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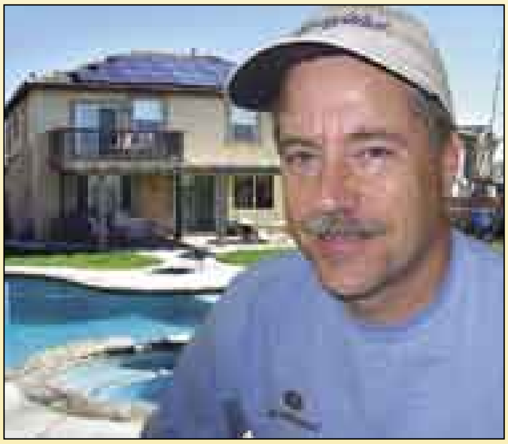

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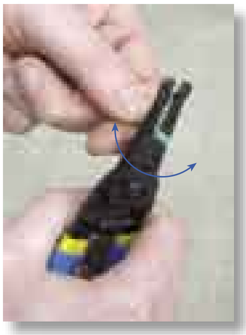

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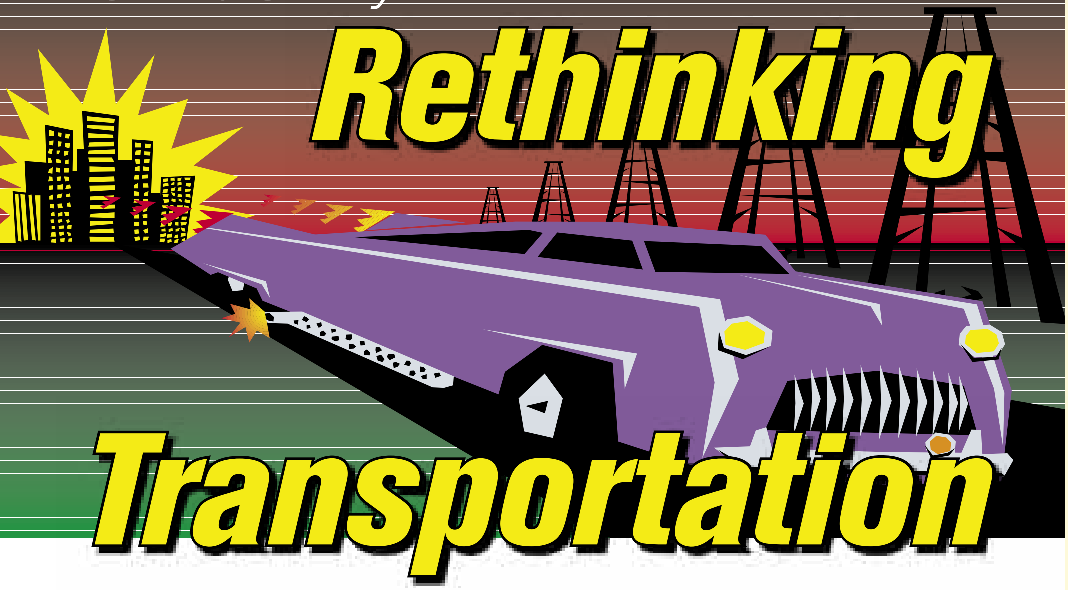

Rethinking Transportation

In January, George W. Bush stated, “America is addicted to oil.” It may have been more to the point if he had said, “America is addicted to automobiles.”

U.S. citizens account for less than 5 percent of the world’s population, yet we own one-third of the automobiles, and drive them an average of 15,000 miles—the equivalent of driving halfway around the planet—each year. The United States guzzles 25 percent of the world’s total oil production, and two-thirds of this is consumed by the transportation sector. Transportation is the largest source of air pollution in the United States. Globally, transportation accounts for 25 percent of the world’s atmospheric carbon dioxide, which is the biggest contributor to climate change.

Unfortunately, forward-looking, well-planned federal transportation policy seems to be hard to come by. A good example is the U.S. Department of Transportation’s recent move to increase fuel economy standards for SUVs and light trucks. While an increase in fuel economy standards sounds like progress, the new standard may actually force several states like California, which has *higher* fuel economy standards than the federal ones, to *reduce* their statewide fuel economy standards.

So what can we do while we’re waiting for the government to steer transportation in a more sustainable direction? If you live near your workplace, consider walking or riding a bike. If you have a longer commute, use public transportation or carpool. If you’re in the market for a new car, consider a hybrid (see page 66). If you drive a diesel rig, fuel it with at least 20 percent biodiesel and you’ll cut your vehicle’s emissions in half. In some cases, it’s even possible to run your car on sunshine (see page 16).

Transportation is the energy elephant in the living room, but we do have options that will help us kick the oil habit.

—The *Home Power* Crew

Think About It...

Worldwide, a new car rolls off the assembly line every...
(A) Second (B) Minute (C) Hour

Answer: (A) Second

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Home Power Inc.
PO Box 520, Ashland, OR 97520 USA
800-707-6585 or 541-512-0201
Fax: 541-512-0343
hp@homepower.com
mailbox@homepower.com

Circulation: Shannon Ryan & Jacie Gray
subscription@homepower.com

Advertising: Connie Said & Kim Bowker
advertising@homepower.com

Marketing & Resale: Scott Russell
marketing@homepower.com

Editorial Submissions: Michael Welch
submissions@homepower.com

www.homepower.com

Ask the EXPERTS!

Hybrid or Not?

I'll be purchasing a new car in the next couple of years, and I'm starting to do research. I'd like something economical to purchase and run, and as environmentally friendly as possible. There's sure a lot of talk about the hybrids, but I'm having trouble sorting out the facts from the marketing hype. Are they worth it? How can I make an intelligent buying decision?

Jean Pine • Dallas, Texas

Hi Jean, You're right, there *is* a lot of marketing hype. Here are some quick questions to ask. How does the hybrid gas mileage compare to the identical model in a gas version? Does the vehicle *ever* run in pure electric mode? (Some do, some don't.) In what type of driving does the vehicle get its best fuel economy, and how well does that match your normal driving pattern? Finally, is it possible to charge the battery pack by plugging it into the grid or a renewable energy system, instead of using the gas engine to charge it? There are no plug-in hybrids currently available in the United States, but there are in other parts of the world, and they may be here by the time you're ready to buy. For a wealth of info to help you shop for a hybrid, go to www.hybridcenter.org.

For a real-number analysis of hybrid efficiency and return on investments, see Andy Kerr's article on page 66 in this issue.

Shari Prange • Electro Automotive

Solar Thermal Calculations

I'm trying to calculate what I can expect from my hot water system to be installed this spring. One Btu raises one pound of water one degree Fahrenheit. If solar hot water panels produce about 250 Btu per square foot and I have 144 square feet of panels, I calculate 36,000 Btu minus 30 percent for losses, so 25,000 Btu. The hot water will go into a 120-gallon tank for storage. With this kind of Btu numbers going into the tank, how fast will it warm up? How do you calculate the temperature increase in relation to time? How many degrees F will the tank increase in four hours of full sun, assuming no water or temperature loss from the tank? The heat exchanger in the tank is 100 feet of 1/2-inch copper tube.

Paul Melanson • Nova Scotia, Canada

Hi Paul, Your figures for solar input and efficiency are within reason for lower tank temperatures. At 25,000 Btu per hour, in four hours it will put 100,000 Btu into the exchanger (which we will say is 90 percent efficient), and give us 90,000 Btu into the tank. It takes about 960 Btu to raise a 120-gallon tank 1°F. So 90,000 Btu will raise the 120-gallon tank about 90°F—some serious hot water no matter what temperature you started with in the tank!

In reality, the system would not produce this much in four hours, since the efficiency would decrease significantly

as the temperature increased. Exactly how much it decreases and how fast is a nice little rocket-science-type problem that gives plumbers like me headaches. But this is a good way to estimate the total system output. I would guess it would take about eight hours or so to actually raise the tank about 90°F if the starting temperature was about 40°F. It would also matter what time of year it is. The system would normally have better performance in the summer with the higher outdoor temperatures. It's a fairly easy question to answer with ballpark estimates, but very difficult to mathematically predict with great accuracy because of the constant drop in efficiency with the increase in temperature. I hope this helps.

Chuck Marken • AAA Solar

Why Tall Towers?

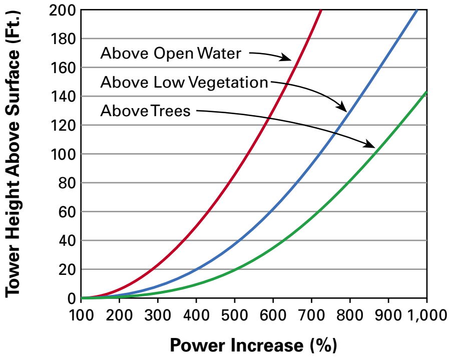
What's all this talk about the need for tall towers for wind generators? It sure feels windy on my roof, and tall towers are so expensive, not to mention the dangers. Is it really worth the investment in a tall tower?

Bob Winston • Manchester, New Hampshire

Hi Bob, While it feels windy on your roof, you'll find that it's actually much windier well above your roof and surrounding trees, as well as much less turbulent. I take a lot of people up towers in our area, and they are always surprised at how much windier it is aloft. This is confirmed by plenty of data from wind test sites.

The power available in the wind is related to the cube of the wind speed. So even small increases in wind speed mean big increases in power output. The graph shows how significant this is. Getting 60 feet (18 m) above trees can boost your wind generator output by 700 percent, and the same distance above water can boost your output 400 percent! See Mick Sagrillo's fine series on tower economics in *HP37–39* (available for free download on the *HP* Web site) for more detail. Putting up a taller tower is almost always a better

Power vs. Tower Height



investment than improving any other part of your wind-electric system.

Ian Woofenden • Home Power

DC for Computer?

In trying to make my off-grid home as efficient as possible, I'm wondering if it would be worthwhile to convert my computer and most of its peripherals to eliminate the AC-to-DC transformers in them. It seems rather wasteful to go from DC to AC and then back to DC. What are your thoughts?

Fred Minter • Aguilar, Colorado

Fred, You're right. You waste energy in converting your battery-stored DC power to AC and then back to DC again. Typically, half the energy is lost. Touch one of those transformers you refer to, and you will feel the waste in the form of heat. If you have a 12 V (small) system, you can power portable devices directly. You can get a 12 V charger for a laptop computer, for example. But for nonportable devices in a 24 V, a 48 V, or even a 12 V system, you run into problems. Your devices use (internally) a wide variety of DC voltages, most of which do not coincide with that of a typical battery system. Also, if you are suggesting internal modifications to a commercially made computer, that can be difficult, and can void warranties. You would also need DC wiring in your home.

The practical approach is to choose an inverter that is efficient for the power range of your electronic loads, and use a laptop or other flat-screen computer that draws only 20 to 100 watts. Disconnect the power to your

peripherals when they are not needed to avoid phantom loads when they are off. We live in a world of multiple standards in which we have to accept some conversion losses.

Windy Dankoff •
Dankoff Solar (founder)

Car Alternator for Wind Turbine?

I'm thinking about using an automobile alternator for a homebuilt wind generator. Will this work?

Ron Johnson • Albuquerque, New Mexico

Hello Ron, A car alternator is a bad choice for a wind generator. The efficiency in normal use is never more than about 60 percent. The bearings are too small to reliably support large blades (more than about 1.5 meters diameter). It is designed to be lightweight and robust, and to withstand running at very high rpm. At low rpm it produces nothing, and low rpm is where wind generators spend the majority of their time running.

If you use a car alternator in a wind turbine, the speed problem can be addressed in one of several unsatisfactory ways:

- Use a small blade area so that the short blades can spin at high rpm. This means that you cannot catch much wind, and even so, you will need a high wind speed to get the necessary rpm. It will also take a lot of wind to produce high enough power to excite the magnetic field and actually have energy to spare.

- Use gearing to increase the rpm. This involves extra cost, extra losses, extra unreliability, and overall ugly and clumsy engineering.

- Rewind the coils to work at lower speed. This means more turns of thinner wire in each coil. This reduces the cut-in rpm, but also increases the losses in the coils themselves, limiting the power output and further reducing the already low efficiency.

A car alternator's rotor needs to be powered to excite the magnetic field. The field has to be at a maximum to get output at the lowest speed. This represents a constant power loss of 30 to 40 watts during operation. You will also have to remove and bypass the internal regulator. The internal regulator in the alternator is not suitable for charging a deep-cycle battery via a long wire run.

While it is cheap and attractive at first look, the car alternator is more trouble than it is worth. It is better to build a purpose-built alternator for a wind turbine.

Hugh Piggott • Scoraig Wind Electric

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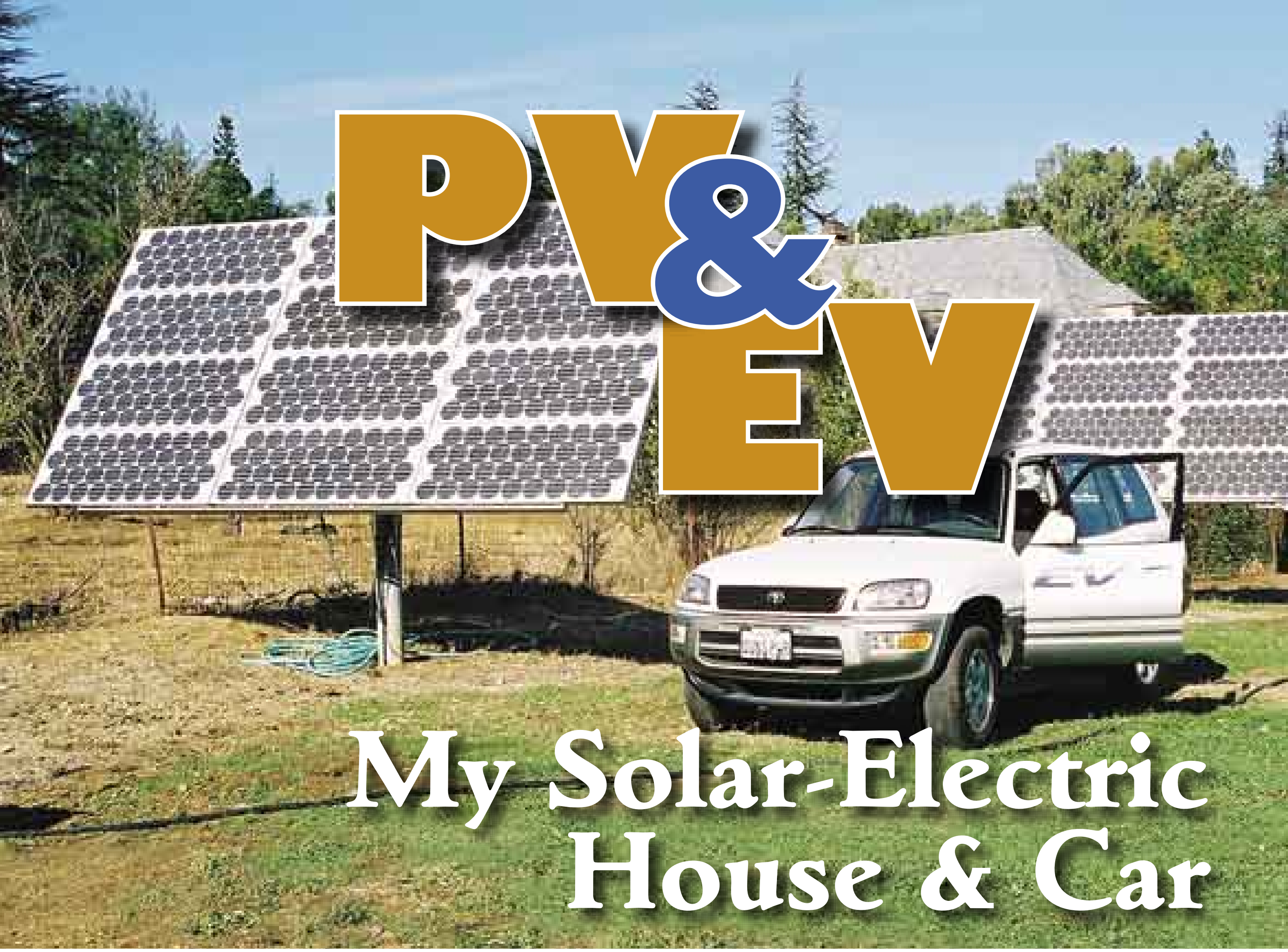


PV & EV
My Solar-Electric House & Car

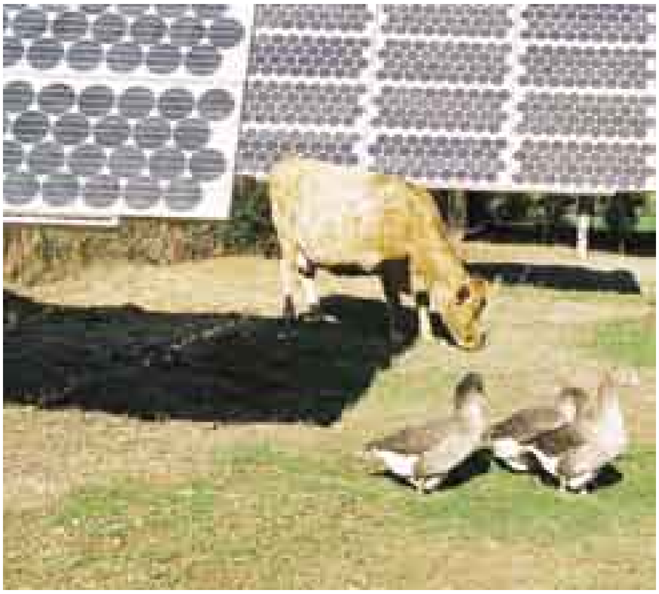
The author's electric vehicle and the solar-electric arrays that power it and his home.

Mark Jensen

Most people will tell you that you can't run your car on solar electricity, but that's exactly what I do. In 2001, during California's energy crisis, I installed a grid-tied solar-electric system with design assistance from Bob-O Schultze of Electron Connection. My original motivation was the desire to avoid rolling blackouts. Today, not only am I powering my home with solar electricity, I'm running my car on sunshine too!

Our system has 3,600 watts of solar-electric (photovoltaic; PV) modules mounted on three dual-axis tracking pole mounts. At our location, the tracking arrays generate about 30 percent more energy than fixed arrays on an annual basis. Since the system is tied to the utility grid, there is always somewhere for our electricity to go, and regulation losses are avoided. To ensure that we have electricity during power outages, a deep-cycle battery bank was included in the system. The inverter maintains the batteries at 100 percent state of charge, so they're always ready for the next utility outage.

The cow, geese, and solar-electric modules have coexisted without any problems.



Top & bottom, left: The author's electric Toyota RAV4 is plugged into the charger during off-peak hours. Achieving a full charge takes about five hours.

Top right: The license plate on the author's electric vehicle says it all.

I have been extremely happy with my PV system, and delighted with the decision to include battery backup. While the grid goes down periodically, our home has never experienced any blackouts. When the grid fails, our inverter seamlessly switches our appliances over to the battery bank, and life continues normally. The system functions as a whole-house uninterruptible power supply for all 120 VAC loads.

Efficiency & Rates

Before the installation, I reduced my monthly electricity use from about 1,000 KWH to around 600 by replacing a refrigerator and freezer with new energy efficient Kenmore appliances from Sears, and converting all the house lights to compact fluorescents.

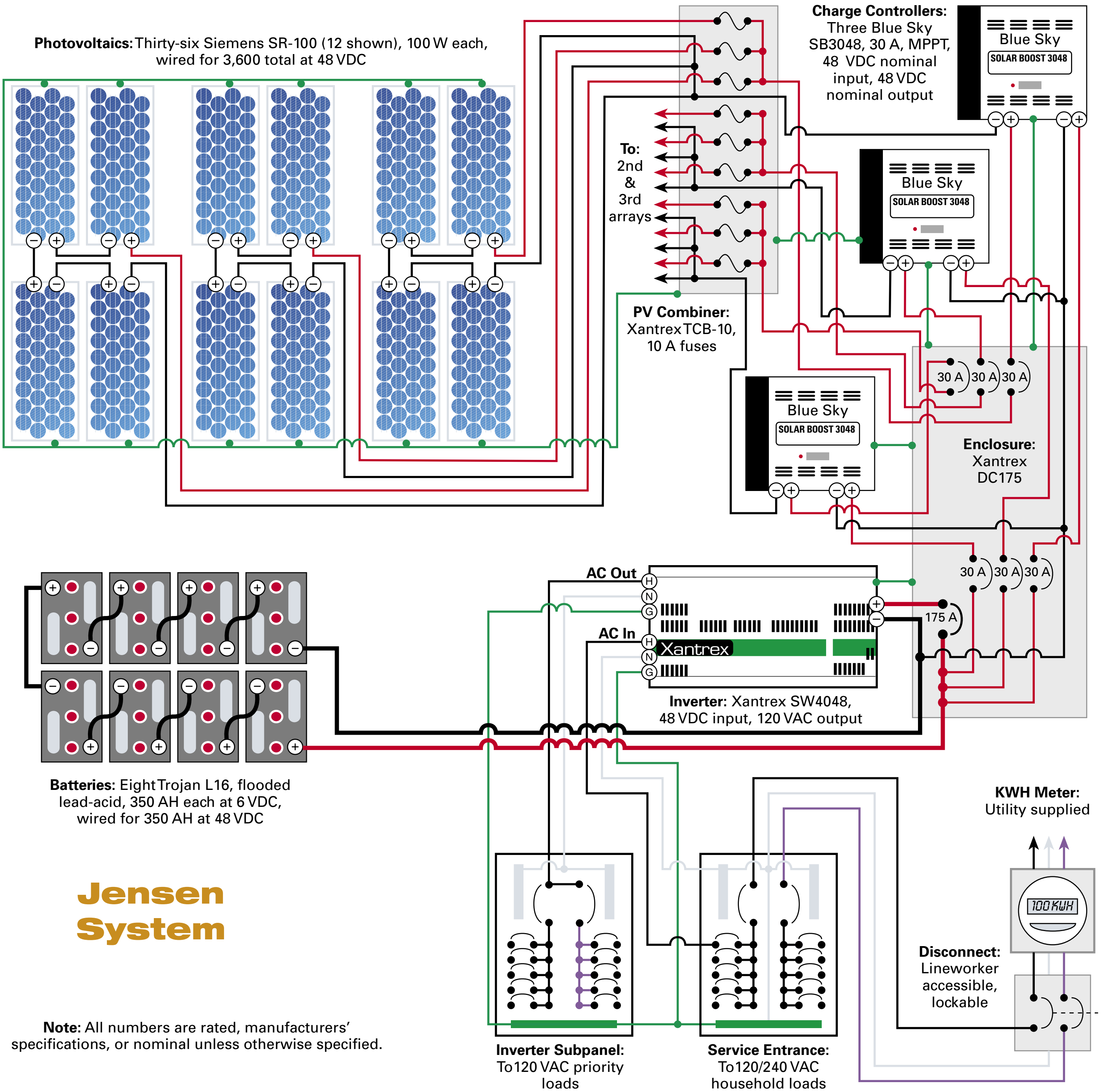
I signed up for the then-new, E-7 time-of-use (TOU) net metering rate schedule from Pacific Gas and Electric (PG&E), which paid US$0.31 per KWH, the peak rate, for all electricity metered back to the grid for the six "summer" months, from noon to 6 PM, Monday through Friday. The off-peak rate was US$0.08 per KWH, and covered all the other times.

This large differential in rates provided a strong incentive to shift electrical loads out of the peak period and into the off-peak period. With the help of several timers, my wife and I manage to use very little electricity during the peak period. As a result of the TOU rate schedule and our load shifting, at the end of the first twelve months we had a positive balance with PG&E of US$88. This is called the true-up period, and unfortunately our utility does not have to pay us this amount. On the other hand, the TOU schedule did allow us to use 1,840 KWH more from the grid than we generated that first year.

By the middle of the second year, it became obvious that our surplus for the second twelve months was going to be almost two-and-a-half times the US$88 of the first year because of improvements in our load shifting and further conservation efforts. We started to talk about how to use up this surplus because there was very little appeal in handing more than US$200 to PG&E.

Electric Vehicle

The obvious solution was to buy one of the Toyota RAV4 EVs that were available at that time (the end of 2002). I was dragging my feet, but my wife prodded me into action, and we traded in our Acura for this electric vehicle. If I had not



Jensen System

followed my wife's prodding, we would not have this car. Soon after placing our order, Toyota announced that they were discontinuing production of this vehicle and taking no further orders.

We bought the car late in the year, so after the second twelve months we still had a US$112 surplus with PG&E and a 1,550 KWH positive energy balance. I was somewhat expecting this car to more than use up our surplus. But after the first full year's use of the RAV4 EV, we still had a zero bill with PG&E, but had used 3,568 KWH more from the grid than we generated. We put about 12,000 miles (19,000 km) on the EV for the year, and it uses about 300 watt-hours per mile.

All of these watt-hours were charged during off-peak times at US$0.08 per KWH. Without the solar-electric modules, if you had to pay US$0.08 per KWH to charge this car, it would cost less than US$0.03 per mile for the electricity, compared to the US$0.10 per mile (or more) you pay for a gasoline-fueled car.

The car uses about 3,600 KWH per year, just about what our net usage from the grid is per year. The fact that we owe nothing for electricity used by our house and car is entirely due to the E-7 TOU net metering, and really demonstrates the effectiveness of the combination of a solar-electric system with this rate schedule. Unfortunately, the gain available with this rate schedule is entirely dependent on the size of the summertime peak rate, and PG&E lowered it from US$0.31

Tech Specs

System Overview

Type: Battery based, grid-tie PV

Location: Los Altos Hills, California

Solar resource: 7.1 average daily peak sun-hours (dual-axis array tracking)

Production: 500 AC KWH per month

Utility electricity offset: 100 percent

Photovoltaics

Modules: 36 Siemens SR-100, 100 W STC, 17 Vmp, 12 VDC nominal

Array: Three arrays made up of three, four-module series strings, 1,200 W STC each array, 3,600 W STC total, 68 Vmp, 48 VDC nominal

Array combiner box: Xantrex TCB-10, 10 A fuses

Array installation: Three, dual-axis Wattsun trackers

Energy Storage

Batteries: Trojan L16, 6 VDC, 350 AH at 20-hour rate, flooded lead-acid

Battery bank: Eight batteries in series, 48 VDC nominal, 350 AH total

Balance of System

Charge controller: Three Blue Sky SB3048, 30 A, MPPT, 48 VDC nominal input, 48 VDC nominal output

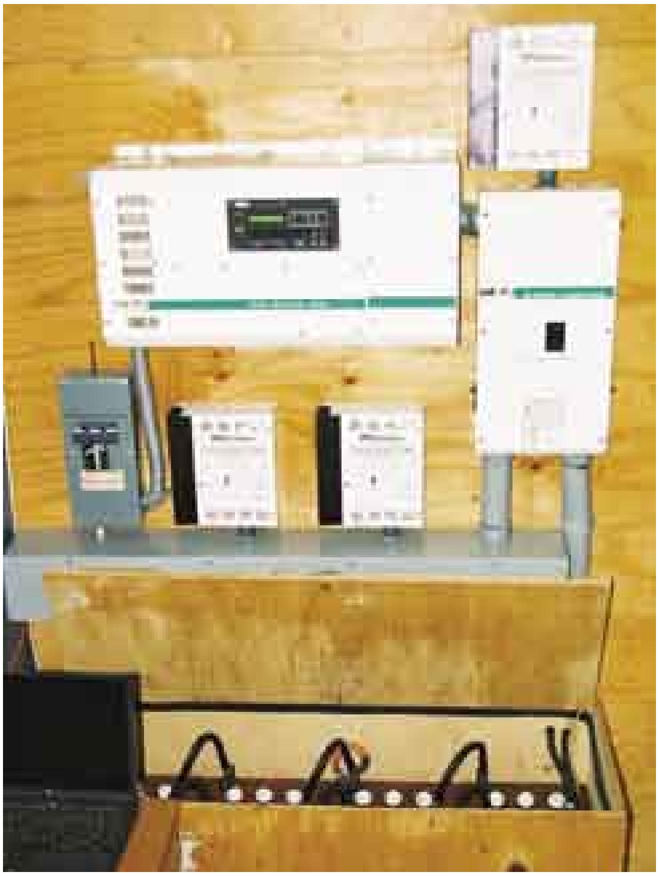
Inverter: Xantrex SW4048, 48 VDC nominal input, 120 VAC output

System performance metering: Utility KWH meter

per KWH to US$0.29 per KWH. This may have the effect of pushing my current year's bill into positive territory, which has given us incentives for further conservation.

