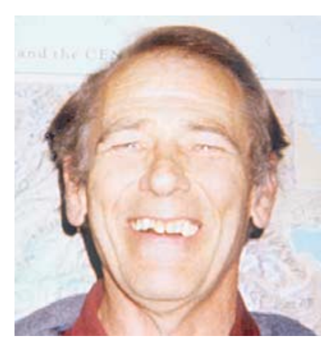
John Wiles

Code Corner *Columnist*

I am a program manager at the Southwest Technology Development Institute at New Mexico State University. I assist the PV industry, electrical contractors, and electrical inspectors in understanding the PV requirements of the *National Electrical Code (NEC).* I drafted the text for Article 690 in the 2002 *NEC Handbook*, and serve as secretary for an NFPA-appointed task group involved with Article 690. I installed my first PV system in 1984, and live in an off-grid, PV/wind-powered home (permitted and inspected, of course) with my wife Patti, two dogs, and two cats. • jwiles@nmsu.edu

Don Loweburg

Independent Power Providers *Columnist*



I was born in 1943 in Los Angeles, California. After being in the army, I completed an MS (Physics) on the GI bill. My wife Cynthia and I own and operate Offline Independent Energy Systems, and have been in business since 1983. The company is a licensed California contractor, specializing in the sale, design, installation, and service of RE systems. We have lived off-grid for 22 years with a solar and microhydro system. I research and write the Independent Power Providers column in *HP.* I also teach algebra part-time at a local junior college, and sit on the boards of IPP and CalSEIA. • don.loweburg@homepower.com

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Dueling Charge Controllers

My stand-alone hydroelectric system has been in operation for over 20 years, and it wasn't until last summer's East Coast drought that I decided to supplement with PV. The hydro's charge controller is a vintage Enermaxer with a simple, one-knob adjustment for the float voltage. The solar-electric system uses a Trace C35 charge controller, which has both bulk and float voltage adjustments. I know that the simplest arrangement would be to set the Trace controller to "load diversion" and get rid of the Enermaxer, but this would mean upgrading the controller (combined output of hydro and PV is too much for a C35) and adding more resistance load. My budget won't allow for that now. What I need to know is how to set up the two controllers so that they work together. Vinnie Valentino • valentinomasonry@hotmail.com

Vinnie, Set the bulk and float regulation point of the C35 at 0.5 VDC below the regulation point of the Enermaxer so that the PVs regulate first. If the Enermaxer regulates first, it will attempt to divert the entire load (both PV and hydro), which could possibly damage the controller or the diversion load. The C35 will regulate the PV output, and the Enermaxer will continue to regulate the hydro output. The accuracy of controllers' voltage sensing can vary. Make sure to observe the first couple of regulation cycles to make sure the settings are appropriate and that the controllers are regulating properly. You may need to increase the differential between them in some cases. Joe Schwartz • joe.schwartz@homepower.com

Homebrew Heat Exchangers

I am considering some solar water heating and want to make my own system. I was wondering if you have heard of anyone using car or truck radiators in reverse to collect heat. The basic principle of heat transfer would seem to indicate that something that gives off heat well will collect/absorb it well. I was thinking of building a glass-covered box to contain used radiators from the junkyards, which should be easy to get to keep cost down. Please point out any errors in my thinking if you can so that I won't waste too much of my time and money. Thanks Patrick Mckowen, Toronto, Canada • elyse.cohen@sympatico.ca

Patrick, You are correct that heat exchangers can be used in either direction to heat or cool depending on the desired application. An auto radiator is designed to achieve a high rate of heat transfer from a hot fluid to a high volumetric flow of cooler air. Therefore it would be just as effective in reverse, transferring heat from a flow of hot air to a cooler fluid circulating within. This suggests that you may have better results by passing solar heated air from one or more air collectors through an auto radiator.