Petroleum Free

After rebates and tax credits, the solar-electric system cost about US$26,000 and the car about US$29,000. I would have bought both without the rebates and tax credits, and never intend to go back to a gasoline car. The PR campaign by the automakers and the petroleum industry to turn the people of this country against EVs is a national disgrace and a big step backward for the sustainability of the planet. It is possible to live petroleum free for both home and transportation needs!



The 48 VDC electricity from the solar-electric arrays feeds the charge controllers, the batteries, and the inverter. The inverter sends AC electricity to household loads and the grid.

The author's portable charger, which allows charging away from home, increases the vehicle's normal range.

Death of the Production EV

In the early 1990s, electric vehicles (EVs) were the new big thing. Every manufacturer had one or more in the works. By 2006, millions of them were supposed to be on the roads. But today, no full-function factory electric vehicles are offered in the United States. What happened?

Simply put, it was a failure of will. The manufacturers never *wanted* to build EVs. They were forced into it by the California Air Resources Board's (CARB) Zero Emissions Vehicles mandate. This required a phase-in of EVs, so that by 2003, 10 percent of the vehicles offered for sale in California would be electric.

With their backs to the wall, the manufacturers smiled and nodded, and produced "concept cars" and "test vehicles." They produced lots of hype and empty promises to show how green they were. Meanwhile, behind the scenes, they poured money into lawyers and lobbyists to grind relentlessly on CARB. They pleaded that the mandate's requirements were impossible to meet. They badgered and cajoled and bargained for concessions, delays, and alternatives.

In the end, they produced a few thousand vehicles, very few of which were actually transferred to private ownership. Many were leased, and most of these were repossessed at the end of the lease over the leaseholder's vehement objections, and were crushed.

EVs were declared a market failure, despite long waiting lists. Of course, only a few hundred were ever even available for private sale, and then only by lease, only in a few selected cities, and only if you passed rigorous requirements, including owning your own home. No other production vehicle has ever been required to prove its market worthiness under such adverse conditions.

The manufacturers said that they could not build EVs that could meet the needs of the driving public at an affordable cost. And yet, thousands of affordable EVs *are* on the roads, meeting the needs of their owners. They were produced by tiny mom-and-pop businesses, or built by amateur mechanics, using off-the-shelf components. They fulfill the driving needs of most of the cars in use in America today—local commuting and errand running. If a high school kid can build an effective EV with parts at hand, why can't a major manufacturer, who can start with a clean sheet of paper, a substantial development budget, and a fleet of engineers?

Because they don't want to. Because they are depending on consumers wanting to trade in their new cars every three to five years as parts start to wear out. There is precious little on an EV to wear out.

Historically, automakers have resisted new safety, efficiency, and pollution measures strenuously until they were forced into them by legislation—seat belts, crash standards, fuel economy standards, the list goes on. They have a long history with internal combustion. They understand it. They don't want to give it up.

Only one other force can make them come around, and that is the marketplace. Japanese automakers usually respond to this first. Detroit is usually the last to catch on. But if the buying public would demand electric cars, they would get them.

—Shari Prange

The author with his EV.

Access

Mark Jensen, 26225 Purissima Rd., Los Altos Hills, CA 94022 • 650-941-2254 • Fax: 650-941-3488 • mejensen@pacbell.net

Shari Prange, Electro Automotive, PO Box 1113-HP, Felton, CA 95018 • 831-429-1989 • Fax: 831-429-1907 • electro@cruzio.com • www.electroauto.com

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Electric Auto Association, 2 Smith Ct., Alameda, CA 94502 • 510-864-0662 • contact@eaaev.org • www.eaaev.org

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Compact Fluorescents

Your Best Lighting Investment

Geoffrey Talkington

Ninety-five percent of the energy used to illuminate an incandescent lightbulb is wasted as heat, and only 5 percent of the energy consumed actually produces the light you're after. Using these antiquated lighting devices is about as "old-school" as you can get compared to today's technology. If you're still using them, you are paying the price in more ways than one.

Compact fluorescent (CF) lighting is the best and most reliable way to make light with electricity. CFs are now abundantly available in most markets. The most common place to find them is in the electrical department of your local hardware store, and some grocery stores even have a decent selection.

Choosing CFs

CFs come in an amazing assortment of sizes, styles, and types. First, decide where you are replacing an old incandescent. Find the size that will fit, and make sure that if it will be enclosed, the CF is rated for that sort of service.

A CF screws in a regular socket, just like an ordinary incandescent (medium-base is the standard size). There are also 2- and 4-pin replacement bulbs for some CF fixtures. The most common type of CF is the "twister" or spiral shape. The

This CF bulb's translucent plastic cover gives it a more traditional look.

newer mini-twists are about the same size as incandescents, and fit most applications. Some CFs have diffusers on the fluorescent tubes to make them look like incandescents. Three-way bulbs are available, as well as dimmable CFs that work with dimmer switches. You can also find CFs with the smaller candelabra-sized base.

Decide how much light you will need. Light equals lumens. A 25-watt CF can replace a 100-watt incandescent, based on lumen output. Both have approximately 1,600 lumens. Take a look at the watts-to-lumen output ratio on the CF packaging. Some CFs take a moment to achieve the full lumen brightness, especially if it is cold.

LIGHTBULB LIFETIME COSTS

Description [Calculation]	Incandescent	CF
Wattage of lamp (for equivalent lumens)	100	25
Rated life (hrs.)	750	8,000
Cost per lamp	$0.75	$3.75
Equivalent lamps needed [CF life ÷ rated life]	11	1.00
Lifetime energy usage (KWH) [wattage x rated life x lamps needed ÷ 1,000]	825	200
Operating Cost [lifetime energy usage x cost per KWH*]	$74.25	$18.00
Total purchase price [lamps needed x cost]	$8.25	$3.75
Total Costs [operating cost + purchase price]	$82.50	$21.75
Total Savings with CF bulb [Incandescent Cost – CF Cost]		$60.75

*Based on US$0.09 per KWH

LIGHTING TEMPERATURE

The "temperature" of a bulb indicates where it belongs on the color spectrum between cool (blue) and warm (red). Use cool light for close, visual tasks because it shows details better. Use warm light for living spaces because it shows skin tones, wood, and clothing better.

Warm

- Color temperature 2,700–3,500 degrees kelvin
- Brings out natural tones
- Used in kitchens, bathrooms, and offices

Cool

- Color temperature 3,500–4,100 degrees kelvin
- White light for general use
- Used in shops, laundry rooms, garages, and basements

Daylight

- Color temperature 5,500+ degrees kelvin
- Shows "true" colors
- Used in galleries, stores, and restaurants

Some manufacturers have recently introduced a wider range of color in their product lines. By color, I mean color rendition and color temperature measured in degrees kelvin. A standard soft-white-style incandescent is typically in the range of 2,750 to 3,200 degrees K. CFs can range from 2,000 to 5,000 degrees kelvin. You choose the quality of light that you like best.

It is important to have a positive experience with saving energy, so I recommend selecting a reputable brand of CF. The Energy Star rating on a CF ensures that the manufacturer has submitted their product to the high standards of rigorous quality testing. Any product that bears this seal of approval will have met U.S. Environmental Protection Agency and Department of Energy specifications. Try different brands, styles, and models to receive the performance you want.

You can find CFs priced at US$4 or less now, and some retailers have promotions in the fall and spring. The Energy Star Web site has a dealer locator and even a rebate finder (see Access).

Try CFs

Modern CFs have minimum startup times (less than 1 second), electronic ballasts (no "hum"), a wide working-temperature range. Their good light quality (3,200 degrees K, average), long life (8,000 to 12,000 hours), and one-year (or more) warranties translate into great value. A hardened electronic ballast is standard now, with a built-in spike protector for up to 130 volts.

Lighting typically accounts for about 15 percent of a home's electrical load, and using CFs can reduce your lighting load by as much as 75 percent compared to using incandescent or halogen bulbs. You also save time by using CFs, since you won't have to replace bulbs as often. A CF rated at 10,000 hours, used three to four hours a day can last up to seven years.

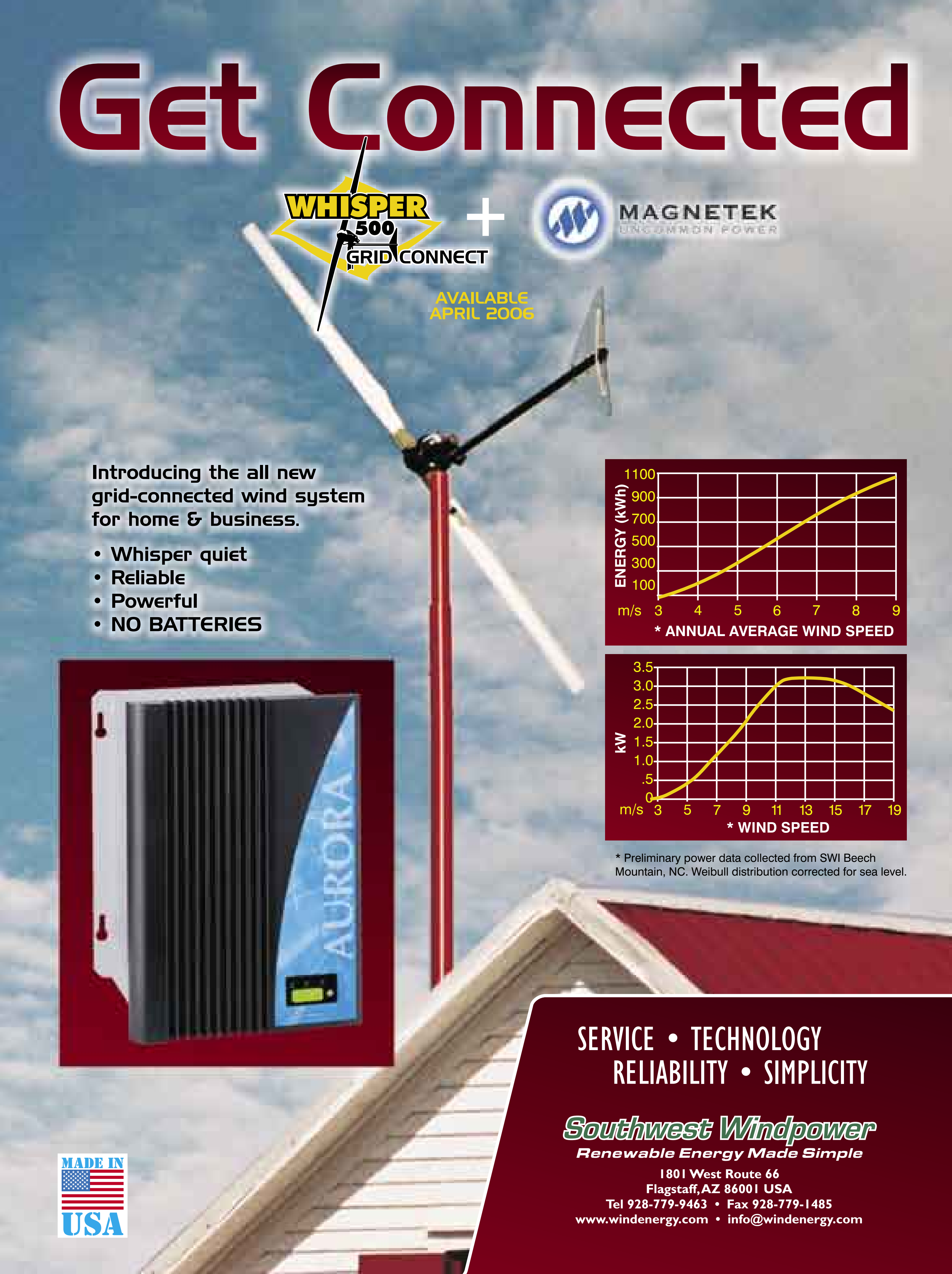
Just try it for yourself. CF technology is stable, proven, and readily available off the shelf. It has a terrific payback in benefits to the buyer, and to the community at large. Get your hands on some CFs and start saving today.

Access

Geoffrey Talkington, PO Box 333, Harrington, WA 99134 • 509-869-TALK • biofuel@asisna.com

Energy Star • www.energystar.gov

Info on proper disposal of used CFs • www.lamprecycle.org • www.earth911.org • www.nema.org/lamprecycle/epafactsheet-cfl.pdf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The Sun-Inspired House

by Debra Rucker Coleman
Reviewed by Jacie Gray

When I read the title of Debra Rucker Coleman's new book, I assumed that it was going to be a coffee table book, full of beautiful pictures for the green-builder wanna-be. Instead, it's more of a reference handbook for the novice homebuilder and remodeler interested in passive solar home construction. Although there are many attractive homes presented, they are used mostly to support and illustrate Coleman's home-building tips.

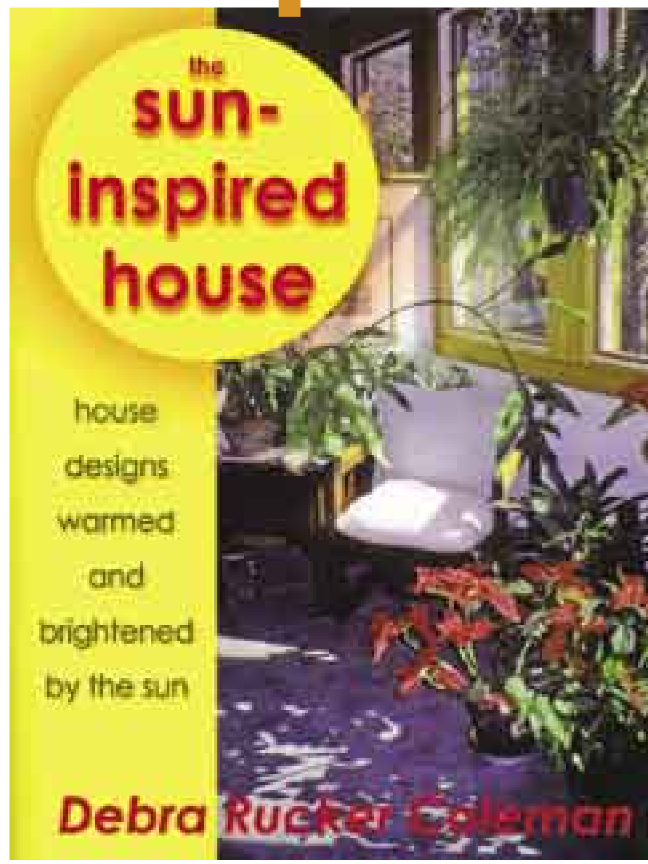
This primer opens with simple conceptual drawings and photos of the basic theories behind passive solar house design and home energy efficiency. The author has coined the term "Sun-Inspired" home to describe a design concept that focuses on daylighting, and passive solar heating and cooling, helping to make a home energy efficient.

The book is divided into two parts. In the first half, Coleman outlines nineteen elements essential to building a more efficient home, such as orienting a building properly, calculating the ideal proportions of south-facing glass, and sizing thermal mass. Detailed information is given, for example, on balancing the amount of south glass needed for passive heat versus losing heat from installing too many windows. She also discusses mechanical systems, lighting, construction costs, and more.

The "Construction Drawings" chapter is the perfect example of how important this book is to the novice builder. It lists what should be included in construction drawings, such as a schematic site plan, floor plan, exterior elevations, and wall detail. For the layperson, Coleman gives information and definitions about building codes, drawing options, blueprints, vellums, and CAD files.

The second half of the book is 50 Sun-Inspired house plans. Included with each floor plan and front elevation is a detailed description of the first and second floors, a "daylight" basement (where applicable), and a garage, as well as construction information and plan modification ideas. For quick reference, a house plan summary compares the primary design elements of the 50 different floor plans. Coleman also provides detailed feedback from several owners of the homes she has helped design, and includes their challenges, disappointments, and hindsight.

The appendix is full of great tools for homeowners who are trying to get a handle on building a home to meet their land's unique attributes. Coleman covers magnetic declination, lists international residential building codes for insulation requirements, and gives additional solar resource listings.



Coleman is convinced that "a custom-designed home is within reach of everyone." Her book is a good beginner's guide to understanding passive solar design concepts and energy efficient building strategies. The finest compliment I can give this book is to say that it will be dog-eared by the end of your building project.

Access

Jacie Gray • jacie.gray@homepower.com

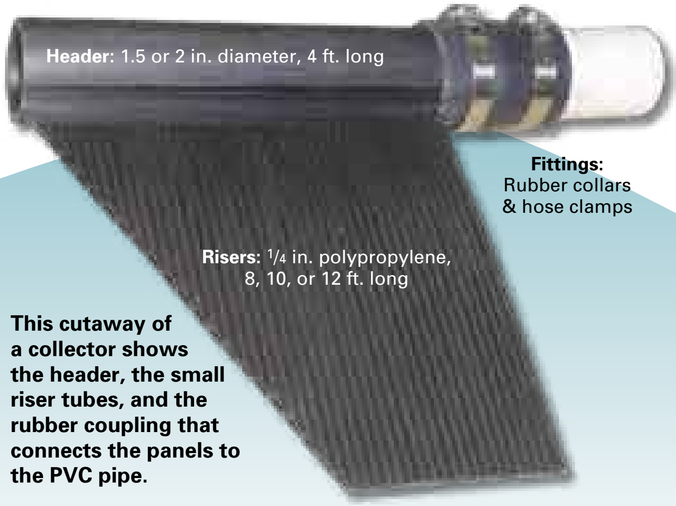
The Sun-Inspired House: House Designs Warmed & Brightened by the Sun, by Debra Rucker Coleman, 2005, Paperback, 248 pages, ISBN 0976731800, US$29.95, distributed by Chelsea Green Publishing, PO Box 428, White River Junction, VT 05001 • 800-639-4099 or 802-295-6300 • Fax: 802-295-6444 • info@chelseagreen.com • www.chelseagreen.com

Get a Jump On Summer With Solar Pool Heating

Chuck Marken

Solar pool-heating systems offer faster payback from lower initial investment and an easier installation than most any other renewable energy technology.

If you have a pool and can't wait for the summer swimming season to start, a solar pool-heating system may be exactly what you need. Besides extending the season by boosting the pool's temperature, these relatively inexpensive, simple systems are efficient, durable, and virtually maintenance free. Even if you're already heating your pool with natural gas or electricity, switching to the sun for heating can save you a bundle. With very few exceptions, you can recoup this investment more quickly than with any other type of active solar installation.



This cutaway of a collector shows the header, the small riser tubes, and the rubber coupling that connects the panels to the PVC pipe.

The Collectors

Pool collectors are specifically designed to heat large amounts of water to relatively low temperatures, usually between 80°F and 90°F (27–32°C). The collectors are made of polypropylene, a plastic with unique properties that make it well suited for "low temperature" collectors. The collectors differ from their domestic hot-water cousins, as they are composed of just an uninsulated, unglazed absorber plate.

The polypropylene in pool collectors is ultraviolet-light (UV) stabilized for longer life. Pool collectors are usually warranted for ten to twelve years, but I've seen collectors more than twenty years old that are still reliably cranking out heat. When installed correctly, the collectors are virtually maintenance free. In their later years, the collectors can develop leaks in individual riser tubes, but these can be repaired with factory supplied rubber-repair kits. (Polypropylene products are usually thermally welded, and normal sealants like silicone and epoxy will not repair leaks in pool panels.) Copper absorber plates with large headers are still used in some instances, but the higher cost and possible damage from acidic water make the polypropylene collectors a better choice in most situations.

Pool collectors typically come in three sizes—4 feet wide by 8, 10, and 12 feet tall (1.2 x 2.4 m; 3 m; 3.7 m). The collectors have 1 1/2- or 2-inch-diameter header tubes (inlet and outlet) and very small (1/4 inch or less) riser tubes. The collectors are manufactured with the riser tubes adjacent to each other, which gives the collectors a much higher wetted surface area compared to copper tube collectors. The large wetted surface area compensates for polypropylene's reduced heat transfer properties (the thermal conductivity of polypropylene is significantly less than copper).

Because pool collectors have no glass cover (which can intercept sunlight), under certain conditions, they are actually *more* efficient than standard domestic hot water collectors. Efficiencies of 80 percent or greater are possible when the ambient temperature is 10°F to 20°F (4–9°C) above pool temperature. However, efficiency quickly drops if the pool temperature is more than 15°F (7°C) above daytime temperatures. Because these panels lack insulation, during winter in moderate or cold climates, they are incapable of producing any usable heat for pools. If they were placed in an insulated box with a glass cover and oriented toward the sun, they would be able to produce usable heat in colder conditions. But polypropylene has an upper service temperature limit between 220°F and 240°F (104–116°C). Because of this, pool manufacturers advise that subjecting the panels to the high temperatures possible in an insulated box will void any warranties.

Roof-mounted solar collectors for pool heating are unobtrusive and a highly effective use of space.

The basic components of a solar pool-heating system fit right in with the existing pool pump and filter plumbing.

Courtesy www.solarexpert.com (3)

The Systems

Solar pool systems deserve a KISS—keep it simple solar. They are one of the most straightforward and easiest do-it-yourself solar projects for homeowners. They're also a favorite with installers—to such an extent that an estimated 60,000 systems were installed in 2005.

I like to call the technology "glue and screw." White PVC pipe, fittings and valves (glue), and hose clamps (screw) are all that's needed to put a system together. In many cases, the existing pool pump can be used. Pool water is piped from the pump to the collectors, and then back into the pool. PVC pipe and fittings glue together for the piping system, and rubber couplings secured with hose clamps join the collectors together.

The collectors need to be mounted securely, and are normally placed on a roof. They can also be mounted on racks on the ground or on flat roofs, or integrated into a patio cover next to a pool. The panels are strapped to the mounting structure in a manner that allows the large polypropylene collectors to expand and contract with temperature swings. Failing to allow for expansion and contraction can cause the panels to fail prematurely and void warranties.

Systems using polypropylene panels are configured as drainback systems, which only fill the collectors when water is being circulated. When it is no longer being pumped through the collector, the water in the collectors and piping drains back into the pool. In colder climates, this keeps the collectors and pipes from freezing.

Many solar pool systems use a differential controller, which measures the temperature difference between the pool water that enters and exits the collectors. Because of the relatively high flow a pool pump provides, this differential is low when compared to most solar water heaters—the high volume of water moving through the panels doesn't raise the temperature much on each pass. A rise of only 5°F (2°C) or so is normal in many systems. The controller energizes a motorized valve that diverts the pool water to the collectors.

Don Keefe and Jason Urias of AAA Solar in Albuquerque, New Mexico, install a pool system. Note the strapping that secures the collectors to the roof.

Whenever there is enough heat in the collectors to add heat to the pool, the valve is actuated. If not, the valve returns the pool piping to its original configuration for filtering the pool without adding heat.

Sizing the System

Many solar pool-heating systems are the sole source of heat for backyard pools. A properly sized system will keep a pool in the 80s and 90s during swimming season. In some regions, pool systems are configured to allow a backup boiler to heat the pool when the sun's energy isn't enough to do the job.

The basic rule of system sizing is predicated on the physical size of the pool and assumes that the pool is covered when not in use (see the "Cover Up" sidebar). Sizing is calculated by using the pool's square footage, as opposed to the volume. Most of a swimming pool's heat loss is due to evaporation—and more surface area equals more evaporation.

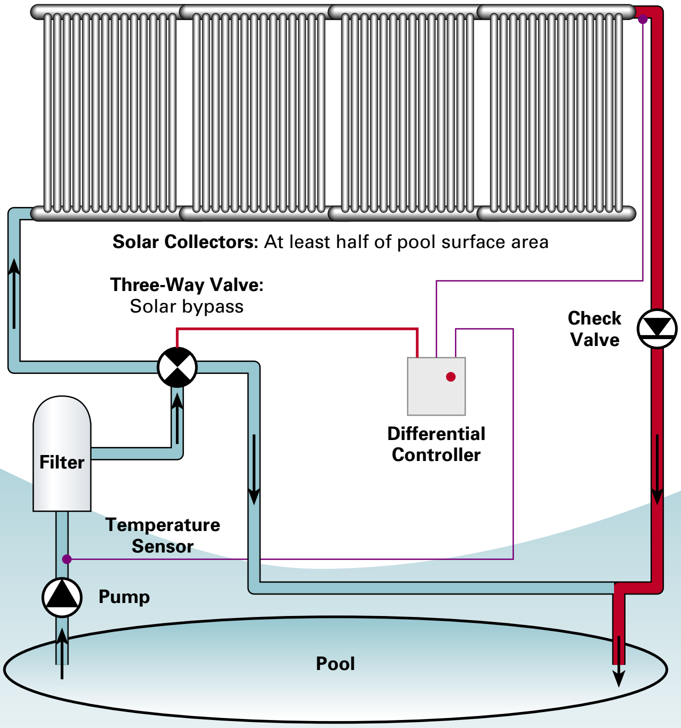
In the southern United States, basing the system size on 50 percent of the pool's surface area will provide adequate heat. This assumes that the pool is not shaded at any time, is protected from the wind, and that the collectors will be oriented to the south. These factors are important in sizing a pool because they affect heat gain and loss.

Heating Indoor Pools

In most regions of the United States, glazed and insulated solar domestic-type hot water collectors are the only choice for indoor pool heating because the pools are used during cold winter temperatures. These hot water collectors are constructed with a copper-tube absorber plate in an insulated enclosure that's faced with a pane of glass and oriented to the sun. Indoor pool systems are sometimes installed as closed-loop antifreeze systems. If there is any chance that the pool water's pH will fall below 7 and become acidic, damage to the copper-tube collector is likely. Using a stainless steel heat exchanger between the pool water and the closed-loop antifreeze solution solves the problem. (See *HP84* for more information on hot water collector construction.)

Sizing the system for an indoor pool is much more complex, and must take into account the building that houses the pool. It is best to leave this job to professional installers.

Solar Pool Heating System Overview



A shaded pool will have little or no passive solar gain, so the basic sizing parameter of 50 percent must be increased by at least 15 percent. If the pool is not protected from prevailing winds, it will also suffer increased heat loss from evaporation. In this case, plan to adjust the basic sizing figure by about 10 percent. In some locations, orienting the collectors due south (or within 20 degrees east or west) may be impossible. If all of the collectors must be placed on an east- or west-facing roof, increase the amount of collector surface area by an additional 50 percent.

Cover Up & Save

Evaporation of swimming pool water accounts for a whopping 70 percent of a pool's total heat loss. This goes for both indoor and outdoor pools. The best solution to curb this energy and money drain is to invest in a pool cover—and use it! Adding a pool cover decreases the need for heating, lowering the initial cost of a solar heating system and the daily cost of heating a pool with gas or electricity.

Covers come in a couple of different styles, each with its own costs and benefits. A simple "bubble" cover (similar to bubble packing material) usually can be purchased for less than US$100. Its transparent design also aids pool heating by directly trapping solar gain. Heavier-weight bubble covers may last a few years.

Vinyl covers are more durable and long-lived, but also are more expensive. They are available insulated or uninsulated, and can be integrated with an automated roll-up system to make cover placement and removal hassle free. Prices range from a few hundred dollars for a basic cover to more than US$1,000 for covers that come with a motorized reel.

For more information on pool covers, visit the U.S. Energy Efficiency and Renewable Energy Web site at www.eere.energy.gov/consumer/your_home/water_heating/index.cfm/mytopic=13140

Courtesy Pool Cover Specialists, www.poolcovers.com

A differential control with a narrow temperature difference actuates the three-way valve.

Here's an example: A pool system is installed on a west-facing roof to heat a 16- by 30-foot (5 x 9 m) pool. The pool is not shaded and is protected from the wind.

Using the general rule of basing the system size on half of the pool surface area gives a collector size of 240 square feet (16 x 30 = 480; 480 x 0.5 = 240). But this system has to be installed on a west-facing roof, so we factor in an adjustment of an additional 50 percent, which gives us 360 square feet of collector area (240 x 1.5 = 360). If we plan to use 4- by 10-foot panels (40 ft.^{2}; 3.7 m^2), we divide the 360 by 40 to get nine panels to do this job. If we were able to mount the collectors on a south-facing roof, we would have been able to do the same job with only six 4-by-10 collectors.

In Florida, Arizona, and southern California, where solar pool heating is possible ten to twelve months out of the year, pool-heating systems are sized at about 100 percent of the pool's surface area. This extra collector surface area yields enough heat to keep the pool warm during what the rest of the country calls winter.

A "three-port" (also called a three-way motorized valve) diverts the pool water to the collectors.

This basic rule is a coarse method of system sizing, but seems to work well in most circumstances in the southern states. But many local conditions can affect sizing a pool collector system, and the advice of a local installer can provide you with a more accurate assessment of how much and what equipment is required to heat your pool.

Recouping Your Investment

The return on investment (ROI) of a pool heating system is fast—faster than any other type of solar energy system, unless government or utility incentives change the equation. Recouping your investment in two to five years is commonplace when you've displaced gas, propane, or electricity used to heat a pool. For an installed system, expect to pay from US$3,000 to $5,000. Do-it-yourself kit prices typically range from US$1,500 to $2,500. Your ROI will vary depending on the complexity of the installation. And, as with all paybacks on solar energy systems or energy efficiency measures, the return is tax free.

Pool systems are the solar thermal industry's biggest success—by far. It's no wonder—these simple systems made with inexpensive parts represent fast payback and great value. Only a few homes with pools have too many shade trees or roofs that are not compatible with a pool system. In most cases, you can use the sun to heat your pool and save. If you have a pool or are planning to install one, you owe it to yourself to check out solar pool heating.

Access

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

For a listing of pool collector thermal ratings and a list of manufacturers, go to www.fsec.ucf.edu/Solar/testcert/collectr/tprpool.htm

For more detailed articles on solar pool heating, see the two-part series in *HP94* & *HP95*

OutBack FX

Xantrex SW Plus

Samlex PST

Off-Grid Inverter Efficiency

Richard Perez

Magnum Energy MS

Exeltech XP

SMA America
Sunny Island

An inverter converts the DC electricity produced by a renewable energy (RE) system into 120- or 240-volt AC electricity for use by your home's appliances. It is the essential link between RE resources and actual electricity use, so its overall operating efficiency is of the highest importance. Efficiency characteristics such as peak efficiency, average or typical efficiency, and idle consumption are all variables that contribute to an inverter's overall operating efficiency.

Inverters used in off-grid systems differ from those used in batteryless grid-tie applications. Off-grid inverters are designed to convert stored battery energy to AC. Batteryless inverters are designed to convert DC electricity from solar-electric modules (PVs) directly into grid-synchronous AC. While some inverters are designed for both battery-based off-grid systems and grid-tied solar-electric systems with battery backup, most battery-based inverters are designed for off-grid use only.

Peak Efficiency

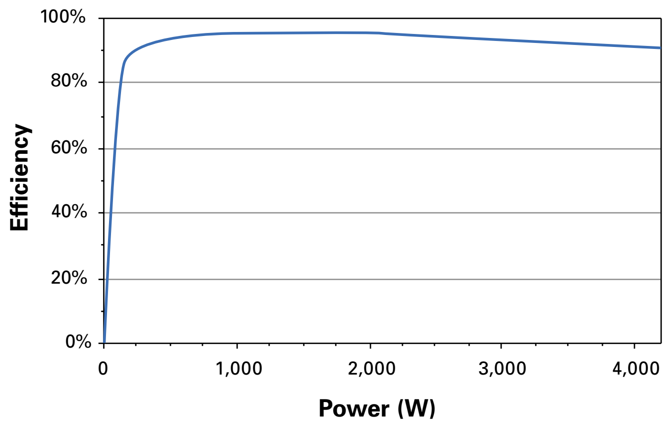
Every inverter has a point of maximum efficiency, a "sweet spot" where it is the most efficient at converting DC into AC. This peak efficiency point is usually between 20 and 30 percent of the inverter's maximum rating. For example, an inverter with a 4,000-watt rating will be most efficient when operating between 800 and 1,200 watts.

Typical peak efficiencies vary from about 92 to 96 percent. The power versus efficiency curve (opposite page) shows that a given inverter will have a relatively low conversion efficiency at low power. Conversion efficiency increases as the inverter reaches its peak efficiency point. As power levels rise beyond the inverter's point of peak efficiency, conversion efficiency will remain relatively linear, dropping only a few percent up to its rated power output.

Average Efficiency

The average or typical efficiency of an off-grid inverter depends on how the system's users operate it. If the inverter is to be the most efficient, most of its operating time should be at or above its sweet spot. In an off-grid system, an inverter operates at a variety of power levels. Sometimes, there is lots of appliance use and the inverter is heavily loaded. At other times, such as at night, only low levels of power are demanded from the inverter.

Typical Inverter Efficiency Curve



Idle Consumption

Even during the night with no electricity usage at all, an inverter still consumes some energy. This is called "idle" or "standby" consumption and is generally between 10 and 25 watts. Keeping the inverter idling allows low power appliances, like AC clocks, to run uninterrupted, but can add a significant daily electrical load to small RE systems. An inverter's idle consumption should be included in your appliance energy use list when sizing your renewable energy system.

Sleep Mode

In the early days of RE, we used the inverter only when necessary, and inverters had a low power "sleep" mode (typically between 2 and 6 watts) for when no appliances were in use. When the user turned on a load, the inverter would wake up. Sleep mode was only active when there was no demand on the inverter.

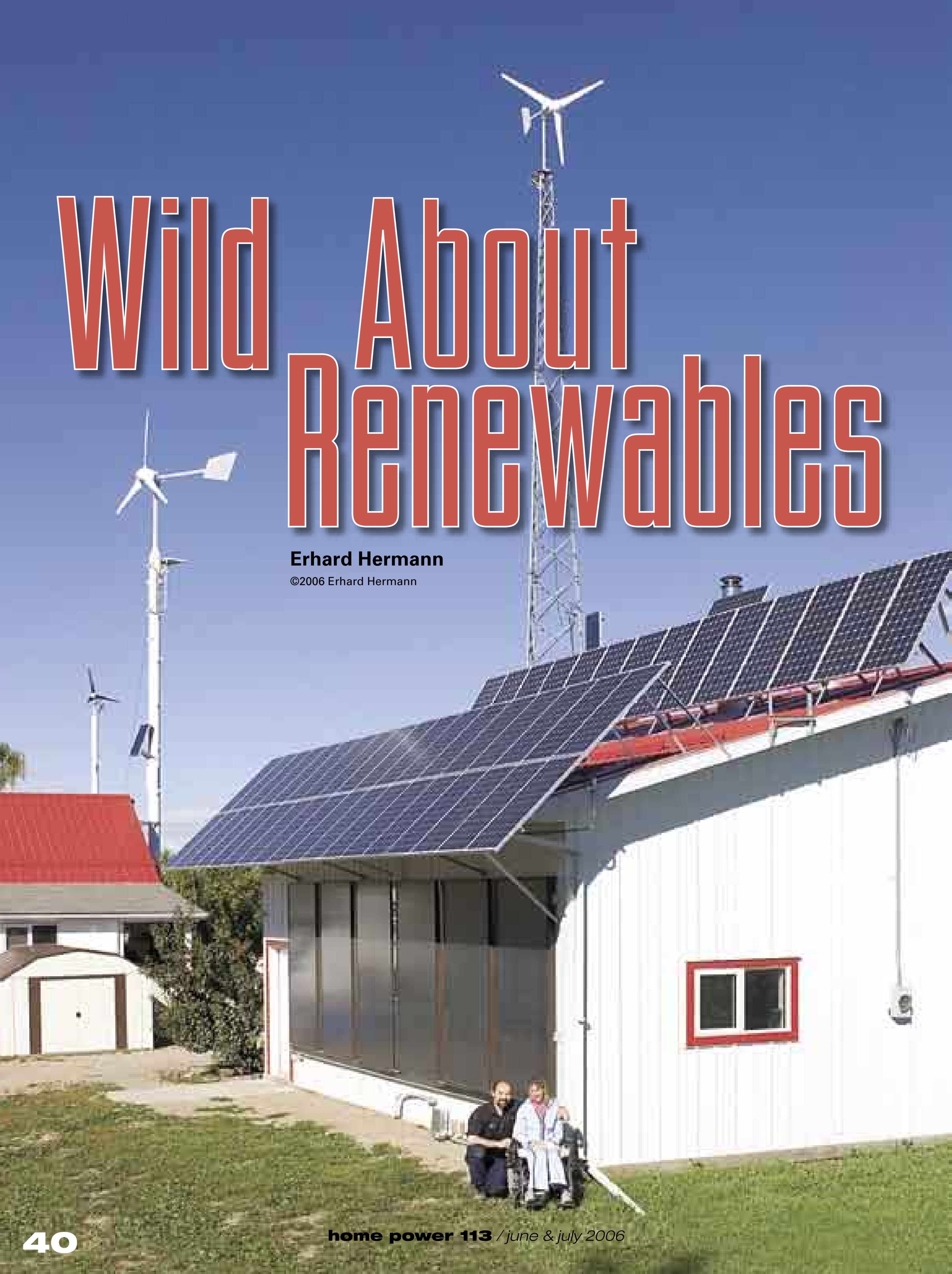
These days, there seems to be some appliance using electricity all the time—devices like telephones, fax machines, and answering machines. Thus, the sleep mode is seldom used in modern systems, and the inverter is usually active 24/7.

Efficiency is Sweet

When buying an off-grid inverter, you need to consider its maximum power and surge ratings, which you will need to power your largest appliance or collection of appliances. But don't forget to also pay attention to the power point where the inverter will spend most of its operating time. If the bulk of your electricity use is close to or above the inverter's sweet spot, it will be operating at high efficiency, and you'll save valuable renewable energy.

Access

Richard Perez, *Home Power*, PO Box 520, Ashland, OR 97520 • 541-941-9716 • richard.perez@homepower.com • www.homepower.com



Wild About Renewables

Erhard Hermann

I'm a master electrician, and in the fall of 2000 one of my agricultural customers inquired about wind power. Using the wind to generate electricity was new to me, so I began to do some research. I quickly realized that the information I was after wouldn't be found in the phone book—wind power was not listed in the Yellow Pages. After some phone calls to my regular wholesalers, I got in touch with Soltek, a major Canadian supplier of solar and wind equipment. The customer did not proceed, but the research did pique my interest.

Today, just a handful of years later, my entire home and shop are off grid—powered by the sun and wind. Since I'm now in the business of designing and installing renewable energy (RE) systems, I feel that it's important for me to have firsthand experience with the products I'll be installing for customers. The system I've built up allows me to test a variety of system components—from wind generators to inverters to charge controllers. It's much, much more complex than a typical system used to power an individual home, but it gives me the data I need to choose the right component for the right application when I'm working in the field.

The author doing routine maintenance on an AWP 3.6.

Starting from Scratch

When my wife Renée and I decided to build a new house in 1999, we wanted to make it as energy efficient and maintenance free as practical. We built it behind our existing 1942 farmhouse, which was not very efficient. The new house has an insulated concrete foundation frost wall and double-wall construction, with a total of R-44 insulation in the walls. The attic has R-80, the floor has R-5, and the windows are triple-pane, argon gas-filled to minimize heat loss.

With a special permit, the Hermanns were able to install three wind generators on their 0.7-acre home site.

As Renée and I talked about our energy situation, we considered several factors about our future. I would not be able to make as much money as I got older, especially since I am taking care of Renée (she was diagnosed with MS). Utility prices would continue to escalate, and I didn't trust the electrical grid to be there all the time because of infrastructure deterioration, weather, and sabotage vulnerability. Investing in on-site renewable energy production made a lot of sense to us.

Starting the Process

I had the tools and knew enough about electricity to determine our loads and daily energy consumption. We started by taking meter readings once a week from the utility meter on our house, and found that our electricity use averaged between 7.5 and 8.5 KWH per day. We got a catalogue from Brian at Soltek and started to go through the information in it, including a good little chart that gave us an approximate output on solar-electric panels for our location.

The top PV array feeds electric heaters and the middle array charges the system's main battery. The vertically mounted thermal collectors produce hot water for space heating.

As we browsed through the catalogue, we also looked at the wind generators. After getting some more information from Brian, we settled on a Southwest Windpower H80 wind generator and eight Shell SR100 solar-electric panels. We ordered a Trace (Xantrex) SW5548 inverter and some 2-volt Deka batteries, since industrial 2-volt cells have the longest life. I started putting the system together using the electrical equipment that I normally use in my trade.

Reducing Our Loads

We also realized that it would not be practical for us at this point to get enough panels to come up with the 8 KWH per day, so we started looking at our loads again, and at how to reduce the consumption. The fridge was the big hog, at 2 KWH per day. The heating system was the other big one, even though I already had it operating on a timer so the pumps would not run as much.

We decided to replace our side-by-side Maytag refrigerator with a Sun Frost RF12, since it uses less than one-sixth of the energy of the Maytag. We also decided to heat with wood and solar thermal collectors. The top-loading clothes washer was replaced with a horizontal-axis, front loader, which uses less than a third of the energy. We have no dryer, just drying racks.

Since we were already using efficient T8 electronic-ballasted fluorescent fixtures and compact fluorescents in most of the house, and 18-watt, low-pressure sodium lights outside, there was not much to be done in that department. We then made sure that nothing was plugged in that did not need to be. By doing these things, we reduced our daily appliance load to an average of 5 KWH.

Building an RE Business

Once we got our own system up and running, we realized that not many people in our area knew about solar and wind electricity, nor could they offer good advice on it. Even the salespeople from the various companies generally did not have their own systems, and a lot did not have much hands-on experience.

Seeing the need for someone to enter this field and provide good service and knowledge, we decided to move ahead. One thing that I feel quite strongly about is that if you are going to sell something, you need to be familiar with it and be able to provide good, sound information based on experience. We upgraded our systems, and purchased different products for testing to become familiar with them.

I followed up on the leads that Soltek provided, and sold and installed some systems. As word got out about our own system, various news media (radio, TV, and newspapers) did stories on us. Some people have seen our system while passing through town, and have contacted us.

One rather unfortunate thing that I have run into several times is that unqualified people have sold and installed systems and products and left a bad taste for the renewable energy industry. This, I believe, is the result of two things. First, people who are interested in the technology but do not have the qualifications have gotten into selling and installing systems and making a mess of them.

The second problem is consumers who do not want to pay for qualified people to sell and install the products, believing that they can save some money. My experience so far has been that it costs more if they try that route. I have made it a practice to try to provide excellent service and train the people in operating their systems. I really believe that providing good service and information has been key to building our RE business.

Going Off the Grid

In late December 2001, we called our electricity supplier to have our utility service disconnected. This, of course, was something that did not make a lot of sense to the lady at the call center, but she did it anyway. On December 28, Gary, one of our local linemen, came out and disconnected the lines to our house and removed the meter. We were on our own! In February, we called the gas company and had them disconnect the gas line from our house as well. We had a similar response at the call center—the local gas company fellow (another Gary) said he knew I was up to something, but did not know what. He had no trouble disconnecting us.

One factor that influenced our decision to go off grid is that in Alberta, net metering is not legal yet. You can sell your surplus, but the costs and regulations basically mean that you will pay to send electricity into the grid. Going off grid requires that you design the system carefully, and become much more aware of your energy status and consumption. As we looked at the functioning of the grid and the direction that this society is going, we felt that we wanted to be independent of the grid, since the future does not look good to us.

We continued to keep close tabs on our energy consumption and production. I installed a meter to see how much input we were getting from the solar-electric panels and one to record the wind generator input. We charted this on a spreadsheet and found that we averaged just above our minimum of 5 KWH per day. I started to think about expanding the system and doing a bit more with it.

Then we read Mick Sagrillo's article on wind generators in *HP90*. After some more research, we decided to try a Bergey XL.1 and an African Wind Power (AWP) 3.6. We had some more towers manufactured and got the appropriate development permit for adding two wind generators. I didn't find the Bergey to be well suited for our low wind-speed area, and it was hard to incorporate into the 48-volt system.

The continually evolving and extensive control center.

Household Loads

Item	Hrs./	Watts	Daily WH
Air exchanger	8.0	120	960
Electric range top	1.0	750	750
Computer	4.0	150	600
Microwave	0.5	1,200	600
Computer	4.0	120	480
Sun Frost fridge	—	—	350
Well pump	0.5	650	325
Answering machine/fax	24.0	10	240
Wall transformers	24.0	10	240
Lights	8.0	20	160
Clock	24.0	5	120
Cordless phone	24.0	4	96
Washing machine	—	—	35
Battery chargers	2.0	15	30
Radio	1.0	15	15
		Total Daily WH	5,001

The Big Revamp

We got to the point where I realized that I needed to do a major revamp of our system. The regular electrical disconnects and wiring methods took up too much space and were too cumbersome to work with, so we redid our whole system with the OutBack AC and DC disconnect boxes. What an improvement! We also went to Rolls/Surrette batteries since they were the ones that I would normally be selling.

We replaced the Xantrex SW5548 with two OutBack FX2548Ts, since they had better motor-starting characteristics and a much better sine wave. The original PV charge controller was replaced with a Solar Converters unit and then with the OutBack MX60 controller. The H80 was rather noisy in high winds, so I replaced it with a Aeromax Lakota, which was much quieter, but due to our low average wind speed, it does not generate very much electricity on our site.

I sold most of the solar-electric panels we had, and purchased new modules that allow the maximum use of solar energy from our roof structure. The PVs overhang the roof edge and provide some shade for the solar hot water collectors in the summertime when we do not want heat from them. This setup has worked quite well.

We also decided on a second AWP 3.6 to go on a taller tower. We were able to get a used, 80-foot (24 m) freestanding tower from Robert at

Solar-electric array input meters.

Abundant Renewable Energy along with the second AWP 3.6. Since we are in town, the original height restriction was 50 feet (15 m), but we were able to get a permit to go to a 100-foot (30 m) tower height and have a maximum of three wind generators. The town of Didsbury has been really good to deal with in terms of our renewable energy system.

Hot Water

Our solar hot water system consists of six flat-plate solar collectors on the south wall of our house. We wanted to use solar energy to heat the slab of our

Three amp-hour meters monitor battery state of charge and wind generator energy production.

Tech Specs

Main System Overview

Type: Off-grid, battery-based PV and wind-electric

Location: Didsbury, Alberta

Solar resource: 4.5 average daily peak sun-hours

PV production: 375 AC KWH per month

Wind resource: 7 mph (3.1 m/s) average wind speed

Wind production: 240 AC KWH per month

Photovoltaics

Modules: 36 Shell SM110, 110 W STC, 35 Vmp, 24 VDC nominal

Array: 18 two-module series strings, 3,960 W STC total, 70 Vmp, 48 VDC nominal

Array installation: Custom mounts installed on south-facing roof, 45–60 degree tilt

Wind Turbines & Towers

Turbines 1 & 2: African Wind Power 3.6

Rotor diameter: 11.8 feet (3.6 m)

Rated energy output: 192 DC KWH per month at 12 mph (5.4 m/s) average

Rated peak power output: 1,000 W at 22 mph (9.8 m/s)

Towers: 80-foot (24 m) and 46-foot (14 m) Rohn 8n, freestanding

Turbine 3: Aeromax Lakota S

Rotor diameter: 7 feet (2.1 m)

Rated energy output: 155 KWH per month at 12 mph (5.4 m/s) average

Rated peak power output: 900 W at 28.8 mph (12.9 m/s)

Tower: 30-foot (9 m) freestanding tower

Energy Storage

Batteries: Eight Rolls/Surrette 6CS-21PS, 6 VDC nominal, 683 AH at 20-hour rate, flooded lead-acid

Battery bank: 48 VDC nominal, 683 AH total

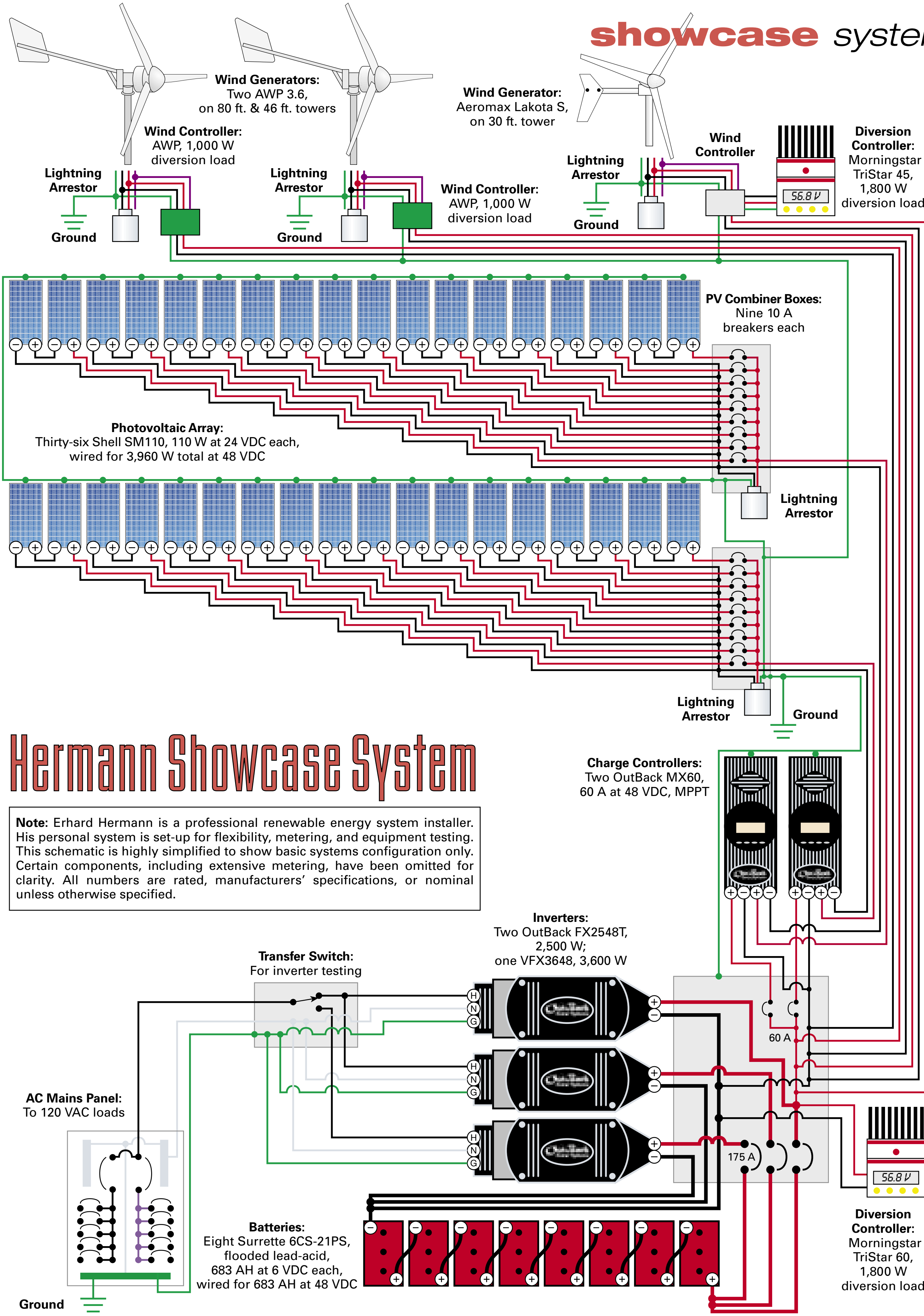
Balance of System

Solar charge controllers: Two OutBack MX60, 60 A, MPPT, 48 VDC nominal input voltage, 48 VDC nominal output voltage

Wind charge controllers: Two AWP controllers with diversion loads, two Morningstar TriStar controllers with diversion loads

Inverters: Two OutBack FX2548T, and one OutBack VFX3648, 48 VDC nominal input, 120 VAC output

System performance metering: Two Bogart Engineering TriMetric, two Xantrex Link 10, one Xantrex TM500, seven analog volt and amp meters



Hermann Showcase System

Note: Erhard Hermann is a professional renewable energy system installer. His personal system is set-up for flexibility, metering, and equipment testing. This schematic is highly simplified to show basic systems configuration only. Certain components, including extensive metering, have been omitted for clarity. All numbers are rated, manufacturers' specifications, or nominal unless otherwise specified.

Main PV & Wind System Costs

Item	Cost (Can$)
36 Shell SM110 modules, 110 W	$29,203
Towers misc. (concrete, welding, labor, cranes, etc.)	8,115
2 AWP 3.6 wind generators	8,000
8 Surrette 6CS-21PS batteries	6,697
2 OutBack FX2548T inverters	5,448
Tower, 80-foot lattice, used	5,000
Tower, 46-foot	4,800
Miscellaneous	3,875
Aeromax Lakota wind generator	2,950
OutBack VFX3648 inverter	2,724
Racking for modules	2,500
2 OutBack MX60 charge controllers	1,527
30-foot tower	1,500
Breakers for disconnect	1,197
2 Link 10 meters	567
7 Analog meters	560
2 TriMetric meters	523
OutBack AC disconnect box	500
OutBack DC disconnect box	477
OutBack PS2DC	459
OutBack Hub 10	447
24 Hydrocaps	444
OutBack Mate	352
Xantrex/Trace TM500 meter	350
TriStar 45 load diversion control	214
Solar Converters battery equalizer	206
Total	$88,635

home. As the sun heats the collectors and the temperature rises to a setpoint of 100°F (38°C), an Aquastat controller turns on a DC pump that is powered by a dedicated PV module. The flow is then modulated according to the temperature of the collectors. If the temperature in the collectors drops below the setpoint and differential, the pump is turned off until the collectors are warm enough again.

This type of system is simple and only requires the energy of the PV module to operate. Systems that rely on AC electricity will shut down if the grid or an inverter fails, causing the collector loop to stagnate. Stagnation may cause excessive heating of the glycol, destroying its ability to protect the system from freezing. I am planning to have a backup pump operated by a second Aquastat and a second PV module to protect the system against this worst-case scenario.

Erhard and Renée are happy with the performance and independence of their hybrid renewable energy system.

Independence in Town

It has been a lot of work and a lot of trial and error, but we sure do like having this system. Our current goal is to get as much of our required energy from our 0.7 acre as possible. We have quite a number of trees on our property and have planted more. It is tricky having the trees and the wind generators and PVs together on such a small piece of property. The type of tree and placement has been critical.

By relying mostly on the wind and sun for our electrical and heating needs, we use relatively little wood for heating. As the price of energy increases and availability decreases, we will likely see more people doing this. The town of Didsbury has expressed interest in putting up a system as well. While we started out simply trying to cover our modest load, I definitely caught the RE bug, and have built a large and complicated system that makes more energy than we need most of the time. But having a showcase system has really helped us to open others' minds to the possibilities of renewable energy sources.

Access

Erhard Hermann, Erhard's Electric, Box 1942, Didsbury, AB, Canada T0M 0W0 • 403-335-3330 • Fax: 403-335-3330 • solar@erhardselectric.com • www.erhardselectric.com

Abundant Renewable Energy, 22700 NE Mountain Top Rd., Newberg, OR 97132 • 503-538-8298 • Fax: 503-538-8782 • info@abundantre.com • www.abundantre.com • AWP 3.6 & used 80-foot tower

Aeromax Inc., 1157 Highway 89, Chino Valley, AZ 86323 • 888-407-9463 or 928-775-0085 • Fax: 928-775-0803 • info@aeromag.com * www.aeromaxenergy.com • Aeromax Lakota S

Bogart Engineering, 19020 Two Bar Rd., Boulder Creek, CA 95006 • 831-338-0616 • Fax: 831-338-2337 • bogart@bogartengineering.com • www.bogartengineering.com • TriMetric battery monitor

EA Energy Alternatives Ltd., 5-4217 Glanford Ave., Victoria, BC, Canada V8Z 4B9 • 800-265-8898 or 250-727-0522 • Fax: 250-727-2286 • sales@energyalternatives.ca • www.energyalternatives.ca • Kyocera PVs & TriMetric meter

Morningstar Corporation, 1098 Washington Crossing Rd., Washington Crossing, PA 18977 • 215-321-4457 • Fax: 215-321-4458 • info@morningstarcorp.com • www.morningstarcorp.com • TriStar, ProStar15 & SunSaver charge controllers

OutBack Power Systems, 19009 62nd Ave. NE, Arlington, WA 98223 • 360-435-6030 • Fax: 360-435-6019 • sales@outbackpower.com • www.outbackpower.com • Inverters, charge controllers, etc.