However, it may not be the most cost-effective approach. Solar air collectors are generally less efficient than liquid collectors; ducts are larger than pipes, and blowers more costly to operate than small circulating pumps. You should also consider that those auto radiators have been used to circulate ethylene glycol, which is highly toxic. I suggest you flush them well and design the collectors into a closed loop type of system with a double-walled heat exchanger. Use a 50-50 mix of propylene glycol with distilled water. This will give you a good measure of safety from contamination of domestic water. You'll also have the freeze protection you need in a cold climate.

One more thought: I suggest you look for used solar collectors in your area. If available, they will work better than the auto radiator. Either way you proceed, please keep us posted. There are plenty of folks interested in your experience with it. Ken Olson • sol@solenergy.org

Patrick, A car radiator will work, and in fact some collectors manufactured in the U.S. used a radiator-type design for the absorber plate. None I know of are manufactured like that today—too much cost to value. Make sure the fins and tubing are black; paint them with flat black engine paint if needed. The only significant problem with a radiator is the typically large pipe connection size. If you use radiator hose for connections, they will probably deteriorate quickly. Everything inside a collector should be metal or a synthetic that will take both temperature and the harmful spectrum of sunlight. And you must use tempered glass, since plate glass can't take the temperatures.

The reason more people don't do this is cost. Once you have gathered enough radiators for the surface area needed, enclosed and insulated them, and covered them with a good glass cover, your cost probably exceeds the cost of a good used collector. If you already have the radiators and glass, then this probably won't be true. Chuck Marken • chuck@aaasolar.com

Clocks on Inverters

Hey, I really like your magazine. I have been receiving it for the last four years. I'm looking for a brand of alarm clock that will work with my Trace DR2412 modified square wave inverter. I have tried the Sylvania brand; they do not keep time properly. Do you have any ideas? Thanks, Rocky Etherington

Hello Rocky, First off, there are many different types of clock circuits. Synchronous motors haven't been used in clocks for decades. Ever since the displays went digital, the circuitry in clocks has been electronic, not electromechanical.

Some AC powered clocks rely on the fact that the grid is very frequency stable and accurate (60 cycles per second). These clocks basically count cycles as the waveform crosses zero volts, divide by 120 (each AC wave crosses zero twice during one cycle), and increment the result as a second of time. The transition from full voltage (about 160 volts) to zero volts is very rapid (less than 20 microseconds) with inverters. The clock is unable to detect the zero crossing point quickly enough to get an accurate count. Many of these clocks will actually run "double time" when powered by a modified square wave inverter. Inverter waveforms—both modified square and sine—are also not anywhere near as frequency stable as the grid. It's very common to find an inverter running at 59 Hz or 61 Hz, and even this small a difference will render a clock wildly inaccurate if it is counting cycles.

Noise on the AC line is also a factor for some clock circuits. The sharp corners on the inverter's AC waveform contain odd numbered harmonics up to infinity. Some clock circuits are confused by these harmonics and do not count cycles accurately. This problem varies depending on what appliances the inverter is powering. Large inductive loads, such as motors, will make the harmonics larger in amplitude and make the clock even less accurate.

It's common today for electronic clocks to use their own crystal time base and not to count the AC power's cycles. The reason for this is two-fold—higher accuracy and reliability. You can easily recognize these clocks because they use a small battery (usually a 9 VDC battery) to keep time when the grid fails. In this type of clock, the incoming 120 VAC is converted into low voltage DC that powers a crystal time base usually running at several thousand cycles per second. The result is greater accuracy due to the time base's greater number of cycles; and reliability, since the clock's time base is backed up by battery power. Note that in almost all cases, while the time base functions during a grid outage, the display and alarm will not function in the absence of the grid.

The obvious clock solution for inverter users is the strictly battery-powered clock with no connection to 120 VAC whatsoever. These are accurate, inexpensive, and available everywhere. I do not recommend trying to power these clocks with rechargeable batteries. The self-discharge rate of rechargeable batteries (NiCd and NiMH) is far too high to make them suitable for use in clocks. A rechargeable cell will self-discharge in months while a primary cell will last for years in most clocks.