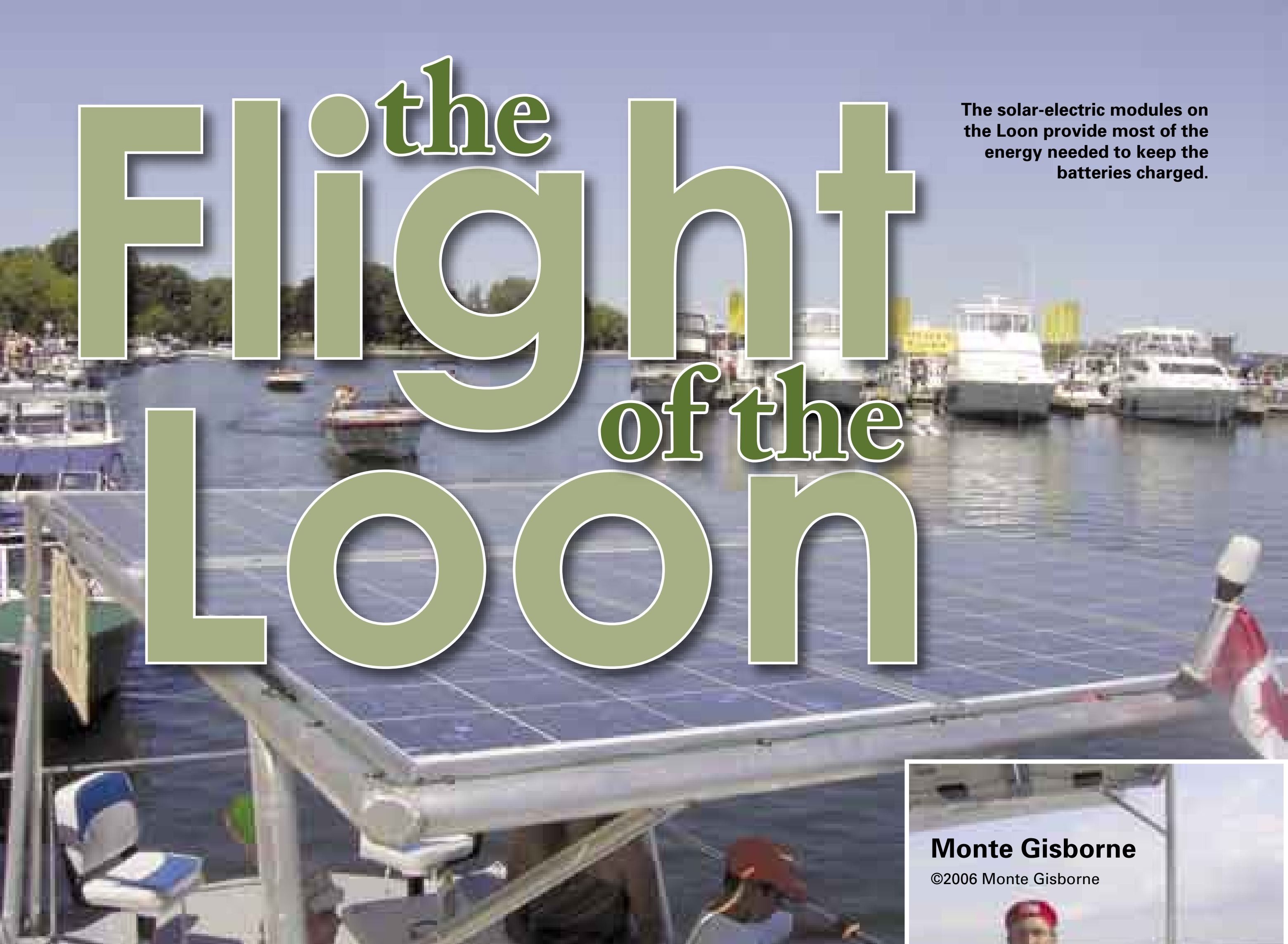
Solar Converters Inc., 558 Massey Rd., Unit 1, Guelph, ON, Canada N1K 1B4 • 519-824-5272 • Fax: 519-823-0325 • info@solarconverters.com * www.solarconverters.com

Soltek Powersource, #16 - 2333 18th Ave. NE, Calgary, AB, Canada T2E 8T6 • 888-291-9039 or 403-291-9039 • Fax: 403-291-9049 • sps@spsenergy.com • www.spsenergy.com • System components

Surrette Battery Company Ltd., PO Box 2020, Springhill, NS, Canada B0M 1X0 • 800-681-9914 or 902-597-3767 • Fax: 800-681-9915 or 902-597-8447 • sales@surrette.com • www.surrette.com • Batteries

True-North Power Systems, Lion's Head, ON, Canada N0H 1W0 • 519-793-3290 • Fax: 519-793-3290 • info@truenorthpower.com • www.truenorthpower.com • Lakota wind generator

Xantrex Technology Inc., 8999 Nelson Wy., Burnaby, BC, Canada V5A 4B5 • 800-670-0707 or 604-422-8595 • Fax: 604-442-1591 • information@xantrex.com • www.xantrex.com • TM500 meter, Link 10 meter



the Flight of the Loon

The solar-electric modules on the Loon provide most of the energy needed to keep the batteries charged.

Monte Gisborne

"C'mon family, hop in the electric vehicle—we're going on vacation!" These words seemed odd as they fell from my lips, but what was odder was that it didn't surprise them at all. They clearly had become unfazed by my antics; numb, really, to my incessant efforts to rid ourselves of any dependence at all on oil.

The electric vehicle for our six-day mission would be the Loon, my own design of solar-assisted electric boat, which was about two years in the making. A 738-watt photovoltaic (PV) array charges a 11.7 kilowatt-hour (KWH) battery bank wired for 48 volts DC. If shore power is available, additional battery charging can be provided via a 10-amp AC charger. A 3-horsepower brushless, DC motor propels the boat, giving the same power characteristics as a 10 hp gas motor.

Our route would be the historic Trent-Severn Waterway, an incredibly beautiful system of constructed canals and nature-made lakes that spans 240 miles (385 km) of rural cottage country in southern Ontario. We live on the shores of Lake Simcoe, which was the departure point of this great trek, specifically Bayshore Village, near Orillia, Ontario.

Shakedown

The day was August 13th, and having only just recently launched the Loon, I hadn't had as much time as I would have liked to fully test it out. But the 20-foot (6 m) pontoon boat seemed quite seaworthy, and a number of bugs had already been ironed out to the point that the boat had completed a $3^{1}/_{2}$-hour run without incident.

All systems seemed a go, so my wife Denise and daughter Deanna boarded the vessel, and if there was any doubt in their minds, they kept it entirely hidden from me. They had seen my electric vehicles succeed and they had witnessed the "back-to-the-drawing board" moments as well. This time they had a more personal investment in the outcome.

Top: A simple control console with a GPS keeps the Loon on course.

Bottom: The author and his family about to embark on a six-day boating vacation.

Lake Simcoe is a rather large lake, known for kicking up swells easily and with little notice. Casting lines on a beautiful summer day as it was, Simcoe seemed to welcome our vessel's passage. About two hours later, we were entering the Trent Canal near the village of Gamebridge.

The canal system presents ever-changing scenery, ranging from simple pastoral settings to cottage country to urban backdrops. The canals include many locks, some of which are more than 150 years old and are manually operated. To complete this first leg, we had to pass through five locks, some separated by as little as a mile. Each takes about half an hour—time spent in the sun with the solar-electric panels working all the while to try to catch up with earlier energy use.

At peak, the boat's solar-electric array can put out about 740 watts, which equates to about 15 amps of charge. What I found most interesting is that while traveling during periods of direct, intense sunlight, the typical 15 amps generated by the array subtracts from the 35 amp, 5-knot cruising draw of the motor, so that the batteries only have to supply 20 amps. German scientist W. Peukert observed that battery capacity is inversely proportional to draw. Reducing my battery's draw from 35 to 20 amps increases the boat's range by more than 40 percent—perhaps the most important benefit of all to having the solar-electric panels.

The author and a friend enjoy a leisurely cruise.

Novelty?

We had arranged to spend our first night at Sunset Cove Marina, and we arrived there late in the afternoon, having successfully completed our first and shortest leg of approximately 15 miles (24 km). The crowd that gathered when we docked was quite amazed by the sight before them. The Loon is a striking craft with lots of shiny aluminum—quite unlike any other boat plying these waters.

The usual questions were asked. How far can you travel? Answer: 30 miles (48 km) on a cloudy day; more on a sunny day. How fast can it go? Answer: 5 knots cruising; 6 knots full speed. How much does it cost to run? Answer: Nothing, if you're only traveling about 10 miles (16 km) per sunny day; 3 cents per mile if all the energy has to come from the utility grid.

Left: The author fastens the composite decking material to form the base of the boat.

Right: The PV array also serves as a roof for sun protection.

Below: The finished deck, prior to installing the solar-electric canopy, furniture, and drive system.

At first, the Loon appeared to come off as something of a novelty, not to be taken seriously stacked against the preponderance of gas-powered boats. What made points with a lot of boaters (myself included) is that we would bump into the same crowd everywhere we went for the duration of our trip. This drove home the point that our boat could do everything their boats were expected to do, the only difference being that it takes us a little longer. But isn't spending time on the water the purpose of recreational boating? Many a dockside chat centered on just this point.

Range Testing

Sunset Cove Marina and Rosedale Marina are separated by about 25 miles (40 km) of waterway without another marina between them. I knew from the outset that this was going to be a challenge, especially since we awoke to find that our battery charger had cut out during the night due to overheating. The battery's state of charge was somewhere between half and three-quarters. This is probably every EVer's worst feeling—can you make it through the day? Falling short would mean subjecting my family to the indignity of asking for a tow, or (even worse!) begging electricity from an unconvinced public. What ignominy lay ahead for the Gisbornes?

The boat's batteries were nearly taxed to the limit about 4 miles (6.4 km) from the Rosedale Marina. To make the best of the situation, the Loon had to be throttled back to about 2 or 3 knots to get the battery volts up so that the low-voltage disconnect of the Briggs & Stratton brushless DC outboard wouldn't kick in. We made it into Rosedale under our own power, very satisfied with the boat's performance.

The reliable 3 hp, 150-pound thrust motor proved to be an excellent workhorse, with high electrical efficiency and a propulsion system that quietly makes the most of every

Tech Specs

System Overview

Type: Off-grid, battery based, PV system

Location: Any freshwater body

Photovoltaics

Modules: Six Sharp ND-L3EJE, 123 W STC, 17.2 Vmp, 12 VDC nominal

Array: One six-module series string, 738 W STC total, 103.2 Vmp, 72 VDC nominal

Array installation: Custom solar-electric canopy installed on flat roof

Energy Storage

Batteries: Eight Pow-R-Surge US145, 6 VDC nominal, 244 AH at 20-hour rate, flooded lead-acid

Battery bank: 48 VDC nominal, 11.7 KWH

Balance of System

Charge controller: ElectroCraft, 20 A, MPPT, 72 VDC nominal input voltage, 48 VDC nominal output voltage

AC charger: ElectroCraft, 120 or 240 VAC input, 48 VDC output, 10 amps maximum output

System performance metering: ElectroCraft available electron. In Rosedale, I purchased a fan to put an end to the battery charger's overheating situation, and we slept well, knowing that our problems were dealt with.

Relaxing Days

The next day's 17-mile (27 km) leg to our terminus, Bobcaygeon, was a relaxing one. The weather was holding out nicely, and even if it did start to rain, the six solar-electric panels overhead would provide excellent shelter. Time was spent the following morning filming a segment for the local TV news program. After that was wrapped up, we headed back home, reversing the route that we had just taken, and enjoying three more peaceful days of solar boating.

There was little fanfare as the Loon approached its familiar berth at Slip 43 in the Bayshore Village Marina. About the only sounds that could be heard were the whoops and yippees that we made ourselves, having had a less-than-fully-enjoyable return trip across Lake Simcoe, due to the more than 10-knot winds we encountered.

Solar Boating

Safe and sound at our home port, the experience fresh in our minds, we seemed a little wiser, empowered with the knowledge that family fun doesn't have to involve the burning of fossil fuels. We didn't think that our 8-year-old daughter would have to struggle to put pen to paper when asked upon her return to school: "What did you do that was different this summer?"

So where to from here? I'm so convinced that the world would benefit from a boat such as the Loon that I have decided to produce more of them. I am presently making Loons available to the marketplace this year, built by my start-up company, the Tamarack Lake Electric Boat Company. I'm using commercially produced electronics and the tried-and-proven components as used on the prototype Loon. I also sell and distribute innovative components for people who may wish to build their own style of electric boat and can offer assistance to them too.

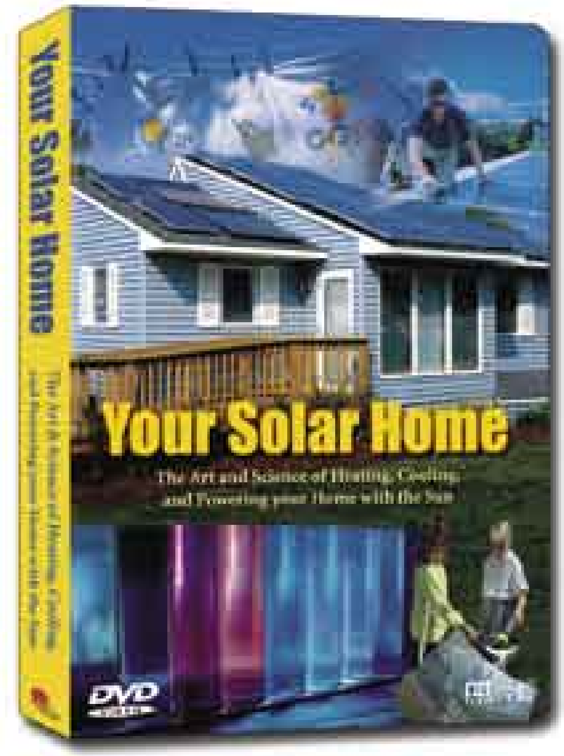
We also have future plans for the original Loon, such as traveling the Rideau Canal, other segments of the Trent-Severn Waterway, and maybe even an American waterway or two. If this experience has taught us one thing only, it is that water and electricity—and family fun—do mix!

Access

Monte Gisborne, Tamarack Lake Electric Boat Co., 207 Bayshore Dr., RR #3, Brechin, ON, Canada L0K 1B0 • 705-484-1559 • monte@tamarackelectricboats.com • www.tamarackelectricboats.com

ElectroCraft Systems, 107 Larkfield Dr., Toronto, ON, Canada M3B 2H6 • 416-391-5958 • Fax : 416-391-2486 • sales@evcraft.com • www.evcraft.com • Charge controller, AC charger

Your *Solar* Home



Produced by The Rahus Institute

Reviewed by Ian Williams

How do you teach concepts such as solar radiation, southern orientation, and solar heating to those who aren't aware of the free energy benefits of the sun? While there have been many books written on these subjects, they only reach a limited audience. Videos and DVDs, on the other hand, have the potential to reach a far wider audience.

In the five years I've spent in the renewable energy industry, first as an intern with the California Energy Commission and later working for a solar-electric dealer, I have seen my fair share of the good, the bad, and the ugly in educational media. The DVD, *Your Solar Home,* falls decisively into the "good" category.

According to producer Tor Allen of the Rahus Institute, a nonprofit dedicated to promoting the use of renewable energy, the video is an outgrowth of working with schools and is intended for academic use. This short and sweet, 24-minute DVD introduces basic solar energy concepts, and follows a simple format that's easy to follow. While this is the Rahus Institute's first video production, it shares the same easy-to-understand and uncluttered aesthetic of their other educational materials.

Three characters, "Sunny," "Ray," and "Crystal," take the viewer through simple lessons on the historical use of the sun's energy, mechanisms of heat transfer, solar architecture and design, and solar-electric systems. The first segment provides the historical perspective on the applications of solar energy, spanning passive solar architecture in ancient Greece and Rome to the use of greenhouses in 18th century Netherlands. The next segment covers basic energy concepts: heat transfer by conduction, radiation, and convection, and explains the seasonal variations caused by the Earth's tilt.

Where this video really shines is in its excellent presentation of how a solar-heated home works. Using easy-to-follow computer animations, it demonstrates how the thermal mass of a Trombe wall combined with appropriately sized roof overhangs and a series of controllable vents can keep a house at a comfortable temperature.

After this discussion of passive solar design, the program introduces viewers to solar thermal collectors. This segment also touches on the concept of tankless, on-demand water heaters, making the striking analogy that keeping a large amount of water hot in a conventional water heater is akin to keeping your car idling continuously, just in case you need to drive somewhere.

Following a brief segment on solar cooking, the program moves on to discussing generating electricity with photovoltaics. Sunny introduces the concept of making electricity with sunlight, and a computer animation helps illustrate how a photon in sunlight hits the silicon in a photovoltaic cell, knocking loose an electron and creating voltage. Another simple animation illustrates the concept of net metering.

The DVD ends with a humorous nod to the oldest and most widely used solar energy system—the tensile textile dehydration device, more commonly known as the clothesline. Also included with the DVD is an eight-page booklet that illustrates several key concepts. This serves as a helpful tool for reviewing the concepts covered and as an easy reference guide. *Your Solar Home* will be most useful for those who need a fun introduction to or a refresher course on the fundamental concepts of solar energy.

Access

Your Solar Home: The Art & Science of Heating, Cooling & Powering Your Home with the Sun, written and directed by Clay Atchison, produced by The Rahus Institute, US$25 from The Rahus Institute, 1535 Center Ave., Martinez, CA 94553 • 925-370-7262 • Fax: 925-889-2322 • info@rahus.org • www.rahus.org

Reviewer: Ian Williams • 916-761-2260 • ianaw@juno.com

WIRE STRIPPING SIMPLIFIED

A graduated stripper is perfect for small-gauge wire.

William Miller

Anyone who wants to install solar-electric equipment needs to learn some basic electrical skills. One primary skill is stripping wire. Like any skill, it can be done right or it can be done wrong. And like any skill, practice makes perfect. In this article, I will give you some techniques, and then you need to get some scrap wire and experiment. With practice, you'll soon be stripping wire like a pro.

In the United States, wire is measured by the American Wire Gauge (AWG), a system that uses sequential numbering. Larger numbers indicate smaller wires. I divide wire into four categories based on the tools and techniques used in stripping.

Wire Sizes & the Right Tools for Stripping

Size	AWG	Metric	Tool
Small	18–10	0.8–5 mm^2	Graduated stripper
Medium	8–1	8–42 mm^2	Hook knife
Large	1/0–4/0	53–107 mm^2	Straight knife
Cable, fine stranded	2/0–4/0	67–107 mm^2	Insulation slitter

Procedures

Small gauge. For these sizes of wire, a typical stripper is graduated—it has notches of varying size. Find out what size of wire you are using so you can pick the right notch. The wire size is marked on the wire, though it may not be that easy to read the markings. Here's a secret: If you're careful, stripping is easier using one notch smaller than the gauge you are using. But you have to do it correctly or you will damage individual strands of the cable.

Note two things here: One, your thumb is a big helper to push the stripper. And two, if you look closely at the photo (at right), you'll see that the stripper is not fully closed. Suppose you are stripping #12 (3 mm^2) wire. Try the 12 notch first. If it's difficult to sever the insulation, try the 14 notch, but after you close the stripper, open it slightly before you push the insulation off.

For PV work, I strongly recommend stranded wire, but the procedures are the same for stripping solid wire. Some strippers are designed for either stranded or solid wire. Others have different notches specified for each wire type. If you use the technique described above, with some practice, the strippers can be interchangeable.

Here's how you check your work with any size wire. After a practice strip, strip the wire again a little farther back. Examine the copper in the area where your first strip was. If you see nicked, or worse yet, severed strands, you need to

Small Gauge


1. Squeeze


2. Rotate


3. Relax grip and push with thumb

improve your technique. Move up one notch larger, make certain the tool is perpendicular to the wire, and make sure the wire is centered in the notch.

Medium- and large-gauge wire. These sizes are stripped with a knife. You can buy specialty knives, but I like the standard replaceable-blade utility knife. The difference between the procedure for medium and large wire is the blade. For medium, use a hooked, carpet blade. For large, use a straight blade. Some knives have a quick blade-change feature and a compartment for blade storage.


A utility knife can be fitted with a hook blade for medium-gauge wire, or a straight blade for large-gauge wire.

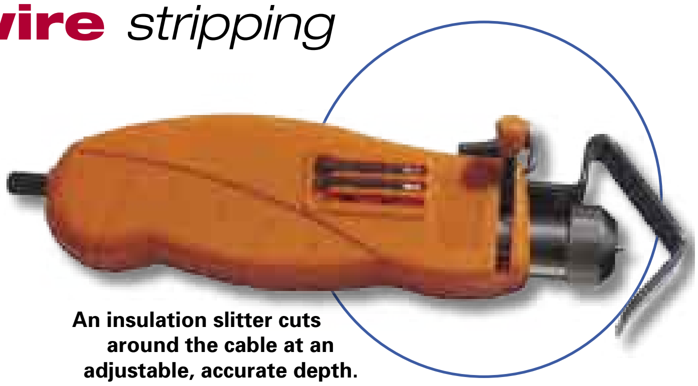
With blades, the trick is to avoid nicking the conductor, especially at a right angle to the wire. A nick can cause the strand to break. Slice the insulation off just as if you were sharpening a pencil with a knife. Start at one area and then rotate the wire (or the knife) so that each successive slice overlaps the last cut. Again, the thumb of the hand holding the wire (the left, if you are right handed) is the leverage tool. If you do cut into the conductor slightly, you will take out a little curved sliver of copper. This is not a big problem and is preferable to a nick. Again, make a complete practice strip and then strip again a little higher so you can examine the strands.

Medium & Large Gauge


1. Cut away from yourself

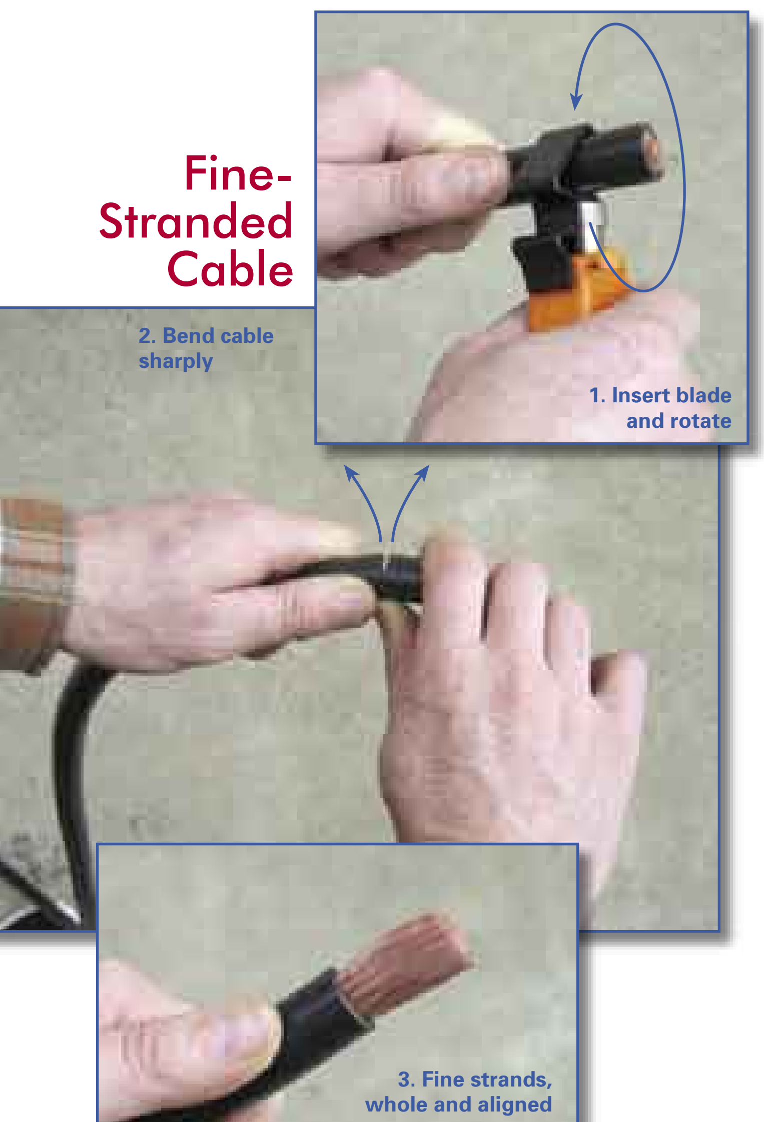

2. Repeat, working around the wire


3. Perfection


An insulation slitter cuts around the cable at an adjustable, accurate depth.

Fine-stranded cable. This is a cable used to interconnect batteries and inverters. Most battery systems require large cables—#2/0 and 4/0 (67 and 107 mm^2). This wire has a thicker insulation that requires a unique stripping method. The trick here is to slice partway through the jacket, at 90 degrees to the cable, without cutting into any of the copper strands. When done properly, you will not see copper at the bottom of your cut until you bend the wire sharply. The remaining thin membrane of insulation will tear, and you can slide the insulation off with your fingers.

Fine-Stranded Cable


1. Insert blade and rotate

2. Bend cable sharply

3. Fine strands, whole and aligned

If you are very careful, you can perform this strip with a knife, but I prefer an adjustable insulation slitter (shown at left) and can justify its expense, since I work with a lot of cable. This tool has a small blade inside an adjustable collar. You adjust the collar until the blade depth is just enough to slit most of the way through the insulation.

Push the spring-loaded hood up with your thumb, put the cable into the device, and release the hood. The photo (below left) shows the slitter being rotated around the cable. Go ahead and go around two or three times. Push the hood up and remove the tool from the cable. Grasp the cable with a hand on either side of the slit and bend the cable sharply, as in the middle photo. If the strip is the right depth, you will not see copper until you bend the cable, but the last bit of the insulation will tear easily. Rotate the cable and keep bending until the insulation is severed completely. Slide the insulation off.

⚠ SAFETY ⚠

Wire stripping requires using sharp tools, so the usual precautions apply. Always direct a knife away from you when you cut. Before stripping, make sure the other end of the wire is not connected to an energy source. This sounds unlikely, but sound safety procedures require checking.

Strip It Right!

Safe and efficient installation of solar-electric systems requires that each connection be as good as you can make it. Poor connections add resistance. Cumulative resistance adds to unnecessary inefficiencies. Resistive connections create heat, creating safety hazards.

Making good electrical connections requires that the wire ends be prepared properly. If you get the right tools and put in a little practice, good wire stripping will soon become second nature.

Access

William Miller, Miller Power & Communications, 17395 Oak Rd., Atascadero, CA 93422 • 805-438-5600 • Fax: 805-438-4607 • wrmiller@mpandc.com • www.mpandc.com

Graduated strippers: www.kleintools.com & www.idealindustries.com/ht/wirestrippers.nsf

Utility knives: Stanley 10-788, 6-inch quick-change retractable utility knife, at most hardware stores.

Hooked blade knives: Stanley 11-961 (regular) and No. 11-983 (large) hook blades, at most hardware stores.

Paladin insulation slitter/stripper: www.hmcelectronics.com/cgi-bin/scripts/product/6800-0070

Small Wind Initiative

for Western North Carolina

Dennis Scanlin, Brent Summerville & Mike Dooraghi

The Appalachian Mountain region of North Carolina has more than three-quarters of a million acres of land with average annual wind speeds above 4.5 meters per second (10 mph) at 30 meters (98 ft.) height. But very little adoption of wind turbine technology has taken place. With the notable exception of the construction of what was then the world's largest wind turbine in 1978, there has never been a tradition of using wind power in the region.

The Small Wind Initiative (SWI) was established in 2004 to demonstrate and assess small-scale wind turbine technology, to educate the public about the potential of small-scale wind energy production, and to assist people in measuring their wind resources. It has been supported by the North Carolina State Energy Office, the Tennessee Valley Authority (TVA), the U.S. Department of Energy (DOE), Appalachian State University, and several wind measurement and small wind turbine manufacturing companies.

Mike Dooraghi of the SWI team makes the long 120-foot climb up to the Jacobs for some maintenance.

Workshop participants on Beech Mountain at the Whisper 200 grid-tie installation.

SWI's goal is to focus on small-scale wind energy with this project, because more than 80 percent of the windy land in this region is in the lower Class 2 and 3 range, which is not typically considered adequate for utility-scale projects. (Wind resources are classified on a scale from 1 to 7, with Class 7 being the highest.) Smaller turbines have less-significant impacts and will be less controversial than utility-scale wind farms.

Research & Demonstration Site

The central core of this initiative has been the establishment of a small-wind technology research and demonstration center on Beech Mountain in Avery County, western North Carolina. The center is at an elevation of 1,565 meters (5,136 ft.), with an average wind speed of about 8 meters per second (18 mph) at 50 meters (164 ft.), and an average annual power density of almost 600 watts per square meter. This makes it an outstanding wind site. The 3-acre site is being leased from a private landowner and a building permit has been issued to the project for seven years. The site includes two buildings for equipment storage and datalogging, good road access, and a utility grid connection.

The research and demonstration site has become the focal point for a variety of educational activities, including hands-on installation workshops. It is open to the public, and educational displays have been designed and constructed describing the potential of wind energy production in the region, the equipment used at the site, and the estimated performance and cost of each turbine.

The electricity from the turbines runs underground into a building that contains the power conditioning equipment, inverters, batteries, and datalogging equipment. All the electricity produced is being monitored and fed into the Mountain Electric/TVA utility grid system, contributing to TVA's Green Power Switch program.

Performance

In addition to demonstrating the technology, SWI has also been involved in assessing the performance of the turbines. We are keeping a log of our activities and repairs, power and energy output, wind speeds and direction, temperature, barometric pressure, solar insolation, wind shear, sound, and avian impacts.

The datalogging system uses a Campbell Scientific CR1000 datalogger, a Windows-based computer, twelve anemometers, seven wind vanes, a temperature sensor, a barometric pressure sensor, and six power transducers. Each turbine is being individually monitored for power and energy production. Wind speed is being monitored at two elevations on each tower, and wind direction is being monitored on each tower as well. Data is being recorded every second. We have constructed power curves of the turbines on our site and have documented that all produce their rated power output.

An activity log has been kept for each turbine at the site. The log documents in text and photographs each of the eight turbines tested. It describes the problems encountered and the repairs undertaken (and can be found at www.wind.appstate.edu/swiwind/swi.php). We have had more than our fair share of problems. The average availability for all the turbines was 79 percent.

Birds

The SWI team met with a regional Audubon Society representative to develop an avian impact study. Using the Audubon procedures, we searched the site for bird carcasses at least weekly and after significant weather events (such as low cloud ceiling and fog). Searches were conducted as early in the day as possible to reduce the chance of carcass removal by other scavenging animals.

Turbines

Between June 2004 and June 2005, eight different wind turbines were erected and monitored at the site. Four companies' turbines represent the range of products existing in the marketplace. The turbines at the site during 2005 included products from African Wind Power/Abundant Renewable Energy, Bergey Windpower Co., Southwest Windpower, and Wind Turbine Industries.

Many of the turbines were installed during workshops to expose as many people as possible to the process and technology. Students from the Appropriate Technology program at Appalachian State University and staff members of the Small Wind Initiative were involved in all of the installations. The turbines installed are listed in the table, along with their rated output, tower height, and tower type.

Tested Wind Turbines

Batteryless Grid-Tie Turbines	Rated Power (W)	Tower Height (Ft.)	Tower Type
African Wind Power (AWP) 3.6	1,500	105	Guyed tilt-up
Jacobs 31-20	20,000	120	Freestanding lattice
Southwest Windpower Whisper 200	1,000	50	Guyed tilt-up
Southwest Windpower Whisper 500	3,000	70	Guyed tilt-up
Battery-Based Grid-Tie Turbines			
Bergey XL.1 (24 V)	1,000	105	Guyed tilt-up
Southwest Windpower Air X (24 V)	400	45	Guyed tilt-up
Southwest Windpower Whisper 100 (48 V)	900	80	Guyed tilt-up
Southwest Windpower Whisper 500 (48 V)	3,000	70	Guyed tilt-up

A "bird sweep" involves inspecting the ground around each tower in a back-and-forth manner, looking for bird carcasses. The inspected area covers the guy-wire diameter, plus about 3 meters (10 ft.). If the tower has no guy wires, the diameter of the inspected area is approximately the tower height. We searched the site under all of the turbines using the Audubon's recommended procedures a total of twenty times during the fall and spring migration period. In addition, we always kept our eyes open while at the site working on other things. Over the last year, we found what was left of one bird carcass.

Noise

Noise can be a problem associated with any piece of machinery. Most permitting guidelines now being developed for wind turbines around the country address noise, and specify allowable noise at the adjacent property line, the nearest dwelling, or at a certain distance from the turbine. While there is no completely satisfactory way to measure the subjective effects of noise, typically 50 to 60 decibels is considered the maximum allowable, with some exceptions for short-term events.

ANEMOMETER LOAN PROGRAM

A goal of the Small Wind Initiative has been to operate an anemometer loan program to help those in the western part of the state more accurately assess their wind resources.

Anemometers measure the speed of the wind, wind vanes determine the direction of the wind, temperature sensors determine the possible icing of these sensors, and dataloggers collect and store all of this data. These sensors are mounted on a tower at prospective wind turbine sites.

An anemometer loan program provides the public the opportunity to use these towers to determine their own wind resources. This is an important service for both the landowner and the small wind industry in general. The landowner can borrow the equipment instead of making a big financial investment. It is good for the small wind industry because it helps prevent the use of the technology at inappropriate sites, which makes the technology seem like it is ineffective.

This program has also been beneficial to Appalachian State University's Appropriate Technology program. It has allowed students the opportunity to learn about the process behind wind assessment by getting involved with the construction of these towers. The general public has also had the opportunity to learn about wind assessment through joint ventures between the Small Wind Initiative's workshops and scheduled anemometer tower installations. There are now more than twenty anemometer loan programs in the United States supported by the DOE's Wind Powering America program.

The range of 50 to 60 decibels has been described as the noise in a typical house or office building. The SWI used the International Electrotechnical Commission standards for acoustic emission measurement techniques as much as possible for this work. Our study shows that noise from small wind turbines typically tracks the ambient noise fairly closely. Except during high winds, gusting conditions, and while furling, turbines can barely be heard above the ambient wind noise. The amount of time during the year when they exceed the 60-decibel limit being adopted by many communities is less than 1 percent at our very windy site.

Prospective Wind Sites

Another educational goal of the project has been to identify the owners of windy land, and provide them with the information and tools necessary to take advantage of small-scale wind power. A total of 16,000 property owners in our region were identified as having Class 3 or higher wind resources.

A postcard was developed with a brief note indicating that our research has led us to believe that the recipient owns land with good wind resources on it. The card also provides:

- Information about wind energy
- A picture of a small residential wind turbine installation
- Contact information for local companies that sell and install wind turbines
- Contact information for manufacturers of wind equipment
- Upcoming workshops information
- Contact information for the Small Wind Initiative
- Information about the anemometer loan program in western North Carolina
- Incentives for producing electricity with wind energy

We have been contacted by more than 100 of the postcard recipients for additional information. While the numbers are still small, we hope that a seed has been planted that will eventually motivate those with good wind resources in western North Carolina to learn more about wind energy and to adopt the technology.

Investing in Wind

The Small Wind Initiative has created a research and demonstration facility, raised community awareness, contacted owners of windy property, reached out to key decision-makers statewide, established a nationally respected training program, and conducted wind measurements with the hope of increasing the level of acceptance and understanding of wind power in the Southeast. In doing so, the Small Wind Initiative has given hundreds of people the opportunity to experience wind-electric technology firsthand.

Investing in a wind energy system is generally not a step most landowners can make immediately—many may even think about it for years before they make a decision. The education and information provided by the SWI are expected to continue impacting the wind industry and North Carolina's energy portfolio far into the future.

Access

Dennis Scanlin, Appalachian State University, Dept. of Technology, Boone, NC 28608 • 828-262-6361 • scanlindm@appstate.edu • www.wind.appstate.edu

Brent Summerville, Appalachian State University, Dept. of Technology, Boone, NC 28608 • 828-262-7333 • wind@appstate.edu • www.wind.appstate.edu

Mike Dooraghi, Appalachian State University, Dept. of Technology, Boone, NC 28608 • 828-262-7333 • mojisimo@yahoo.com • www.wind.appstate.edu

North Carolina State Energy Office, 1340 Mail Service Center, Raleigh, NC 27699 • 800-662-7131 or 919-733-2230 • Fax: 919-733-2953 • energyinfo@ncmail.net • www.energync.net

AWS Truewind LLC, 255 Fuller Rd., Ste. 274, Albany, NY 12203, 518-437-8660 • Fax: 518-437-8659 • info@awstruewind.com • www.awstruewind.com • Wind mapping

Campbell Scientific Inc., 815 W. 1800 North, Logan, UT 84321 • 435-753-2342 • Fax: 435-750-9540 • info@campbellsci.com • www.campbellsci.com • Dataloggers

International Electrotechnical Commission, PO Box 131, Ch-1211, Geneva 20 Switzerland • 41-22-919-02-11 • Fax: 41-22-919-03-00 • info@iec.ch • www.iec.ch • Acoustic standards

NRG Systems Inc., 110 Riggs Rd., Hinesburg, VT 05461 • 802-482-2255 • Fax: 802-482-2272 • info@nrgsystems.com • www.nrgsystems.com • Wind assessment technology (anemometers, dataloggers, etc.)

Omni Controls Inc., 5309 Technology Dr., Tampa, FL 33647 • 800-783-6664 • Fax: 813-971-5117 • sales@omnicontrols.com • www.extech.info • Anemometers & dataloggers

Turbine Manufacturers:

Abundant Renewable Energy, 22700 NE Mountain Top Rd., Newberg, OR 97132 • 503-538-8298 • Fax: 503-538-8782 • info@abundantre.com • www.abundantre.com • AWP 3.6

Bergey Windpower Co., 2200 Industrial Blvd., Norman, OK 73069 • 405-364-4212 • Fax: 405-364-2078 • sales@bergey.com • www.bergey.com

Southwest Windpower, 1801 West Rt. 66, Flagstaff, AZ 86001 • 866-807-9463 or 928-779-9463 • Fax: 928-779-1485 • info@windenergy.com • www.windenergy.com

Wind Turbine Industries Corp., 16801 Industrial Circle SE, Prior Lake, MN 55372 • 952-447-6064 • Fax: 952-447-6050 • wtic@windturbine.net • www.windturbine.net • Jacobs

Cost-Effective HYBRIDS

Andy Kerr

Hybrid electric vehicles (HEVs) may be the green thing to do, but can you save enough greenbacks on operating costs to justify paying a higher upfront purchase cost? Maybe, maybe not. As you'll find out here, it all depends.

This article examines economic and financial methods you can use to evaluate the "profitability" of purchasing an HEV. The example I'll use is my purchase of a 2006 Ford Escape Hybrid, actually bought in 2005. In my case, buying a hybrid was an excellent investment that will reap profits far in excess of other financial investments. Because of new federal income tax credits for 2006 and 2007, as the calculations show, it would have been an even better investment had I waited.

The big question is: Can you too benefit by investing in an HEV? You won't know until you run the numbers.

Needs Vs. Wants

For buying a new automobile, the best economic choice is not necessarily the best financial choice. Even an "inexpensive" new car costs thousands of dollars. Though in most of modern America a car is a necessity, it is also a luxury. If you have the money to pay for it, your choice of automobile reflects your *wants* more than your *needs*. Larger size, more power, and other extras are wants, though the purchaser often perceives them as needs.

So, given that I need—er, want—a certain kind of vehicle with a certain set of options and accessories, I can apply economic and finance principles to determine the most "efficient" purchase. This is usually the lowest price tempered by perceived quality—and getting all the bells and whistles that you want.

Financially speaking, you don't "invest" in an automobile. Cars are not only hugely expensive to own and operate (and hugely fun and convenient, so we buy them anyway), but they depreciate in value, while investments usually appreciate. However, given that you can expect reduced operating costs, mostly in buying less fuel and fewer oil changes, you *can* consider the marginal additional cost of purchasing an HEV as a financial investment.

Making the Switch

My 1995 Toyota four-cylinder, four-wheel drive (4WD) Tacoma had 225,000 miles (362,102 km) on it and was beginning to burn oil. It probably could have made it to 300,000 miles (482,803 km), but at the risk of increased

The Ford Escape Hybrid is currently the most energy-efficient SUV on the market.

repair costs and decreased reliability. Therefore, I deemed it "economic" to buy a new vehicle. I wanted an all-wheel drive with some clearance, which is necessary for my work. (I also turned 50 last year, so it was my equivalent of buying a red sports car.)

Since I wanted a 4WD hybrid SUV, I had only two choices—a Toyota Highlander Hybrid or a Ford Escape Hybrid. I've long been a Toyota man, and never did I think I'd buy a Ford. However, compared to the Highlander, the Escape is a small—rather than midsize—SUV, gets better mileage, and costs about US$10,000 less. Finally, when a Toyota engineer was quoted as saying that the vehicle's "intelligent four-wheel drive" meant that the Highlander was not recommended for off-pavement use, my decision was final. I don't drive off-road, but I do drive off-pavement.

Figuring Assumptions

To conduct my evaluation, I built a computer spreadsheet similar to the tables on pages 68 and 69. You can get this Excel spreadsheet and plug in your own numbers from the Promised Files area of the Downloads section at www.homepower.com. It will work for any hybrid vehicle evaluation.

To determine the financial benefits or costs of investing in a hybrid vehicle, several questions had to be answered. Some were easily obtainable and firm, while others were guesstimates. For analysis purposes, I assumed that the car is purchased at the end of a calendar and tax year (Year 0) and is operable for a decade (Years 1–10). It may be at the end of the analysis period that the resale value of the vehicle is higher because it is a hybrid. Or maybe not, if the battery hasn't been replaced. Since it is an unknown market and a decade in the future, I ignored any possible "salvage" value.

Pricing. What is the price difference between the hybrid and conventional versions of the same vehicle with the same options? Determining the actual price of a new car isn't easy. Special fees, what a dealer will give you for a trade-in, manufacturer rebates, and how much the dealer drops the price due to your hard bargaining all determine what you'll pay.

I started by calculating the difference between the manufacturer's suggested retail price (MSRP) for both the standard (no options) hybrid and nonhybrid versions. With the Toyota Prius, which doesn't have a companion nonhybrid model, you'll need to use the closest comparable model, the nonhybrid Camry. Also, at least with the Ford Escape, several features that were optional on the nonhybrid version were standard on the hybrid model. I had to carefully review the price of the options and extras packages to determine the actual cost of "hybridizing" the vehicle. Finally, consider that hybrids are in a seller's market (demand exceeds supply), while nonhybrids are in a buyer's market (supply exceeds demand). While you can likely bargain down the cost of a nonhybrid, expect to pay list price for a hybrid.

Since SUV sales are sluggish due to higher fuel prices, I guesstimated that I could bargain down the dealer at least US$2,000 on the cost of a nonhybrid, though an old sage once told me that there are three things that a man will most

Running the Numbers

In its April 2006 issue, *Consumer Reports* announced that hybrids are more expensive to own and operate ("The dollars & sense of hybrids," *Consumer Reports*, April 2006).

CR later noted that their April auto issue contained flawed data that said, compared to gasoline cars in the same class, no hybrid vehicles could save their owners money. Their revised figures show that two of the six hybrids analyzed do save their owners money in the first five years.

My review of *CR's* original methodology didn't change my conclusions. *CR's* article was a general overview that compared average operating costs of all cars in a class. For example, the Subaru Forester and the Ford Escape are in the same class, but the less-expensive Forester didn't have some features that I wanted. I compared the hybrid and nonhybrid versions of the Ford Escape with similar options and accessories.

Their calcuations didn't factor in possible state tax credits (very significant in my case), and assumed lower resale values for all hybrids, for which there is yet no evidence. It's equally plausible that hybrids will have a *higher* resale value in the future.

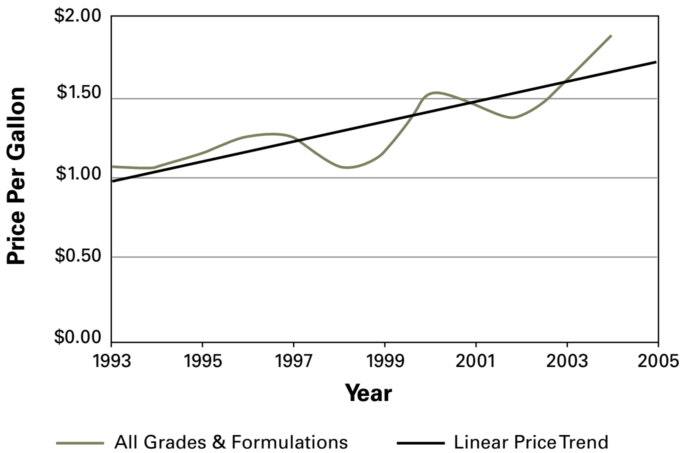
Their article also projected that hybrid repairs will cost more over the life of the vehicle because few independent auto repair shops now work on hybrids. My prediction is that this won't be the case when my rig is out of warranty. And *CR* assumed selling the vehicle after five years, while I'm planning to keep mine for ten.

They also reported that in most cases insurance was higher for hybrids than for nonhybrids. I found no difference in my case and recently learned that Travelers Insurance now offers a 10 percent discount to hybrid owners.

I also used complex financial analysis techniques in my methodology. And, while they used national averages, I used actual numbers based on my personal experience.

To determine if a hybrid is right for you (there is no question it is better for the Earth), you need to collect the data and run the numbers specific to your situation. Like most things in life, "it all depends."

U.S. Retail Gasoline Prices



Source: U.S. Energy Information Administration

always lie about (even to himself): his sexual prowess, his weight, and how much he saved on buying a new car.

Tax Breaks & Subsidies. What government subsidies are available for purchasing a hybrid vehicle? As an Oregonian, I can receive a US$1,500 income tax credit (directly reducing the bottom line of my tax bill). Eighteen other states also offer incentives, though some incentives are limited to merely letting hybrid drivers drive solo in the high occupancy vehicle lanes.

For 2006 and 2007, you can get a federal income tax credit between US$250 and $3,150, depending upon the model. Among other factors, the credit is based upon estimated fuel savings of the vehicle compared to others in its class. Some "hybrids" are so modest in their design that they don't qualify for any federal tax credit.

Miles You Drive. I estimated my annual mileage based on my own documented historical use. The more miles you drive, the better the financial returns on your hybrid investment. Check your odometer: The average American racks up at least 15,000 miles (24,140 km) annually.

Fuel Cost. What are you paying for a gallon of fuel? Just note this the next time you fill up at the pump.

Fuel Economy. What is the estimated mileage difference between the hybrid and nonhybrid options? Choose the closest comparable nonhybrid model. U.S. Environmental Protection Agency (EPA) ratings are not particularly accurate for a given model—the tested "highway" speed is 48 mph (77 kmh), but they are relatively comparable between models.

Scheduled Maintenance. What is the cost of an oil change, and what is the recommended mileage between oil changes for each model (hybrid and nonhybrid)? I estimated US$30 for the cost of an oil change. HEVs offer significant savings in avoided oil changes. A hybrid engine can go twice as far between oil changes because the engine is not actually running for many of those miles.

Future Fuel Costs. Since we're factoring in operating costs over the anticipated ten-year "life" of the car, we'll need to guesstimate how much fuel prices will—on average—rise annually. Though the national average gasoline price per gallon spiked at US$3.12 the first week of September 2005, it started the year at US$1.82 and ended it at US$2.24. Last year saw steadily increasing demand in the United States (despite higher prices), rapidly increasing demand in China, production disruptions due to Gulf of Mexico hurricanes, and continued instability in the Middle East.

Considering the historical data (see graph at left) and that the United States is still fighting Oil War II, I forecast an increase of 10 percent annually. The collection, analysis, and dissemination of data by the U.S. Energy Information Agency (EIA) is excellent. However, I feel that EIA's forecasts are suspect, given that it is not in the interest of this (or any) administration (not to mention Big Oil) to forecast higher energy costs. In any circumstance, if gasoline prices increase faster, the more profitable the hybrid investment; if gas prices rise more slowly, the less profitable the investment.

Inflation Rate. We'll also need to estimate the inflation rate. I guessed 3 percent per year, which is about what it has been in recent history. Though U.S. Federal Reserve Board Chair Alan Greenspan has retired, his successor Ben Bernanke is likely to keep a tight reign on inflation.

Kerr's Ford Escape Hybrid Cost Analysis

2006 or 2007 Tax Year	Data*
MSRP of hybrid electric vehicle (HEV)	$29,140
MSRP of comparable non-HEV	$24,650
Bargained-down savings on non-HEV	$2,000
Out-of-pocket cost of purchasing an HEV	$6,490
State income tax credit	$1,500
Federal income tax credit for Escape hybrid	$1,950
Estimated miles driven annually	20,000
Cost of 1 gallon of gasoline (estimated)	$2.50
Estimated overall EPA mileage of HEV (mpg)	31.0
Estimated overall EPA mileage of non-HEV (mpg)	20.5
Annual cost of fuel for HEV	$1,613
Annual cost of fuel for non-HEV	$2,439
Annual fuel-cost savings of operating an HEV	$826
Estimated cost of oil change	$30
Recommended miles between oil change (HEV)	10,000
Recommended miles between oil change (non-HEV)	5,000
Estimated annual rate of fuel cost increases	10%
Estimated annual general inflation rate	3%
Car loan interest rate	0%
Car loan term (whole years)	0
Cost of capital (aka "discount rate")	10%

*All dollar amounts in US$

Loan Interest Rate. I didn't borrow any money to purchase my new HEV, but if you borrow money to buy a new car, you'll need to know how much interest you're paying on the part of the car loan that covers investing in a hybrid. Don't delude yourself into believing that you are paying no interest on a "0 percent interest" loan—the interest is just buried in the loan principal. To discover the interest, compare the loan principal, term, and total payments with what you would pay if you paid cash.

Discount Rate. What is your personal or business discount rate— the rate of interest used to determine the present value of a stream of future income? Generally, you take the prime rate and add 2 to 3 percent. In late 2005, the prime rate was 7 percent, which would give a discount rate of 9 to 10 percent.

Adding It Up

Let's examine the spreadsheet ("Kerr's Ford Escape Hybrid Cost Analysis"). It is constructed on the assumption that I will own the car for ten years (such is my habit), and projects the annual savings in fuel and oil changes out a decade, discounting them back to present-day dollars.

Analyze This!

The beauty of electronic spreadsheets is the ability to easily analyze different scenarios. Certain costs are known, while other costs must be estimated. Estimates are very rarely spot on. What if there are no tax subsidies? What if gasoline prices increase only at the general rate of inflation? What if the battery lasts 200,000 miles?

By considering the range of alternatives, you can anticipate the financial consequences of your predictions. But in my case, I found that even the potential worse-case scenario (no tax benefits, fuel cost increases limited to the general inflation rate, and having to replace the traction battery) still reflects a good investment.

Kerr's Ford Escape Hybrid Cost Analysis

Investment Analysis	Year 0 2005	Year 1 2006	Year 2 2007	Year 3 2008	Year 4 2009	Year 5 2010	Year 6 2011	Year 7 2012	Year 8 2013	Year 9 2014	Year 10 2015
Out-of-pocket cost (investment)	-$6,490	—	—	—	—	—	—	—	—	—	—
Annual fuel savings	—	$826	$909	$1,000	$1,100	$1,210	$1,331	$1,464	$1,611	$1,772	$1,949
Federal &/or state tax incentives	—	$3,450	—	—	—	—	—	—	—	—	—
Annual oil change savings	—	$60	$62	$64	$66	$68	$70	$72	$74	$77	$79
Finance charges	—	—	—	—	—	—	—	—	—	—	—
Battery replacement	—	—	—	—	—	—	-$3,000	—	—	—	—
Annual savings	-$6,490	$4,336	$971	$1,064	$1,166	$1,278	-$1,599	$1,536	$1,685	$1,849	$2,028
Cash flow	-$6,490	-$2,154	-$1,183	-$120	$1,046	$2,324	$725	$2,261	$3,946	$5,795	$7,823
Annual return on investment	—	67%	15%	16%	18%	20%	-25%	24%	26%	28%	31%

Average return on investment	22%
Net present value	$2,619
Internal rate of return	23%
Simple payback (deduce from cashflow; the years to turn and remain positive)	3.1

Hybrid Electric Vehicle Availability

Compacts & Sedans	Expected Availability	Est. Fed. Tax Credit*
Toyota Prius	Now	$3,150
Honda Civic (automatic)	Now	2,100
Honda Civic (manual)	Now	1,700
Honda Insight (automatic)	Now	1,450
Lexus GS 450h	2006	1,300
Nissan Altima	2006	1,300
Toyota Camry	2007	1,950
Honda Accord	Now	650
Chevrolet Malibu	2007	650
Honda Insight (manual)	Now	0
Ford Fusion	In the works	—
Hyundai—two subcompact models	In the works	—
Mercury Milan	In the works	—

SUVs & Minivans

Ford Escape SUV (2WD)	Now	$2,600
Toyota Highlander SUV (2WD)	Now	2,600
Lexus RX 400h SUV	Now	2,200
Toyota Highlander SUV (4WD)	Now	2,600
Ford Escape SUV (4WD)	Now	1,950
Mercury Mariner SUV (4WD)	2007	1,950
Chevrolet/GMC Tahoe/ Yukon	2007	1,800
Saturn VUE	2007	1,300
Dodge Durango	In the works	—
Honda Pilot	In the works	—
Mazda Tribute	In the works	—
Porsche Cayenne	In the works	—
Toyota Sienna minivan	2007	—

Trucks

Chevrolet/GMC Silverado/Sierra	2008	$900
Chevrolet/GMC Silverado/Sierra (4WD)	Now	650
Chevrolet/GMC Silverado/Sierra (2WD)	Now	250
Dodge Ram	In the works	—

Source: American Council for an Energy Efficient Economy

One extraordinary item is listed in the spreadsheet: battery replacement. The jury is still out on battery replacement for HEVs, but the evidence for battery longevity seems compelling. The first generation Prius warranted its traction (as opposed to "starting and accessories") battery for eight years or 100,000 miles (160,934 km). Very few batteries have been replaced and almost all are still in service well beyond the warranty period.

The traction battery in the Escape hybrid also is warranted for eight years or 100,000 miles. In the so-called "green states" (those with California-level emissions standards), the identical vehicle is warranted at ten years or 150,000 miles (241,402 km). The longer warranty is required to obtain the "AT-PZEV" (Advanced Technology-Partial Zero Emission Vehicle) rating.

Both anecdotal reports from consumers, and research by government and industry strongly suggest that traction batteries will last far longer than originally anticipated. It's very likely the battery will last well beyond 100,000 miles, if not well beyond 150,000 miles. Nonetheless, the risk is mine to assume after the warranty expires. Since I estimated that I drive 20,000 miles annually, and my traction battery will be out of warranty in Year 6, I have included the estimated cost of a replacement battery (US$3,000) in that year.

The Bottom Line

Considering just the anticipated savings in fuel costs and oil changes, the simple payback period (a simplistic capital budgeting technique) on the additional cost of my purchasing and operating an Escape hybrid—as opposed to a comparable Escape nonhybrid—is a little more than three years.

The annual average return on investment (an unsophisticated capital budgeting technique) is 22 percent. The internal rate of return (a sophisticated one) is 23 percent. These expected returns are tax-free, because money I don't have to spend is money I don't have to earn and pay taxes on. Comparing these returns to what my (generally taxable) savings and retirement accounts are producing means I'm dollars ahead.

The most recent stock-market bubble—which has now long since burst—was yielding an annual return on investment between 20 and 30 percent. There is far less risk investing in a hybrid vehicle than in the stock market. I made reasonable assumptions about battery replacement, general inflation, projected costs of gasoline, and miles driven, which led to a conservative analysis of the minimum return I could expect for purchasing the hybrid option.

The net present value (at a 10 percent discount rate) is US$2,615. In other words, for spending US$6,490 today to "hybridize" my new vehicle, I come out US$2,615 ahead in present value, given the anticipation of future savings. It's like writing a check for US$6,490 and immediately getting an asset worth US$9,105 (US$6,490 + US$2,615). You're richer today because you'll have fewer future expenses.

Of course, money is not the measure of all things. Nonetheless, it's always nice when a good investment for myself coincides with doing well for the planet.