If an inverter user (either modified square or sine) must have an accurate clock powered by 120 VAC, look for two things. Both are easy to scope out in the store before you buy the clock. One, does the clock use a battery to back up the 120 VAC power? Two, does the clock come with a low voltage power supply that plugs into the 120 VAC line? If the clock has these two easily viewed items, it should run accurately on any type of inverter.

Probably more than you wanted to know about electric clocks.... Richard Perez • richard.perez@homepower.com

Tapping 12 VDC

Hello, I'm upgrading my power system from 12 VDC to 24 VDC. I know that it's common now to run an inverter-only system, but I have many 12 V appliances that I'd like to keep. It doesn't make sense to me to keep the inverter awake constantly to run the answering machine or charge the cell phone. Also, I've never gone a night without lights, which can't be said by anybody I know with an inverter-only setup. So what's the best way to tap 12 V from a 24 V battery bank? My cells are from a forklift battery (Champion, sealed, maintenance-free, 600 AH, 2,120 pounds). Thanks for this and all your work to give the world an alternative to "blood for oil." Ray • raygris@asis.com

Hi Ray, Thanks for your compliments. We get your question quite often, now that RE systems are going for higher DC voltages. And we're hoping to run a comprehensive article on this subject in the near future.

There are basically two ways to get 12 V out of your 24 V battery bank. If your DC loads are significant in size, you may want to consider using a Vanner equalizer. With that hardware, you tap into a 12 V half of your battery. The equalizer detects when the two sides are unbalanced, and charges the lower half from the higher. Check out www.vanner.com.

The other method is to use a DC-to-DC converter, which will take 24 V and step it down to 12 V to your loads. This is most commonly used if the current draw is not too large. The loads you mentioned could easily be serviced by this method, which would be more efficient than an equalizer. Check out www.zaneinc.com.

Another option would be to install a small, one panel, one battery system just to service your DC loads. This would require an inexpensive charge controller, separate overcurrent protection, and a DC distribution system (which you would also need for the other two solutions). Peace. Michael Welch • michael.welch@homepower.com

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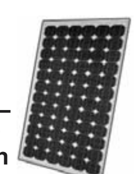
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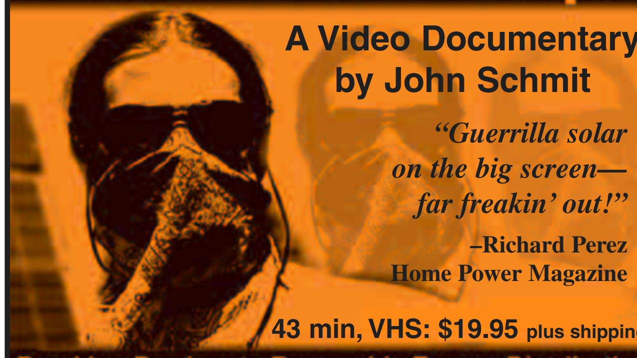

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The following information about your renewable energy usage helps us produce a magazine to better serve your interests. This information will be held confidential. We do not sell our mailing list. Completion of the rest of this form is not necessary to receive a subscription, but we would greatly appreciate your input.

NOW: I use renewable energy for (check ones that best describe your situation)

- ❑ All electricity
- ❑ Most electricity
- ❑ Some electricity
- ❑ Backup electricity
- ❑ Recreational electricity (RVs, boats, camping)
- ❑ Vacation or second home electricity
- ❑ Transportation power (electric vehicles)
- ❑ Water heating
- ❑ Space heating
- ❑ Business electricity

In The FUTURE: I plan to use renewable energy for (check ones that best describe your situation)

- ❑ All electricity
- ❑ Most electricity
- ❑ Some electricity
- ❑ Backup electricity
- ❑ Recreational electricity (RVs, boats, camping)
- ❑ Vacation or second home electricity
- ❑ Transportation power (electric vehicles)
- ❑ Water heating
- ❑ Space heating
- ❑ Business electricity

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):

NOW	FUTURE		NOW	FUTURE	
❑	❑	Photovoltaic modules	❑	❑	Methane digester
❑	❑	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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