Access

Andy Kerr, Czar, The Larch Company, 1213 Iowa St., Ashland, OR 97520 • 541-201-0053 • andykerr@andykerr.net • www.andykerr.net

American Council for an Energy-Efficient Economy • www.aceee.org

Bloomberg • www.bloomberg.com/markets/rates • Prime rate information

Bradley Berman's Hybridcars.com • www.hybridcars.com

Energy Information Agency • www.eia.doe.gov • U.S. gasoline prices

Jason Siegel's GreenHybrid • www.greenhybrid.com

State incentives for hybrid vehicles • go.ucsusa.org/hybridcenter/incentives.cfm

Union of Concerned Scientists Hybrid Web Site • www.hybridcenter.org

www.fueleconomy.gov • EPA mileage ratings and official IRS tax credit determinations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Frank & Jane

Thunder Bay's Renewable Energy Boosters

Hubert den Draak

Suppose you're Canadian and live in the centre of the universe (Toronto). You get in the car and drive in the direction of Sudbury. There you hang a left and keep moving right along to Sault Ste. Marie. Once in "the Soo," you change tack again and head northwest, following Lake Superior's rugged shoreline, finally arriving at our destination—Thunder Bay.

Here, the centre of the universe is a good 1,500 kilometers (932 mi.) away, or two solid days of driving. The scenery is breathtaking, eagles soar overhead, and, other than roaming bear and moose, the land is pretty much unpopulated.

Rugged Individualists

The people who live here can roughly be divided into two categories—those who work in the forest and paper industry, and those who don't. The latter are often rugged individualistic types that don't fit in. Or more accurately, that don't *want* to fit in, and don't particularly care about the latest trends and trinkets in the cities.

Property is still affordable here, but frequently comes with a catch. Often "the grid" is too far away to hook up to without being charged an arm and a leg. So here we are in remote northern Ontario, gawking at the staggering number of solar- and wind-electric systems popping up just about everywhere, and one thing becomes pretty clear—folks here know a thing or two about energy of the renewable kind.

When you start talking to local folks, one particular name keeps cropping up—Frank. Just plain Frank. His last name proves too complicated to commit to memory, and besides, everybody here knows Frank from Frank's Alternate Energy. A phone call conjures up a roaring Volkswagen Jetta with a very bearded Frank Ilczyszyn (pronounced "elcheson") behind the wheel, face hidden by the brim of a well-used straw hat.

A Conversation

The first thing Frank does after extracting his tall frame from the car is hand me three brochures on renewable energy, produced by Natural Resources Canada. "Yeah, I always give those first. People need to do their homework before we launch into anything. Plus, it's a good read." My conversation with Frank had started…

So how *is* the market for solar and wind energy systems in northwest Ontario?

"Well, it seems to be picking up again, mostly because of climbing energy prices. I have a strong feeling that people know that it's not a price-glitch this time. The days of cheap energy are behind us for good. So now I'm getting all these calls from folks who want to switch to solar or wind electricity, thinking it's going to save them a bundle. Of course, they also want to keep their air conditioners and their hot tubs and their freezers, not even considering cutting back on their energy consumption," Frank says, shaking his head. "Then there are those who just say to hell with Hydro's (Ontario's electricity utility) monopoly, and who want to be independent."

And how about environmental concerns?

"Hard to say. Of course it plays a role for a number of my customers, and it's definitely a factor in my personal choices. But for now I'd say it's more for practical reasons, and you can't blame them for that."

When talking to people with a solar- or wind-electric system here, your name is often the first to crop up. Do *you* have a monopoly here?

"He-he-heh, meaning you'd go from one monopoly to another, right? No, there's a few more working in this field, but I guess I'm the only full-service retailer and full-time installer in all of northwest Ontario. The others work on smaller projects, like wilderness cabins or boats. I'm the only guy around who sets up full systems that get inspected and approved by the Electrical Safety Authority."

This is a region where large wildlife outnumbers the human population; in other words, the region may be quite large, but the market is disproportionately small. Doesn't that bother you?

"Nah, not really. I don't have that burning ambition to grow big, having to worry where to hire good people from, and once you have them, worrying how to keep them busy. I like it small; I like dealing with my customers directly, getting to know them and their site, which is almost as important."

How did you get involved in renewable energy sources in the first place?

"I've always been interested in it, and built my very crude first system back in '91. Nothing fancy, and certainly nothing others would be interested in buying. But it worked for me: I was off the grid, off the Hydro monopoly! I'll never forget the moment I switched on my system, and for the first time saw the bright-red digital readout. I mean it was like candy! I just couldn't tear myself away from it. That feeling has never really left me. I decided to go cold turkey, and start making a living in the renewable energy sector right then and there. That was back in '94, and it was scary.

I didn't charge my first client anything other than my expenses; I was basically learning as I went along. The big thing I learned was that I just loved it. I loved the technology, I loved solving all kinds of problems, and most of all I loved the idea of generating clean electricity. With each finished new system, I still get my kicks out of the knowledge that there's another home or cottage that's independent of Hydro's monopoly, generating its own clean energy."

Frank's System

That system was put in more than ten years ago, and things have grown since then. Frank's own "crude little system" was transformed into a more reliable way of providing electricity to an expanding operation. It now consists of a 1.4 KW photovoltaic (PV) array, a 900 W Lakota wind generator on a 110-foot (34 m) tower, a Trace SW4024 sine wave inverter, and a bank of Surrette dual-case batteries.

This powers the typical home and office loads, as well as workshop loads—grinder, welder, drill press, power hand tools, a circulation pump for the wood-fired water heating system, and a freezer. The 5 KW Honda generator was upgraded to a 30 KW diesel for heavy production welding, and to provide backup electricity during extended cloudy periods. Incidentally, Frank is test-running the generator on 100 percent biodiesel made from waste vegetable oil, so far with impressive results.

Frank's Business

Frank's dislike of renewable energy companies that basically send you a standard kit with instructions in the box is clear.

"That's a recipe for catastrophe, unless you have a good deal of previous experience. We do a full site assessment for all of our customers, talk extensively with them, and educate them. I want to be honest with my customers, and always make clear that solar or wind energy is not the silver bullet that solves all of your energy problems, nor is it cheap. Sometimes the result is that they change their minds, but that is still preferable to customers getting into systems or a lifestyle that just doesn't suit them.

With her off-grid home, Jane Oldale has year-round energy security, even in Ontario's bitter winters.

"We do a lot of custom work and structures. Each system is different and has its own challenges, and I love that. Difficulties push you to be creative, be it technical or financial. I also like to use existing materials as much as I can, creating a silk purse out of a sow's ear whenever possible."

Meanwhile, the number of renewable energy systems in northwest Ontario has been growing steadily since Frank started his company here. Most applications consist of smaller off-grid systems, typically on the order of 800 to 1,200 peak watts. Most are just for seasonal use, due to the brutal winters here, but an increasing number of full timers are expanding their systems to include wind generators, usually in the range of 500 to 1,000 watts.

Frank installed northwest Ontario's first Electrical Safety Authority-approved, grid-tied renewable energy system. "I'll be polite here," says Frank, "so let's just say it was an exercise in frustration. The authorities just keep you dangling. They won't answer your calls, won't make decisions, and

Thunder Bay, on Lake Superior in Ontario, Canada.

generally don't seem to know what to make of it. Dozens of these systems have been installed all over southern Ontario without any significant problems, but up here we're still in the dark ages. They need a lot of education, so let's just hope this first system has set a positive precedent for the ones that will follow." (*Ed. note: Ontario recently passed a province-wide incentive program for solar- and wind-electric systems, and the proposed incentive structure may end up being one of the most progressive in North America.*)

Frank's Partner

Then there is Jane Oldale, Frank's business and life partner. She too lives off the grid, and is a self-proclaimed "conservation nut." Her energy needs average a very modest 2 KWH per day, met by a 435 W PV array, an older 600 W Whisper wind generator, a Trace SW2512 inverter, and a 520 amp-hour Absolyte battery bank.

When pressed to describe her role in the company, she hesitates and then offers, "Perhaps a renewable energy advocate?" But Frank is quick to point out that it's much more than that. "I'm no good with computers, but fortunately Jane seems to enjoy that part. So whenever we need something calculated or researched, she will handle that. She's also great with all things theoretical, whereas I'm more of a hands-on kinda guy."

Both Frank and Jane consider an off-the-grid life invaluable in relating to customers who want to know more. Jane especially sees it as an important part of her work to showcase her home and solar- and wind-electric system to people thinking of changing to a similar lifestyle, and does so with a great deal of grace and patience. Their off-grid lifestyles also prove indispensable for the numerous workshops they are involved in, as well as for classroom presentations at the college and university level.

An RE Future

Where does Frank see the renewable energy sector headed?

"Renewable energy is definitely on the upswing. Our government is slowly moving towards making us pay a more realistic price, closer to what it actually costs to produce oil, natural gas, and electricity, which is making renewable energy more competitive. There is an oil crisis coming straight at us, and it will hit us sooner than most of us would like to think."

Access

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"Tree Hugger—Sun Worshipper," Jane Oldale, *HP98*

Get Your GREEN ENERGY

Paige Prewett

Commodities known in the electricity industry as renewable energy certificates (RECs) are helping to drive renewable energy development. At its simplest, a REC is intended to represent the environmental benefits of nonpolluting electricity generated at a renewable energy (RE) facility, such as a wind farm or a grid-connected solar-electric system. These benefits include the prevention of air pollution and greenhouse gas emissions associated with burning fossil fuels.

Consider this: The average U.S. home uses close to 900 kilowatt-hours (KWH) per month. Every 1,000 KWH of electricity generated at a coal-fueled power plant produces an average of 2,071 pounds (939 kg) of carbon dioxide (CO_2), 13.8 pounds (6.2 kg) of sulfur oxides (SO_x), 4.8 pounds (2.1 kg) of nitrogen oxides (NO_x), and 3.2 pounds (1.5 kg) of particulate matter (PM). Similarly, a typical natural gas-fired power plant generates 1,205 pounds (547 kg) of CO_2, 13.8 pounds of SO_x and 4.8 pounds of NO_x per 1,000 KWH. Carbon dioxide and nitrous oxides are greenhouse gases that trap heat in the atmosphere and are associated with global warming. Sulfur oxides are precursors to acid rain, and particulates contribute to lung disease, respiratory infections, and asthma.

A typical REC represents 1,000 KWH of electricity generated at a facility that uses renewable energy sources—and wind- and solar-electric facilities produce *zero* emissions when generating electricity. By buying RECs, you can make an effective choice for clean electricity. And by demonstrating this demand with your dollars, you help encourage developers to invest in and build more RE supplies. Plus, you send a compelling message to utilities and lawmakers: The public *wants* clean energy.

The REC Genesis

An energy generation facility that relies on renewables produces two distinct products: 1) electricity, which mixes with and behaves like any other type of electricity; and 2) the environmental attributes or "greenness" of the source of the electrons entering the electricity system. A REC represents this greenness and the amount of electricity produced.

This electricity is sold at market price and delivered to the grid. The RECs are sold separately to utility green power programs, or through the retail market to people and organizations that are interested in supporting less polluting methods of electricity generation. This revenue plays a key role in making renewable energy projects financially viable and often can provide funding for new projects.

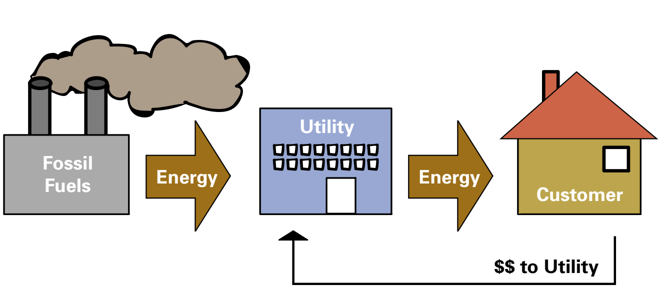
Real-World Applications

Let's say that your local grocery store has a mission statement expressly supporting clean energy. Each day, the store runs lights, freezers, computers, and cash registers to function as a commercial enterprise, but it doesn't have the financial means or solar access to invest in on-site electricity generation.

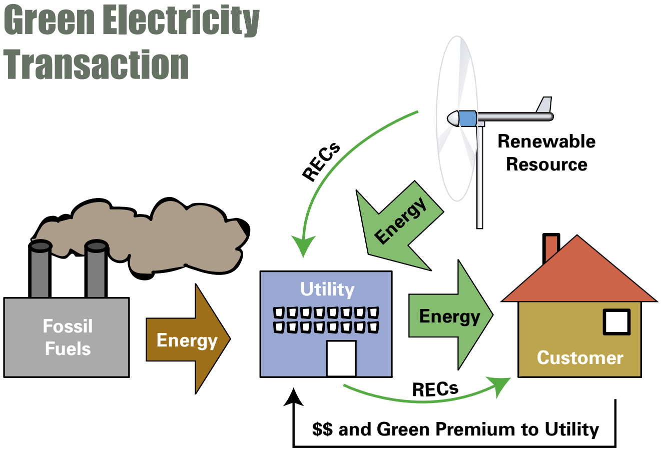
By purchasing RECs, the store supports renewable electricity added to the pool of energy being used in their region, commonly called "the grid." Although there is no way to track a green-energy electron from where it is generated to the customer, buying RECs helps "green" the region's overall energy mix, displacing "brown" energy that would otherwise serve this business and other grid-connected energy users.

In the retail market, RECs aren't purchased directly from RE-based plants, but from RE product brokers (marketers).

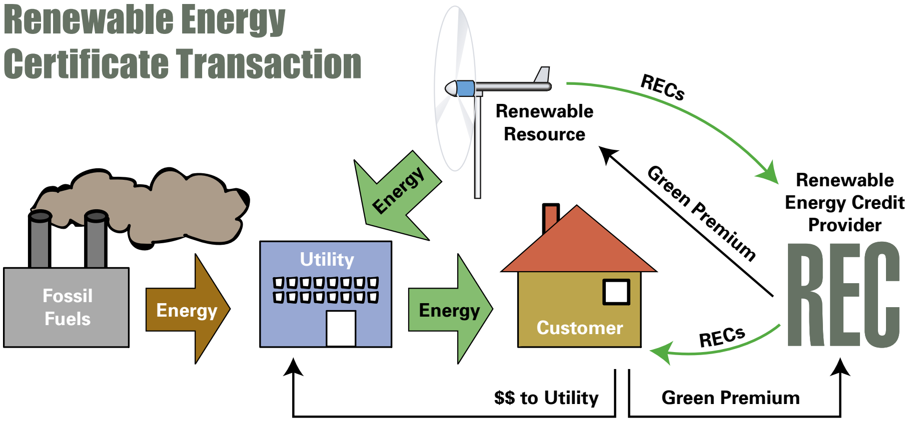
Traditional Electricity Transaction



Green Electricity Transaction



Renewable Energy Certificate Transaction



Although the store cannot purchase clean electrons straight from a regional wind farm, it can buy RECs. The electricity supplied by the store's utility stays the same, and the store makes a separate, voluntary transaction from the marketer to support clean energy from regional projects.

The Power of Green

If you have been wondering how to join the renewable energy revolution, but live in an apartment or house that has limited RE potential, RECs may provide an option. One 1,000 KWH wind or solar REC is intended to displace 1,340 pounds (608 kg) of carbon dioxide, the leading greenhouse gas.

Today, more than fifteen REC retail marketers sell RECs in the United States. You may be familiar with their product names, like Green Tags, ClimateSAVE, and Green Certificates. These for- and non-profit outfits make RECs available to the public. The price of RECs varies by marketer, but a typical 1,000 KWH REC costs from US$15 to $30, depending on the energy mix used to create it (e.g., solar-generated energy costs more than wind). Large purchases may be arranged by contract, resulting in a bulk-rate discount that reduces the cost by 40 percent or more.

In concert with everyday efficiency measures you implement (buying a more fuel-efficient car and driving less, for instance), you could also consider purchasing RECs to make your lifestyle or business activities more "carbon neutral." By analyzing your total energy consumption—the type of energy you use for electricity, transportation, and other carbon-generating activities—you can estimate your own carbon contribution to the atmosphere, and then calculate the number of RECs estimated to "neutralize" the pollution that results from these activities. Online carbon calculators (available on some marketers' Web sites) can quickly estimate your carbon impact.

Festivals, concerts, conferences, weddings, and other events also can have big environmental impacts associated with them. These occasions often present a unique awareness-building opportunity. Event planners can purchase RECs to help "offset" the pollution created by a particular event's energy usage and the pollution associated with travel and transport, while educating attendees about clean energy options.

Most REC marketers stipulate a minimum number of RECs you can purchase—usually one to two RECs annually. (RECs are most commonly sold in 1,000 KWH increments, but some marketers sell them in smaller KWH blocks.) By examining your utility bills, you can determine your home or business' electricity consumption and purchase enough RECs to offset some or even all of your annual use. When choosing a marketer, some people prefer RECs generated in their own region, and make their decision based on the location of generation and the type of energy source. Before you buy, you may also want to make sure that your REC purchase is third-party certified.

Watts New?

An issue of utmost importance is that RECs are derived from *new* renewables. To meet some standards, "new" is defined as a renewable energy facility that began operation or repowered (upgraded according to certain specifications) after January 1, 1997. The concept of new renewables is important because it means RECs buyers are paying to change the energy added to the grid, and not simply endorsing energy sources already available. RECs dollars should either support RE sources that were recently built to meet the growing demand for green electricity or facilities planned for the near future to fulfill anticipated demands.

A resource may be defined as "renewable" if it can be naturally replenished, though definitions vary by state and organization. Renewable sources for RECs are most often wind and solar energy, although some marketers include biomass (including landfill gas), geothermal, and low-impact hydropower in their products.

Access

Paige Prewett, Outreach & Marketing Consultant, Renewable Northwest Project & Bonneville Environmental Foundation • 541-855-5200 • prewett@mind.net • www.rnp.org or www.greentagsusa.org

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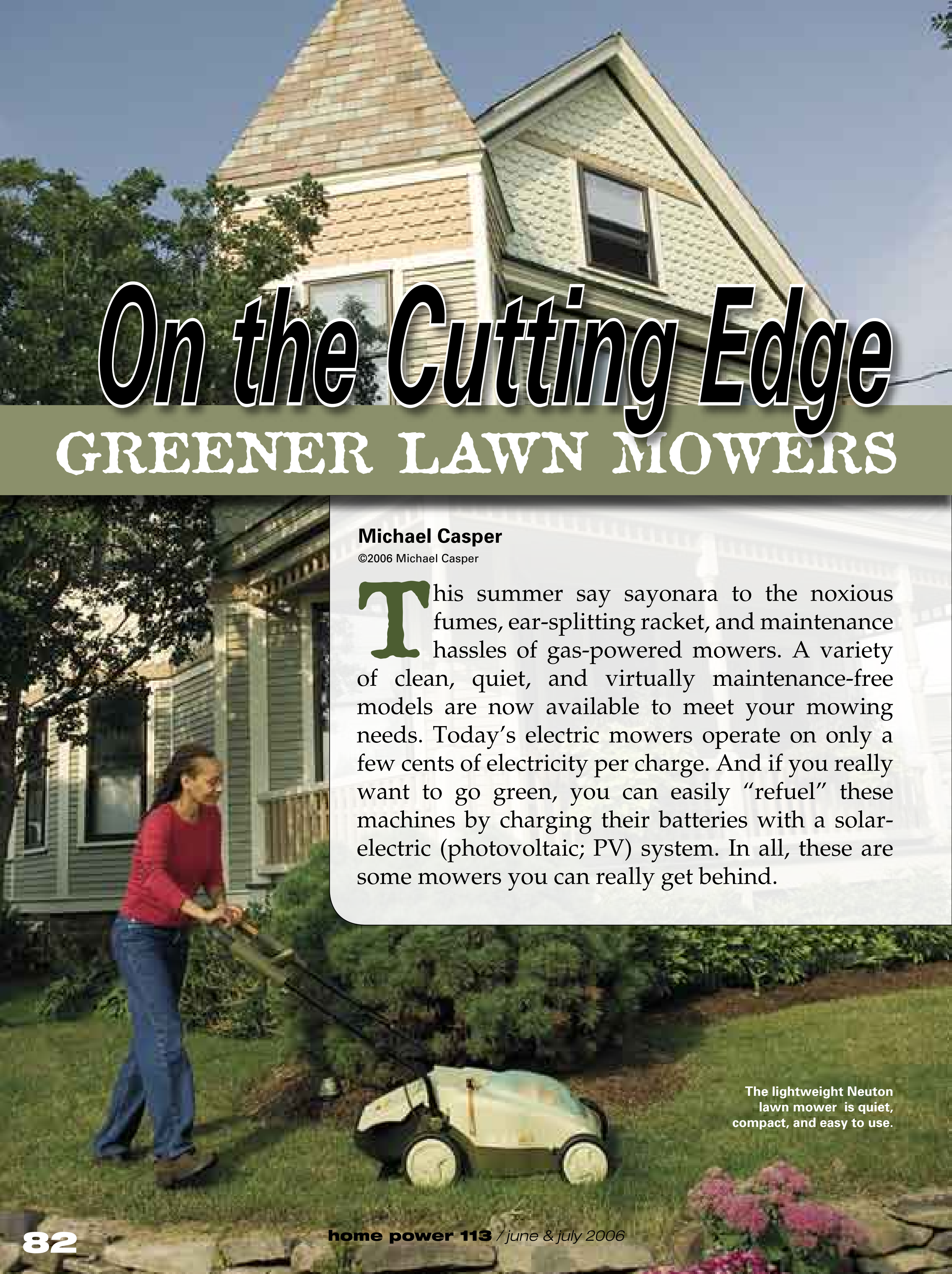
On the Cutting Edge

GREENER LAWN MOWERS



Michael Casper

This summer say sayonara to the noxious fumes, ear-splitting racket, and maintenance hassles of gas-powered mowers. A variety of clean, quiet, and virtually maintenance-free models are now available to meet your mowing needs. Today's electric mowers operate on only a few cents of electricity per charge. And if you really want to go green, you can easily "refuel" these machines by charging their batteries with a solar-electric (photovoltaic; PV) system. In all, these are some mowers you can really get behind.

The lightweight Neuton lawn mower is quiet, compact, and easy to use.

Your Choices

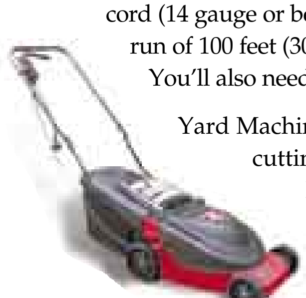
All of the electric-powered mowers will mulch grass—and a few will cut the lawn by themselves while you watch. Mulching mowers cut grass like a regular mower but also chop the grass into much smaller pieces. This "mulch" biodegrades faster than big blades of grass, releasing nutrients more quickly into the soil. A mulching mower blade has a longer sharpened edge and is shaped a little differently, and the mower deck is rounded to recut each blade of grass several times.

Corded Mowers

Black & Decker MM875

These walk-behind mowers look and cut just like the gasoline-fueled kind—they have a mower deck and a familiar blade. Most of them will mulch and some will bag the grass. The blades are easily sharpened and/or replaced at most local hardware stores or lawn mower repair shops.

Corded mowers have a plug-to-extension-cord type of connection. You will need an extension cord (14 gauge or better) if the run is long. Most manufacturers recommend a maximum run of 100 feet (30 m), so you'll need to remember this limitation for your lawn size. You'll also need to change your mowing attack so you don't run over the cord.



Yard Machines by MTD

Yard Machines by MTD (also sold under the Ryobi brand) and Bully's LawnPup are both 13-inch cutting width, corded mowers that are well suited for very small lawns. Their small sizes and light weight (about 27 pounds; 12 kg) make them easy to maneuver and store. For wider cuts, Yard Machines/Ryobi, Black & Decker's MM875, and Craftsman's 19-inch mowers cut with minimal weight (about 50 pounds; 23 kg) and have enough power to mulch grass well. These mowers have 12-amp draws and a 14-gauge extension cord is recommended. Manufacturer's suggested retail prices range from US$169 to $229.

Cut the Cord

Black & Decker CMM1000

Cordless mowers rely on a battery pack to run the mower. While there are no limits on where you cut, there are limits on run-time length. Although cordless mowers are usually designed with the most efficient motors to achieve the longest run times, the battery's charge only lasts so long. These mowers recharge by plugging them into a standard 120-volt AC receptacle. Typical charge time ranges from 12 to 16 hours. Because they have sealed gel-cell batteries, which do not need to stay level, they are especially good for mowing sloped lawns.

With its 14-inch-wide (36 cm) cut, Country Home Product's lightweight Neuton mower is well suited for smaller lawns and for folks who want an exceptionally quiet and easy-to-push electric mower. On a full charge, this mower's 24-volt, 10 amp-hour battery will give you about one hour of mowing time. Because it has a removable battery, you can extend your mowing time by having an extra charged battery handy. A separate mulching kit is available. This mower, which retails for about US$399, is available online (see Access).

For bigger lawns, Black & Decker's cordless CMM1000, which cuts a 19-inch-wide (48 cm) swath, has a 24-volt battery that gives about 50 minutes of cutting time (according to my own multiple test runs that take the battery down to a "yellow" charge level). On a full charge, this mower can cut up to one-third of an acre (1,335 m^2). A full recharge takes 14 hours, but in 4 hours the battery has enough charge to let you mow the last small patch of lawn. According to the manufacturer's literature, this mower's battery can deliver the equivalent of a 5-horsepower gas engine at peak torque. At 76 pounds (34 kg), this lawn mower looks and handles very much like a typical gas mower, but with much less noise. A gauge monitors the battery state of charge with green, yellow, and red charge levels. Expect to pay about US$450.

Opposite page: Courtesy Country Home Products/Neuton Power Equipment; This page: Courtesy Black & Decker; Courtesy Clean Air Gardening/MTD

Automatic Mowers

Courtesy Friendly Robotics

Friendly Robotics RoboMower

If you'd rather be loafing on your lawn than mowing it, an automatic mower could be what you're looking for. Robotic mowers come in several kinds and sizes. Make sure to buy the model with the latest software version that will allow you to program the most effective cutting routine for your lawn. Automatic mowers should not be used where children or pets can access the mowing area.

Due to their complex electronics, these mowers cost more than standard electric push mowers. And because there are some spots that these mowers cannot navigate, you might need to have another type of mower on hand.

These mowers can usually accommodate lawns up to 1 acre (4,046 m^2) and stay in your yard by sensing a perimeter wire you stake around the edges. You can lay out several perimeter areas—a front and backyard, or two halves of a big front yard, for example. The wire has to be laid out with wide, curved corners to accommodate the mower's turning radius. Avoid narrow strips, which could force the mower out of the perimeter by overrunning one side or the other. Trees can be "wired off" by running the perimeter wire around and back to where it started. And a crossover section—a small run in the perimeter that is "doubled back"—can be run with the coming and going wires next to each other, which cancels the signal in the wire. Once you have placed and staked the wire, you can let your mower loose with a test-run setting, where the mower moves but the blades do not revolve. Once you're satisfied with your staking, pressing the "go" button starts a cutting cycle.

Courtesy Kyodo America

The LawnBott Evolution

Friendly Robotics' RoboMower uses three stainless steel blades to cut a 21-inch-wide (53 cm) path. Two power wheels in back propel the mower and a front swiveling wheel acts as a guide. The RoboMower RL850 and RL1000 both have manual and automatic mowing modes, but the RL1000 has a docking station that can be programmed to start the mower automatically. Both have wired keypad remote controls on the top of the decks, which can be used to manually steer these mowers. LawnBott mowers use a four-blade cutting disc and feature a clamshell-type docking station. On a full charge, these mowers can run for 2 to 2.5 hours.

Besides having a hammock ready for your lazy lawn days, you'll need to have deep pockets. Automatic mowers don't come cheap, and you can expect to shell out from US$1,100 to $1,849 for the least expensive models.

THE LONG & SHORT OF IT

This year, Americans will use about 800 million gallons (3 billion l) of gasoline to mow their lawns. According to the U.S. Environmental Protection Agency (EPA), 17 million gallons (64 million l) of this will be spilled on the ground during lawn equipment refueling—more than all of the oil spilled by the Exxon Valdez.

The figures for air pollution from lawn maintenance are just as staggering. A poorly maintained lawn mower emits about the same amount of pollutants in one hour as a new car driven 340 miles (547 km). Another EPA study determined that the small engines used in lawn maintenance account for almost one-tenth of some types of air pollution here in the States.

Adding insult to injury is the brain-rattling racket gas-powered lawn mowers make. According to the Noise Pollution Clearinghouse, a typical gas-powered mower produces between 85 and 90 decibels, which is almost as much noise produced by a passing motorcycle. Both the EPA and World Health Organization recommend limiting exposure to noises this loud, and warn that prolonged exposure at these levels can cause hearing damage. In comparison, electric mowers are one-half to one-fourth as loud—more on par with an automatic dishwasher (55–70 decibels).

If you already have a solar-electric system installed, or are planning on installing one, consider this: A typical electric mower operated for an hour will only consume about 1.5 KWH of energy. And since the mower will probably be run about one day a week during the sunniest months of the year, solar-charged lawn mowing is not only possible, it's economical—especially when compared to the constant refueling a gas mower requires.

Even if you don't power your home with solar energy, switching from gas to an electric mower will help reduce both air and noise pollution. Besides costing cents to operate, you also avoid costly engine tune-ups and messy oil changes. Electric mowers are easy to maintain, and start with the push of button, putting an end to the tiresome task of yanking on a starter cord.

Riding Mowers

Courtesy Electric Tractor Corp.

The Electric Ox MP

If you have a large lawn or acreage, consider an electric riding mower or pairing an electric lawn tractor that can accommodate mowing implements. Electric Tractor Corporation's Electric Ox Multipurpose Tractor is one of the few electric tractors available today. Besides cutting your lawn, this multipurpose tractor can also tow, grade, and push snow. And with its optional onboard 1,500-watt AC inverter, the Ox becomes a portable AC supply, allowing you to use electric tools in remote areas. Six, 8-volt, deep-cycle lead-acid batteries keep this machine moving, and charging is as simple as plugging it in. The Ox retails for about US$8,250, plus a mower deck at about US$1,495.

Although it's no longer being manufactured, General Electric's Elec-Trak electric tractor has been a favorite mower of many for its reported capabilities, durability, and easy maintenance. You may be able to track down this brand of tractor (or others, like Wheel Horse or New Idea) in your local classifieds or by searching online auctions like eBay.

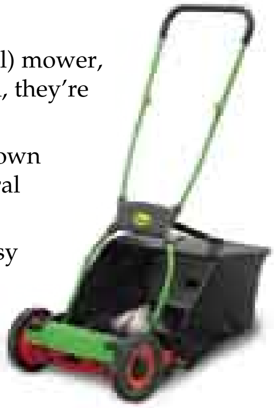
Reel Mowers

True lawn equipment luddites may want to consider a manual hand-push (also known as a reel) mower, which operates solely by your pushing power. Although most of these models are easy to push, they're best suited for well-established lawns under 6,000 square feet (557 m^2).

Typically these mowers leave a small cutting swath and can be somewhat ineffective in overgrown grass. For a more evenly cut lawn, they may also require the mower (that's you!) to make several passes over the lawn, as they can leave long clippings on top of the lawn.

Reel mowers can be a workout, but are hard to beat for their quiet cutting, reasonable price, easy storage, and functional simplicity and maintenance. "Modern reel mowers are not like the old 75-pound antiques of yesterday. They are well designed, lighter weight, and much easier to push and use," says Lars Hundley, president of CleanAirGardening.com.

For those who want less sweat equity, but still appreciate the simplicity of a reel mower, an electric reel mower may be the answer. Manual reel mowers, like the Brill, Sunlawn, Scott's Classic, and Great States, retail prices range from US$120 to $220. Electric reel mowers, like the Sunlawn EM1, cost more (about US$379), but can accommodate larger lawns.



Courtesy Clean Air Gardening

Brill reel mower with catcher

Mowing Maneuvers

This summer you can be on the cutting edge of a cleaner, greener lawn revolution by the simple act of using electric or hand-powered mowers. You'll save some time, money, energy, and—with the quiet operation and zero emissions of these mowers—even stay in your neighbors' good graces.

Access

Michael Casper, 9697 Lenore, Redford, MI 48239 • 313-533-0516 • allterrainhiker@copper.net

Selected Mower Manufacturer & Retailer Web Sites:

Bamabots • www.bamabots.com • Robotic mowers

Black & Decker • www.blackanddecker.com

CleanAirGardening.com • Reel mowers & Yard Machines

Composters.com • Brill & Bully LawnPup

Country Home Products/Neuton Power Equipment • www.neutonmower.com • Neuton

Electric Tractor Corp. • www.electrictractor.com • Electric Ox MP Tractor

FreePower Systems • www.freepowersys.com/sunwhisper.htm • SunWhisper PV-charged electric mower

Friendly Robotics • www.friendlyrobotics.com • Robotic mowers

Kyodo America Industries Co. Ltd. • 770-237-0364 • www.kyodoamerica.com • LawnBott robotic mower

MTD • www.mtdproducts.com • Yard Machines

Sears • www.sears.com • Craftsman; Black & Decker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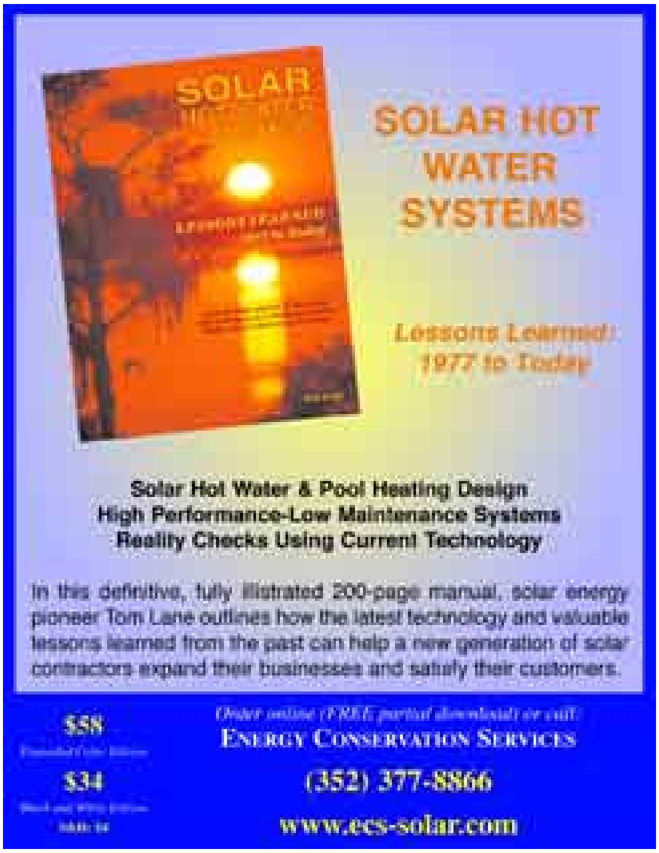
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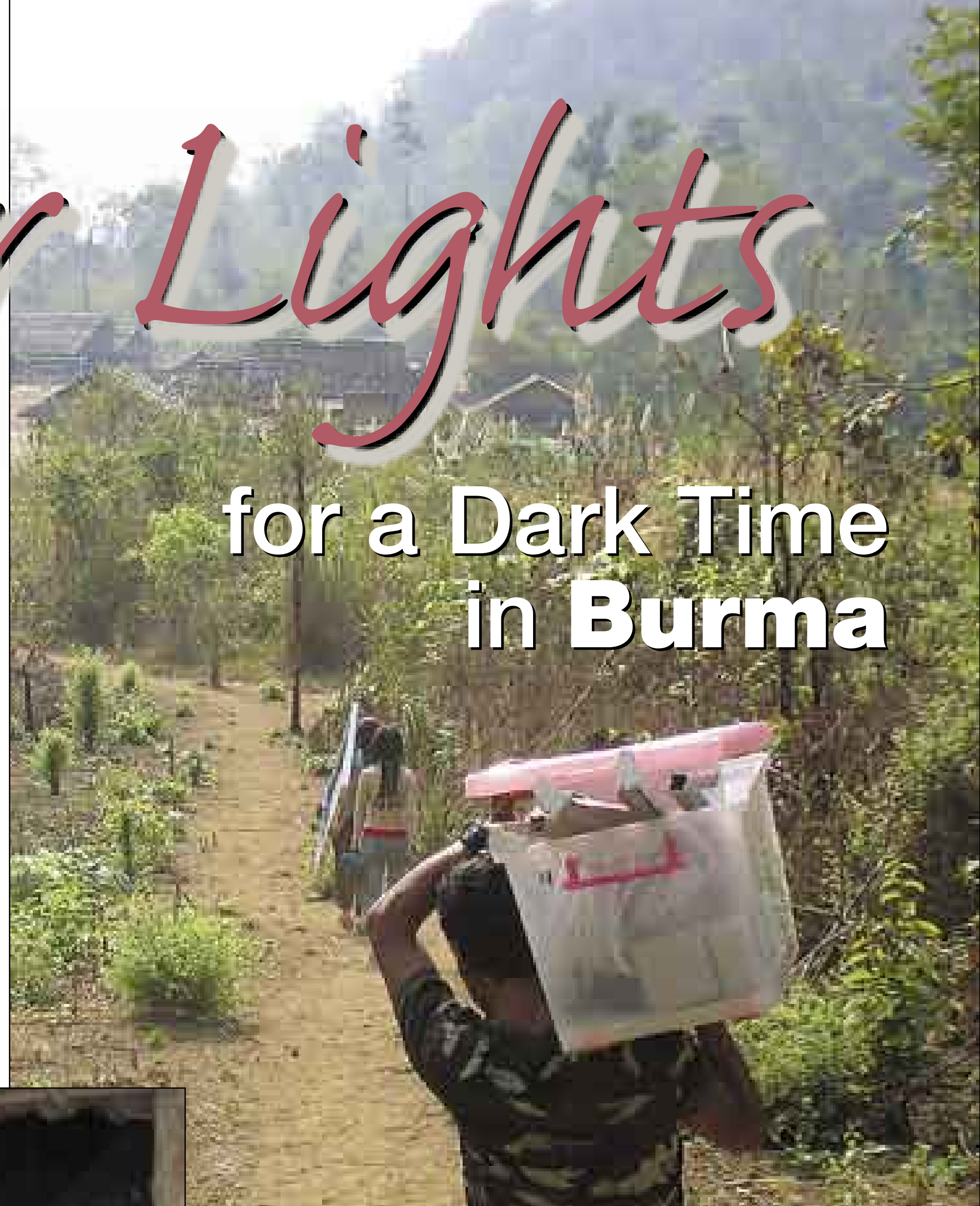
Solar Lights for a Dark Time in Burma

Chris Greacen
& Walt Ratterman



Transporting solar-electric system components to a jungle village clinic in rural Burma.

A patient receives treatment under solar-powered lighting.

"It is difficult," said Eh Kalu Shwe Oo, "to perform amputations by flashlight." Eh Kalu is director of the Karen Health and Welfare Department (KHWD), and oversees 36 medical clinics located in the Karen State in eastern Burma (also known as Myanmar).

The clinics, scattered over 600 miles (965 km) of roadless jungle, have a roster of approximately 75 KHWD surgeons, medics, and nurses. They serve an estimated 200,000 "internally displaced people" inside Burma whose villages and fields have been destroyed in the course of the ongoing civil war. Malaria, parasites, and a variety of medical conditions (diarrhea, pneumonia, blindness) stemming from malnutrition are endemic. Land mines and mortar fire maim thousands.

Twenty-eight of these clinics now have electricity for the first time, thanks to solar-electric systems. The systems provide electric lighting for nighttime medical procedures, radio communications, and basic low-power medical equipment. The clinics were chosen because they were in areas considered "stable." That is, they were less likely to be destroyed by the army of the State Peace and Development Council, widely believed to be one of the most brutal dictatorships on the planet.

Trainings

A collaborative of various organizations (see Access) spearheaded workshops at the clinics, with support from a variety of organizations. Our first training, in August 2003, involved hands-on instruction for fourteen participants, and solar-electric systems for two medical clinics. After the first training, Mr. Eh Kalu from KHWD, who coordinated the pilot project and organized the training, said, "Our dream ten years ago was to have some kind of lighting for these clinics. And when we did the two clinics, I could only hope that we would be able to do so many more." In subsequent trainings in 2004, 2005, and 2006, we built another twenty-six systems and trained more than seventy additional participants.

The trainings have two goals. The first goal is the provision of rugged, reliable solar-electric systems to clinics able to use them. The second goal is basic training of clinic medics in photovoltaic design, system construction, operation, and maintenance. Since the participants are responsible for installing their systems at their respective

Installing a PV module at a village clinic.

The remote clinics are the only source of postnatal care for tens of thousands of families.

Workshop participants take measurements on a PV module.

A nurse prescribes medicine for a patient.

A medic proudly displays the finished controller–switch box.

Clinic PV System Costs

System Equipment	Cost (US$)
Mitsubishi MF130EA2LF PV module, 130 W	$496.34
3K battery, 125 AH, 12 V	76.82
Leonics SB1210 charge controller	52.68
LED light, 1 W, 12 V	18.00
Receptacle, heavy duty, 12 V	16.00
Wire	14.54
Misc. hardware & electrical	13.08
2 Fluorescent lights w/ fixtures, 12 V, 18 W	10.26
Junction box for controller	9.32
Battery box	5.13
Distilled water	5.13
Aluminum angle stock for rack	4.66
Total Equipment Costs	$721.96

clinics, they must understand how to connect, re-connect, and troubleshoot the equipment.

The trainings combine classroom teaching and hands-on building of the systems—with an emphasis on hands-on training. We cover the basics of electricity and the specifics of photovoltaic systems. In the hands-on portion of the classes, participants build the systems from scratch. Each system is assembled and disassembled by each participant to be sure everyone knows how to put them together when they return to their remote clinics.

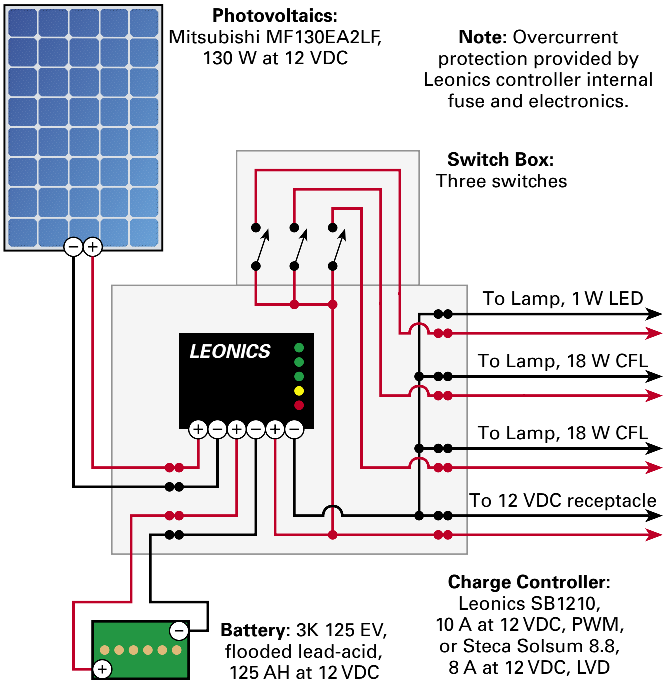
Systems

Simplicity, robustness, and plug-and-play features are key design attributes of the systems. Each system powers two 18-watt fluorescent lights and a 1-watt LED light. The low power, efficient LED is particularly nice for clinics because it can be left on all night. It provides enough light for medics to make their rounds without bumping into patients, while consuming just a smidgeon of energy—about 10 watt-hours per night.

The systems use 130-watt, 40-cell PV modules. Typical 12-volt modules have 36 cells. The higher-voltage modules allow us to use long (50 ft; 15 m) wires from the module to the controller. This increases design flexibility, allowing the installer to find a sunny area if the clinic roof is in the shade.

The PV wires are fitted with MC connectors to ensure that polarity isn't reversed, and for quick disassembly if the clinic comes under attack. The 125 amp-hour, deep-cycle battery is heavy (35 kg with acid; 24 kg dry), so we improve portability by supplying the acid separately, and having medics fill the batteries and do a forming charge on-site. Medics still complain about the weight—some have to carry the systems for as long as two weeks to reach their villages. In future systems, we will use two, 50 amp-hour, deep-cycle 12-volt batteries in parallel.

Clinic PV Lighting System



Tech Specs

System Overview

Type: Off-grid, battery based PV (28 systems total)

Location: Jungle clinics, Karen State, Burma

Solar resource: 3.5 average daily peak sun-hours

Production: 10 DC KWH per month

Photovoltaics

Array: One Mitsubishi PV-MF130EA2LF, 130 W STC, 19.2 Vmp, 12 VDC nominal

Array installation: Homemade aluminum angle mounts installed on south-facing wood rack, 17-degree tilt

Energy Storage

Battery bank: One 3K 125EV, 12 VDC nominal, 125 AH at 20-hour rate, flooded lead-acid

Balance of System

Charge controller: Leonics SB1210, 10 A, PWM, 12 VDC or Steca Solsum 8.8, 8 A, PWM, LVD, 12 VDC

System performance metering: Uses indicator lights built into charge controller. Each system also provided with a digital multimeter.

The system includes a DC receptacle (high-quality cigarette lighter) for DC loads such as battery charging for two-way radios. We are wary about using inverters in these systems, based on feedback from KHWD medics who said that the availability of AC might mean that the electricity would be consumed for nonmedical purposes (tape players, or perhaps television). However, in the latest round, we're adding the Xantrex XPower Plus 60/75-watt inverter as a plug-in option to the DC receptacle, and we will encourage users to use it only for essential loads.

The systems feature a rugged cabinet for the charge controller, switches, and strain-relief terminal strips. The cabinet is built from a large, industrial-strength plastic junction box with a clear cover. A three-gang switch box is bolted on top.

In designing the cabinet, we had several design criteria. First, if any wire is yanked inadvertently, we want to ensure that the charge controller is not damaged. In addition to strain relief where the cables enter the box, we designed the cabinet so that all wires passing into the box are connected to a terminal strip that isolates the charge controller from physical strain.

Second, we want the system to be relatively plug and play out in the field. By pre-wiring all of the light switches into the box, we reduced the number of electrical connections that recipients have to make when installing the system in a clinic. Similarly, through color-coding and MC connectors, we minimized the chances of reverse polarity.

Laying the Groundwork

We're pleased to report that most of the systems we've installed are still operating, even though several have had to be disassembled and moved from their clinics temporarily due to security concerns. In the future, we hope to provide larger systems for vaccine refrigeration.

On the Thai side of the border, we have built four microhydro projects, and we hope, someday, to expand this work into Burma. When peace returns to the area, we trust that having dozens of local, trained renewable energy technicians will help enable a transition toward widespread use of renewable energy in the area.

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Chris Greacen, Palang Thai, 289/770 Bangkok Garden Sathupradit 19, Bangkok, Thailand 10120 • Phone/Fax: 66-2-672-0364 • Mobile: 66-6-34-00-943 • chris@palangthai.org • www.palangthai.org/en/bget

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Working with Inspectors

What Your Checklist Should Include

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

Grid-tied photovoltaic (PV) systems can be quite complex—more complex than the typical residential or commercial electrical systems that most inspectors are familiar with. To minimize the time that the actual inspection requires, and to increase the probability that the system passes the inspection, it pays to prepare before you contact an inspector.

The majority of PV systems installed today are utility-interactive (U-I). This *Code Corner* discusses how to smooth the way for the installation of a safe, code-compliant, inspected batteryless U-I PV system.

Permits Can Educate

Although inspectors are generally approachable and usually willing to answer questions about inspections and the *National Electrical Code (NEC)*, most are not PV system designers and aren't familiar with PV equipment. So your first job is to determine how inspections are accomplished in your local jurisdiction. In many jurisdictions, a permit is required to do any electrical work. There also may be requirements that the work be done by a licensed electrical contractor or licensed electrician.

Once you've done this legwork, it's time to pave the way for a smooth inspection. A system installer can use the permitting process to educate the inspector and demonstrate that, on paper, the PV system meets the basic requirements of the *NEC*.

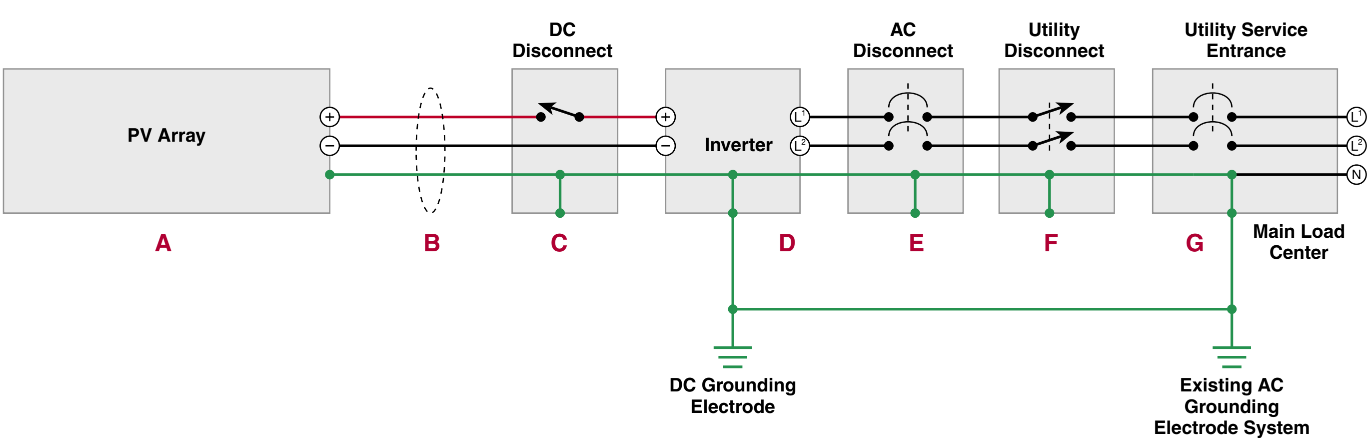
Frequently, an inspector will have more time to check the plans in the office than what is available in the field to perform the actual inspection. For a utility-interactive, residential PV system, giving the inspector the information outlined below during the permitting process or, with no permitting, at least a week before the inspection is scheduled will enable him or her to examine the system's design and maybe even ask a few questions. Some of these items are not necessarily required by your inspector, but will still be helpful.

Your Checklist

Equipment Lists & Specs. Include with the permit a list of the equipment used and the specifications for that equipment. This list includes PV-specific equipment, such as PV modules, inverter, fuses, and circuit breakers. Also include listing/certification and rating information. Factory cut-sheets or pages from instruction manuals are the preferred way to present this information. Giving inspectors copies of the module and inverter instruction manuals for their files may be a way to increase their understanding of how these components should be installed.

The Diagram. While a CAD-generated diagram is not required, present something better than a "back of the envelope" sketch. The red letters in the diagram below indicate information that should appear on or be attached to the plan.

Residential PV System



A. PV Array

Indicate the type and number of PV modules in each series string. The open-circuit voltage (Voc) of each module times the number of modules connected in series, times a cold temperature factor (*NEC* Section 690.7) equals the maximum system voltage. This must be less than the inverter's maximum direct current (DC) input voltage and less than the voltage rating of connected components (wires, overcurrent devices, disconnects). A label on the back of the PV module will give the electrical parameters needed for these code-required calculations.

The ampacity of module interconnection cables, after corrections for conditions of use, must not be less than 1.56 times the short-circuit current (Isc) marked on the back of the module. Due to the exposed, outdoor location and high operating temperatures, all conductors should have insulation rated for 90°C (194°F) and wet conditions (in conduit, THHN/THWN-2 or RHW-2). Exposed conductors (usually USE-2) must also be sunlight resistant.

B. Conduits

Conduits will typically be used throughout the system—usually after the wiring leaves the PV array. They will be installed in various locations, some of which may be in sunlight that will cause them to be hotter than the surrounding air. Be sure to include conductor ampacity calculations for conduit fill and temperature corrections. These correction factors can be found in Section 310.15 of the *NEC*; the temperature correction factors are at the bottom of the ampacity tables (Section 310.16 or 310.17).

C. Module & String Overcurrent Protection; PV DC Disconnect

Overcurrent protective devices (OCPD) in DC circuits may not be required when there are only one or two strings of modules. Three or more strings of modules typically require an OCPD in each string. The current rating of the OCPD, when required, should be 1.56 Isc for that circuit. The voltage rating of the OCPD should be not less than the maximum PV system voltage.

The strings may be combined in parallel in a combiner box ahead of an unfused DC PV disconnect or combined at the output of a fused DC PV disconnect. Appendix J in *PV Power Systems and the National Electrical Code: Suggested Practices* provides detailed calculations on OCPD requirements in DC PV array circuits (see Access). Any OCPD connected in series with a module or string of modules should not have a value greater than the maximum series fuse value marked on the back of the module.

The grounded PV output conductor (commonly the negative conductor) must not be switched by the disconnect. This grounded conductor must be color-coded white. Some PV systems have a positive conductor that is the grounded conductor—it will be color-coded white and will not be switched. In this case, the ungrounded negative conductor will be connected to the switch pole. Future PV systems may not have any grounded PV array circuit conductors. In those instances, both PV output conductors would be switched and neither would be color-coded white.

PV output conductors, after any combining of series strings, should have an ampacity, after corrections for conditions of use, of not less than 1.56 times the module Isc times the number of strings in parallel.

D. The Inverter

The inverter must be listed for utility-interactive (U-I) use. The inverter maximum input voltage must not be exceeded in cold weather (see A).

For PV systems with roof-mounted modules installed on a dwelling, the inverter must have a ground-fault protection device (GFPD). When a GFPD is built into the inverter (which is the case with most batteryless U-I inverters below 10 KW), there should be no bond external to the inverter between the grounded circuit conductor and the grounding system.

AC and/or DC disconnects internal to the inverter are acceptable if they are readily accessible and the inspector deems that only qualified people will service the inverter. Otherwise, external disconnects will be needed. Internal disconnects, if circuit breakers, might not be suitably rated for the ampacity of PV output conductors (the rating may be too high) and an external OCPD may be needed.

E. Inverter AC Output Overcurrent Device & Disconnect

Any OCPD located in the inverter AC output should be rated at 1.25 times the maximum continuous output current of the inverter. The maximum continuous current is specified in the inverter manual or is calculated by dividing the inverter rated output power by the nominal AC line voltage. This OCPD may be a backfed breaker located in the load center—the place where any possible fault currents for the inverter AC output conductor would originate. A backfed breaker in the load center could also be the inverter AC disconnect if the inverter were located near the load center.

F. Utility-Required AC Disconnect

Many utilities require a visible-blade, lockable–open disconnect in the inverter's AC output circuit. This disconnect is usually located within sight of the service-entrance meter so that emergency response people can easily find it. The top terminals (line side) of this disconnect should be connected to the circuit that comes from the AC load center because it will usually be energized by utility voltage. The bottom terminals (load side) should be connected to the circuit from the inverter. This disconnect may be fused or unfused depending on the utility's specific requirements. The utility disconnect must have a minimum current rating that is 1.25 times the inverter's maximum continuous output current (*NEC* Section 690.8).

G. Point of Connection—Load Center

Most smaller residential PV systems make the point of connection with the utility through a backfed breaker in the load center. *NEC* Section 690.64(B) establishes these requirements. If the load center is rated at 100 amps and has a 100-amp main breaker, the maximum rating of all backfed PV breakers would be 20 amps (either or both phases of the 120/240-volt panel). A 200-amp load center with a 200-amp main breaker would be limited to 40 amps of backfed breakers. However, many installations have PV systems that are larger than the 100-amp or 200-amp load centers can accommodate. Other combinations are possible as is a supply-side tap of the service entrance conductors (for more information, see *Code Corner* in *HP112*).

Good Planning Pays

Be sure to include all of the listed information when you're submitting your plans for obtaining a permit for your PV system installation. The more information you provide, the easier it will be for your installer to communicate to the inspector that the system design and component selection meet *NEC* requirements. It is far more cost effective to change the design on paper—before any hardware is purchased and installed. The bottom line is that working with your inspector can, and frequently does, result in a safer, more reliable PV system.

Questions or Comments?

If you have questions about the *NEC* or implementing PV systems that follow *NEC* requirements, call, fax, e-mail, or write to me. For more detailed articles on these subjects, visit the NMSU Web site (see Access). The U.S. Department of Energy sponsors my activities in this area as a support function to the PV industry under Contract DE-FC 36-05-G015149.

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

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

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The 2005 *National Electrical Code* and the *NEC Handbook* are available from the National Fire Protection Association (NFPA), 11 Tracy Dr., Avon, MA 02322 • 800-344-3555 or 508-895-8300 • Fax: 800-593-6372 or 508-895-8301 • custserv@nfpa.org • www.nfpa.org

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- Helps installers keep current in latest technology and continues your professional development.

Consumers...

- Provides confidence that PV system will be installed according to safety codes and manufacturers' specs.
- NABCEP Code of Ethics stresses consumer protection, professional conduct and integrity of service.
- Navigate to: www.nabcep.org to locate NABCEP certified installers.

Solar Thermal Installer Certification - *NEW!*

(Application deadline: August 4, 2006)

- Certification is for experienced solar hot water and pool heating installers.
- Certification program used same consensus-based process to create Solar Thermal Task Analysis.
- Industry experts including solar hot water and pool heating installers involved in creating requirements.
- As with Solar PV Exam, test sites will be determined based on geographical dispersion of candidates.
- Exam is 4 hours with 60 equally weighted multiple choice questions.
- Review Solar Thermal Candidate Information Handbook and Application Form at: www.nabcep.org or call 518/899-8186.

Digging Into
the Silicon Shortage

Don Loweburg

That there is a photovoltaic (PV) module shortage due largely to an inadequate supply of refined silicon is not news to most people involved with renewable energy. However, there are many questions arising around this situation. How and why did it occur? Who are the winners and losers? And perhaps most importantly: When will it be over?

Polysilicon Production & PVs

The electronics industry has for many years been the major market for refined silicon. During the last downturn of the computer chip industry in 2000, the PV industry benefited from an abundance of low-cost silicon. However, these were not good times for the silicon manufacturers. An oversupply of silicon resulted in lower prices and lowered profits. When demand increased with the resurgence of the electronics industry and the continued growth of PV, the oversupply of silicon ended and the manufacture of silicon again became profitable.

PV module manufacturers used the temporary abundance of silicon well. From 2000 to 2003, many increased production, while simultaneously reducing module prices. Average retail prices dropped to US$4 per watt, while the industry grew globally by around 30 percent per year.

However, since the end of 2003, prices have increased about 25 percent and growth has slackened. In a Reuter's article last spring, Tim Bruton of Britain's New and Renewable Energy Centre forecast that there wasn't enough silicon to keep fueling that rate of growth. Bruton, a former head of research and development at BP Solar, said he expected growth to slow to around 10 percent this year, before a likely acceleration in 2007. "When [PV manufacturers were] able to buy cheap, scrap silicon," he said, "there was no real incentive to be more efficient. [The industry] has to do so now."

It is clear that as the silicon supply became constrained, module manufacturers did not make timely contracts to secure a sufficient silicon supply. The fact that all of the three major global markets—the United States, Germany, and Japan—depended on inconsistent government subsidies may have contributed to the hesitation. The politics involved within these various government programs also may have added to the manufacturers' uncertainties. But hesitate they did. Contrary to their prognostications, the subsidies remained in place and the markets continued to grow, leading to the present shortage of PV modules.

One might expect manufacturers' profits to have suffered from the limited silicon supply. While smaller manufacturers may be suffering, larger manufacturers have secured supply. In a May/June 2005 issue of *Solar Today*, Rona Fried, editor of the sustainable investing newsletter *Progressive Investor*, writes that, "Customer demand is so high that solar manufacturers are completely sold out and are expanding operations to meet demand. Most importantly, many companies achieved profitability in 2004, followed by more in 2005. The silicon shortage has forced companies to make their operations more efficient, resulting in lower manufacturing costs (falling 5 percent a year), and healthy profit margins."

An April 2005 article in *Red Herring* magazine stated that the PV industry's "total operating profits this year (2005) are expected to be US$2.5 billion, up from US$800 million last year." And, Michael Rogol, a senior analyst for MIT's energy and environment lab, commented that "the demand in the solar sector is so strong you would get much, much stronger numbers if there was enough silicon."

So Who's Feeling the PV Pinch?

PV system retailers and installers are experiencing many problems related to the shortage of modules. Because module delivery is sporadic and pricing uncertain, dealers have difficulty fulfilling orders and contracts in a timely manner. Often, module manufacturers have been increasing prices just before delivery, forcing the retailer to absorb the increase. Long delivery times and uncertain pricing are cutting into dealer profit margins, sometimes severely.

Cash flow challenges have also presented problems for many retail installers. On the supply side, dealers are required to provide sizable deposits to secure module orders from the manufacturers. Module delivery may take four or more months, delaying system installation. And because most systems are also receiving state incentives, which are paid months after the project is completed, a significant amount of time passes before any profit can be realized. Essentially, the dealer is financing the project to completion. The cost of this financing is also borne by the dealer.

The end result is that module shortages are limiting growth for the entire PV industry. Installing and retail sales companies are experiencing the same constraints. It is paradoxical that, just as energy awareness is peaking and a rapidly growing number of customers seek PV solutions, the industry cannot deliver. Established dealers that had planned growth now must tread water and, rather than growing their businesses, many must settle on just surviving during the next few years.

Many customers find it suspicious that just when the economics of conventional electric service have started to encourage the adoption of PV, modules have become difficult to obtain and more expensive. Keep in mind that the PV industry has pushed the conceptual mantra of Sustained Orderly Development for more than ten years, promising a reduction of PV costs as production volume increased. The current situation contradicts that assumption.

In the February 9, 2006, posting from the online newsletter *Renewable Energy Access*, readers responded to the question, "How did the silicon shortage situation catch so many by surprise?" One reader said that he suspected the shortage was actually a marketing ploy to increase investor returns. But another reader countered that the shortage shouldn't have been a surprise: "When I started to look into renewable energy in mid-2004, one could read and hear the complaint from silicon suppliers everywhere that PV manufacturers did not want to commit to long-term orders—[which was] a prerequisite for silicon plant investments of more than US$100 million with a two-year lead time. So the problem has been, for a large part, PV-industry caused."

Moving Forward

PV industry consultant Scott Sklar wisely counsels people not to become unnerved with these market perturbations, which, he points out, are common to *all* emerging high-growth industries.

Certainly, the PV industry is currently perturbed, but the hesitation in the growth of the PV industry will abate. Silicon manufacturers now have future contracts for refined silicon and are building new factories, which should address the silicon shortage issue upon their completion. The major manufacturers, both of silicon and PV modules, are in strong, profitable positions. Investment capital is flowing into the PV market, and no doubt the current profitability of the silicon manufacturers and module manufacturers is attracting that capital. And although these perturbations for the major players may be experienced as mild earthquakes for the smaller players like dealers and customers, who will have to hang on for the next few years until the market turns around, the future of PV-generated energy is on solid ground.

Access

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

Global Cooling Needed Soon

Michael Welch

"The price of ignoring global warming could be staggering, while there are very real economic rewards for addressing it now. Climate action can save consumers money and strengthen the competitive position of California businesses," stated Dr. Michael Hanemann, an economist from the University of California at Berkeley, at a press conference last year announcing that nearly five hundred California scientists had signed a letter calling upon California's governor to take action on global warming.

California has taken to heart the alarming warnings from its scientists and academics and, by executive order, has set aggressive greenhouse gas reduction targets:

- By 2010, reduce to year 2000 emission levels
- By 2020, reduce to 1990 emission levels
- By 2050, reduce to 80 percent below 1990 levels

As one of the world's largest economies and ranking ninth in the world among nations and other large economies for total greenhouse gas emissions, California is certainly a big part of the problem. But the problem is not California's alone. In fact, most of our everyday activities—whether it's buying strawberries shipped from Mexico or using coal-fired electricity in our homes—contribute to global warming. And the cumulative results will prove disastrous, unless we turn things around.

Targeting the Source

Carbon dioxide (CO_2) is a "greenhouse" gas, which means that it can absorb infrared radiation. At the same time, it can act as an insulator, keeping some of this heat from radiating back into space. Normally, this is a good thing. Without this blanket, our planet would be much colder than it is and would not support life as we know it.

But now, due to human activities, there is too much of this "good thing," and it is increasing all the time. The problem is that the amount of CO_2 that is released into the environment is exceeding the amount that nature can sequester, so more and more of it remains in the atmosphere. Excess CO_2 entering the atmosphere, mostly from burning fossil fuels that had been stored for millions of years, has created the situation where global temperatures are on the rise. The two hottest years in recorded history—1999 and 2005—occurred in the last decade.

According to James Hansen, director of the NASA Goddard Institute for Space Studies, a further 1°C (0.5°F) increase in temperature will make Earth warmer than it has been in 1 million years. In a December 2005 article in the *International Herald Tribune*, he said, "Business-as-usual scenarios, with fossil fuel (CO_2) emissions continuing to increase at 2 percent per year as in the past decade, will yield additional warming of two or three degrees [Celsius] this century. That implies practically a different planet."

Hansen goes on to say, "The Earth's climate is nearing, but has not passed, a tipping point beyond which it will be impossible to avoid climate change with far-ranging undesirable consequences." Included in these consequences are dangerous temperature increases, the melting of polar ice caps, and the resulting, eventual rise in sea levels that would reach 80 feet (24 m) above current height. The melting ice around Greenland and northeastern Canada is already having an effect on wildlife. According to the U.S. Environmental Protection Agency, a 2-foot (0.6 m) rise in sea level could eliminate 17 to 43 percent of U.S. wetlands. Rising seawater will increase the salinity of rivers, bays, and groundwater tables.

Mostly, the poor will suffer the consequences of rising sea levels. The cost for building coastal barriers in the United States to deal with only a 20-inch (50 cm) rise in sea level is estimated between US$20 and US$200 billion dollars. We will find a way to pay for that, but how will people in poorer developing nations take on that kind of cost? Dr. Norman Myers of Oxford University predicted that by 2050 there could be 150 million environmental refuges in the world as a result of climate change.

Taking Action

Hansen says that we have the first quarter of this century to stabilize atmospheric CO_2, which will require a 60 to 80 percent reduction in emissions (from 1990 levels). Other climate action leaders put it a little differently, saying that if we can get ourselves on the right track within ten years, we can hit the needed goal of an 80 percent reduction.

You may be familiar with many of the different reasons for adopting energy efficiency measures and for using renewable energy. But perhaps preventing climate change is one of the most important reasons for you to implement your own energy use goals, and to become active in your communities to help others do the same. Climate Solutions, a nonprofit group, offers this list of actions (above right) that you can take in your own home, and how much carbon dioxide pollution each action can offset.

Besides these actions, tell your representatives that climate protection is important to you. Your elected officials make

Climate-Cooling Actions You Can Take

Action	CO_2 Reduction (Estimated Lbs. Per Yr.)
Switch to a fuel-efficient car (rated up to 32 mpg or more) or get a new hybrid electric vehicle that gets 50 to 70 mpg	5,600 or more
Insulate your home, tune up your furnace, and install low-flow showerheads	2,480
Leave your car at home two days a week—walk, bike, or take public transportation instead	1,590
Wrap your water heater in an insulating jacket	up to 1,000
Caulk and weather-strip around doors and windows to plug air leaks	up to 1,000
Recycle all of your home's newsprint, cardboard, glass, and metal	850
Install a solar water-heating system to help provide your hot water	720
Wash clothes in cold water, not hot	500***
Turn down your water heater thermostat—120°F (49°C) is usually hot enough	500*
Buy energy-efficient compact fluorescent bulbs for your most-used lights	500**
Replace your current washing machine with a low-energy, low-water-use machine	440
Buy food and other products with less packaging, or reusable /recyclable packaging instead of those in nonrecyclable packaging	230
Use a push mower to cut your lawn instead of a power mower	80

Adapted from Climate Solutions, www.climatesolutions.org
* For each 10-degree adjustment
** By replacing one frequently used bulb
*** For two loads a week

critical decisions in your name that either hurt or help the fight against global warming. In the U.S. Congress and in the state governing bodies, your representatives need to hear that you want action! To contact your state senator and state representatives, visit your state's Web site, or check the local phone book in the Government section. To find out how to contact your federal representative, go to www.house.gov. To find out how to contact your federal senators, go to www.senate.gov.

As you learn more about global warming, share what you know with your friends, family, and colleagues. Sign up for climate change e-mail lists for your community, join local groups that are working on the issue, and check out the Redwood Alliance Web links for further info.

Together, We Will Change the World

It is going to take effort, and it is going to take some sacrifice, but we must work together to stop climate change. California's goals set an example for all of us, so see what you can do to get your government representatives on board. And more importantly, begin taking your own personal steps to stop global warming.

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

Union of Concerned Scientists, 2 Brattle Sq., Cambridge, MA 02238 • 617-547-5552 • Fax: 617-864-9405 • ucs@ucsusa.org • www.ucsusa.org/global_warming/

WWF–United States, 1250 24th St. NW, Washington, DC • 202-293-4800 • Fax: 202-293-9211 • www.panda.org

James Hansen. "It's Not Too Late," *International Herald Tribune*, December 13, 2005 • www.iht.com/articles/2005/12/13/opinion/edhansen.php • Or you may view the more in-depth presentation of his research made to the New School University on February 10, 2006, by downloading it from the Promised Files section of www.homepower.com

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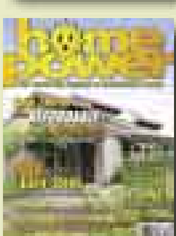

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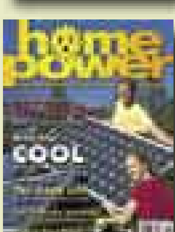

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Photovoltaic...

Cell, Module, String, Array

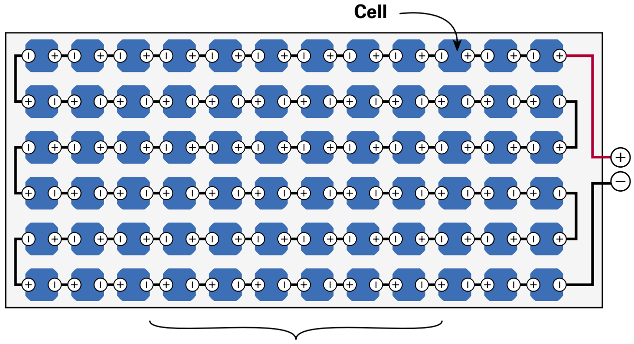
Ian Woofenden

Derivations: "cell" is from Latin cella, *chamber; "module" is from Latin* modulus, *measure; "string" is from Latin* stringere, *to bind; "array" is from Old French* areer, *to put in order.*

Solar-electric systems make electricity from sunlight. The generating devices rely on the photovoltaic (PV) effect—the capability of certain combinations of materials to use the energy of photons from the sun to move electrons in an electrical circuit. PV systems include cells, modules, strings, and arrays. But what do all these terms mean?

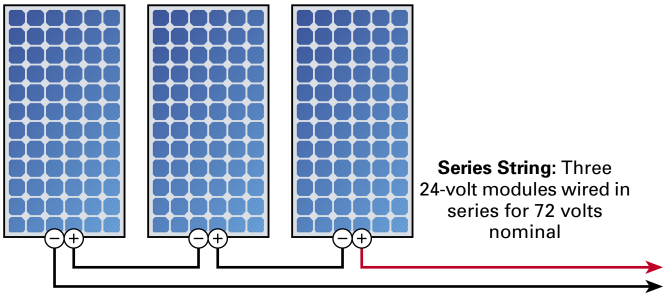
A photovoltaic **cell** (also called a "solar cell") is the basic building block. The most common type of cell is made from silicon doped with minute quantities of boron, phosphorous, gallium, arsenic, or other materials. Each cell develops about half a volt of DC electrical potential when exposed to light. The maximum amperage of the cell is proportional to its surface area, and depends on the intensity of the light. PV cells can produce electricity for 30 to 50 years, and generate the energy it took to manufacture them in a few years.

Cell & Module



A PV **module**, sometimes called a panel, is a grouping of cells. Historically, modules with 36 cells have been most common, producing 18 to 22 volts for a 12-volt nominal output. More recently, we've seen 24-volt nominal modules for higher voltage systems, and modules designed specifically for high-voltage grid-tie inverters, with open-circuit voltages that can be even higher.

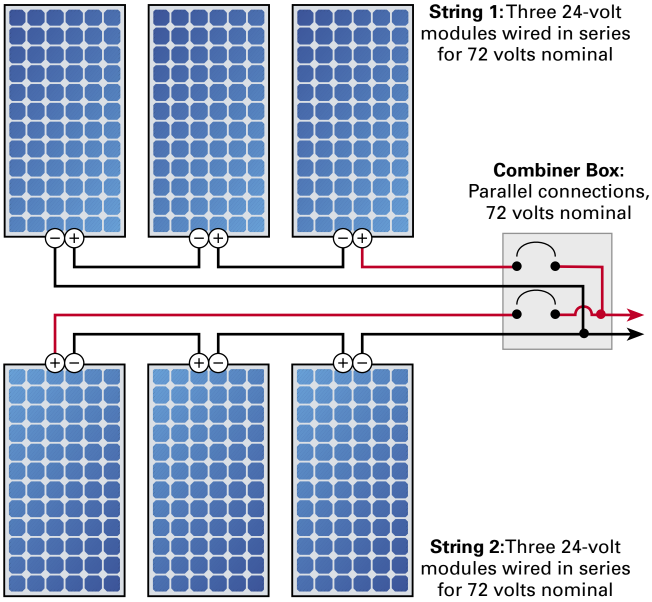
Series String



Series String: Three 24-volt modules wired in series for 72 volts nominal

I've heard some people define a "panel" as a grouping of modules, but to me, this is a confusing use of the terminology. In fact, I think we might be better off avoiding the phrase "solar panel" altogether. It's confusing because it can be used to describe a solar-electric module, a solar hot water collector, or even a wiring and breaker panel in a solar-electric system. Using the word "module" is more precise, and it also reminds us of a key benefit of solar-electric systems—their modularity.

PV Array



String 1: Three 24-volt modules wired in series for 72 volts nominal

Combiner Box: Parallel connections, 72 volts nominal

String 2: Three 24-volt modules wired in series for 72 volts nominal

A **string** is a grouping of modules wired in series. Basic electrical physics tells us that connecting electrical sources in series increases voltage, which is exactly the goal of a string. It's the same as when you put three D-cells into your big flashlight—they are in series to attain higher voltage.

Most modern solar-electric systems operate at 48-volts nominal, and high-voltage grid-tied systems use up to 600 volts. With 12- and 24-volt modules, this means joining together modules to attain the higher voltage. A series string can then be used on its own or paralleled with other series strings, either to charge batteries or feed the utility grid.

The term **array** describes the whole group of modules in a system. These can be modules in series or parallel, at low or high voltage, on a single rack or multiple racks. Sometimes the term "subarray" is used synonymously with "string." At other times, it is used to mean one rack of modules in a multiple-rack array.

Solar electricity is an amazing technology. Simple, durable, quiet, and long lasting, the collection devices just sit in the sun and make electricity for us. Understanding the basic terms—cell, module, string, and array—is one step along the road to making electricity with Earth's most abundant natural resource, sunshine.

Access

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

Boneyards & Backyards

Kathleen Jarschke-Schultze

Back on the Salmon River, city folks have been known to comment on the clutter around people's homes. Remarks like, "Why doesn't anyone haul away the junk in their yards?" or "How can they just leave all that stuff lying about?" and "You know, a couple of trips to the dump would do wonders for that place!" are common.

These are the thought processes of folks used to living within literally minutes of anything they may want or need. But when you live some distance from town, having a good boneyard is a necessity. Boneyard, in the local vernacular, is your personal stash of items that may possibly be useful in the future. Some people's boneyards are tidier than others, I'll admit. But the value of a good boneyard is indisputable. Country folks' comments run more to: "Nice boneyard!" or "He's really set," and "Well, you could drop that off at my house anytime."

Waste Not, Want Not

Many times boneyards reflect interests, hobbies, or professions. They are also colored by how far out in the boondocks their owners live. My husband Bob-O and I don't keep spare-parts vehicles, but on the Salmon, where it is a three-hour drive to a parts store, it just makes good sense.

When Harry Rakfeldt, a customer of Bob-O's, moved from his microhydro-powered homestead (see *HP6*), I was gifted with some nice stuff from his boneyard. Down in my garden, I still have a metal sink and cupboard unit that he gave me. In fact, just like Harry did, it is totally acceptable to give away stuff from your boneyard, while it is *not* acceptable to just throw it away. It is common knowledge that soon after you finally throw away some boneyard item you have kept for years, you will end up needing that exact item.

However, you must be discerning in your choice of boneyard items. Some things are obvious. Roof tin from a fallen barn, as long as it is not bent and full of holes. PVC pipe left over from a hydro pipe upgrade is sure to end up in the yard. Reclaimed lumber, fencing, black poly pipe, fence posts, chicken wire, barrels, windows, and doors—all have found their way into our boneyard.

Calling it a boneyard brings to mind a single area, possibly fenced, where all your junken treasures are kept for future use. However, this is not usually the case. A boneyard can spread out on your property, and be pretty—or just piled. But it's not the look of the yard that has the value, it's the contents. That said, an organized, tidy boneyard is a joy to behold. A spread-out, sloppy boneyard may be less joyous, true, but is still a thing of beauty.

Backyards

Of course, the smaller your property, the smaller your boneyard. If you live in town, out of necessity your backyard is your boneyard. My father acquired some discarded wooden garage doors from a business that installed automatic metal garage doors. By using six of them, he quickly built a backyard shed. He used four for the walls and two for the roof. The first one he built became a shop–storage shed. The second was all boneyard, which kept my mother's comments about the clutter in the backyard down to a dull roar. That second shed was stuffed full, but he always knew where everything was. The shop had rows of labeled coffee cans full of old screws, nails, washers, springs, hinges, nuts, bolts, and anything else

that could be scavenged from an item before its bare bones were discarded.

I have to say I really enjoyed helping out Dad in the shop. Whenever he needed a screw or something for a repair, we would empty the appropriate coffee can onto a salvaged rubber floor mat he kept on the workbench. We would go through the pile until we found just the right thing. Making something work again by using saved parts is a deep satisfaction indeed. I learned it early.

I find a real satisfaction in building or fixing a project by only using stuff from our boneyard. It makes me feel closer to Dad somehow. Consequently, whenever I dismantle a project, the reusable parts are designated to the boneyard. Sometimes a project design will change during the assembly because I have shopped the yard and come up with a piece that will work, but not quite the way I had first planned.

Boneyard projects are a lot like starting a recipe, and then finding out you don't have all the ingredients. You make do with what you have on hand. Sometimes it turns out better. Sometimes it is not better, just different, and, other times, you find out that you will not try *that* again. When this happens with a recipe, you find out what dogs and chickens—and in worst-case scenarios, worms—are for. When this happens with a homestead project, you take it apart and return the parts to the boneyard.

Reduce & Reuse

Bob-O has a house rule. If I bring anything into the house, I have to take away something of the same size. He says this is for self-preservation. I'll admit I could easily become a hoarder. If not for Bob-O, I would probably be a crazy cat woman—and a hoarder.

But the boneyard has no such rule. All viable materials are welcome. Sometimes it takes awhile to figure out their usefulness, but in time it becomes known. Sure, there's trash—just be sure it is trash you are throwing away. Far too many things that could be used again are instead put into landfills. Before you throw anything away, consider its usefulness. And consider the waste of resources on our Earth and the future of life here.

I know my Dad is proud of me for using and adapting what I have on hand rather than buying new. He grew up on a dairy during the Great Depression and knows the real value of a good boneyard. He has passed this on to his children, just as we should pass it on to ours.

Access

Kathleen Jarschke-Schultze is bottling her Pinot Noir, reusing bottles saved, scoured, and sterilized, at her home in northernmost California. c/o *Home Power* magazine, PO Box 520, Ashland, OR 97520 • kathleen.jarschke-schultze@homepower.com

Mailbox

Phantom Loads

Surprise, surprise, *The Economist* just ran an article on phantom loads! It was in the March 11–17 issue, "Pulling the Plug on Standby Power." They did a decent job on the subject and I was very pleased to see it, though I must say they are a bit behind the curve. There are efforts worldwide to reduce phantom loads and introduce standards. I sent this short letter to the paper:

Sir, About ten years ago, my family dispensed with most of our "standby losses," or "phantom loads," with a cheap and readily available device. Most of our electronics are now plugged into plug strips that have an illuminated switch to indicate when they are on. The TV, DVD player, etc., are on one strip, the microwave on another, while the computer has three. The latter arrangement lets us put the computer into sleep mode while turning off electricity to the very inefficient peripherals powered by those nasty black power cubes, the worst offenders in terms of standby losses. Considering the worldwide struggles revolving around obtaining and controlling energy, it is unconscionable to waste it feeding devices that are doing nothing. While we wait for government and industry to work out the right carrots and sticks, for the price of a latte we can fix the problem ourselves. Thanks for bringing this issue to the attention of your readers around the world.

Thanks to the *Home Power* crew for bringing this to the attention of the world more than a decade earlier. All the best,

Jim Palmer • Courtenay, BC, Canada

Solar Hot Air

I've recently built my own 4-by-8 box space heater. Due to location, it sits alongside my house and is ducted through holes in the wall. I am using a bathroom exhaust fan (plugged into the grid) at 70 cfm to pull the heated air into the house. I have four hours of sun in the morning to use the heater. This is giving me a 4°F increase in temperature (from 65°F to 69°F), when outside it has been in the high 20s to 30s. I've been looking for a fan and a PV module to power it that would be strong enough to circulate the air. I've seen the DC Venturi fans, but don't know if they can do the job. The ducts are 4 inches in diameter. The 70 cfm is not enough. I'm trying to heat a 24- by 20-foot room, and believe I need about 500 cfm minimum.

I'm also planning ahead for summer and have been looking at the solar-powered swamp coolers. Have there been any studies done on these as far as efficiency, value, and cost? I was wondering if I could convert my standard home-model swamp cooler into a solar-powered setup. Maybe this subject could be in a future magazine article. Any help or ideas would be appreciated.

Dennis Mann • Reno, Nevada

Hi Dennis, A 4- by 8-foot collector should have 6-inch duct openings. The limitation of 4-inch ducts is huge. It has to do with static pressure, and a bigger blower might just make things worse, depending on the curve of the blower. A 4-inch duct has less than half the cross-sectional area of a 6-inch duct and makes the friction loss of the moving air (static pressure) too large. All blowers have different performance curves and some are so poor that their cut-off static pressure will not allow them to be used on a good solar collector, which should have some static pressure built into it.

On 4-by-8 collectors, we use a 1/12 hp, AC-powered, 380 cfm permanent split-capacitor blower with 6-inch ducts. We have a few thousand of these installed, and time has proven the match is a good one. A 176 cfm, 12 VDC blower is available for about US$90. It takes a 50 to 75 W PV module to run it. It doesn't perform quite as well as the 380 cfm AC blower, but it does a good job. We use it for PV power systems and have never had a complaint. As I said at the start though, the big problem in your system is the inlet and outlet size—they are too small for the size of collector.

A well-built 4-by-8 collector with adequate airflow should have about a 30°F to 70°F rise in temperature, inlet to outlet. The temperature difference is dependent on the time of day and year, the outside temperature, and flow through the collector. In spring, it will produce a good deal more heat than in the middle of winter.

Southwest Solar (www.southwest-solar.com) manufactures DC swamp coolers in a variety of sizes (650–4,000 cfm.) Both 12 and 24 VDC models are available, as well as 120 and 240 VAC units. You could probably also convert your AC cooler by using a DC pump and fan. Please be sure to let us know what you end up doing and how it worked out.

Chuck Marken • AAA Solar

Insulation Vapor Barriers

Claire Anderson's recent article on insulation options (*HP111*) was comprehensive and informative, but the article contained an error. She wrote, "Compared with closed-cell polyurethane, open-cell products also use significantly less material, making them attractive from a resource standpoint. These spray-foams provide an airtight, water vapor resistant seal, and eliminate the need for vapor barriers in stick-framed homes."

In fact, open-cell polyurethane is not water-vapor resistant. The three most common brands of open-cell polyurethane insulation (Icynene, BioBased 501, and Demilec Sealection 500) are very vapor open, with a permeance of 10 perms. Manufacturers of open-cell polyurethane, including Icynene, emphasize the importance of including an interior vapor barrier when the foam is installed in a cold climate (colder than 7,200 heating degree days). Failures—that is, moisture accumulation on the interior surface of wall sheathing and roof sheathing—have been reported in cold-climate houses where installers forgot to include a vapor barrier. If *HP* readers are interested in using a polyurethane insulation that is water-vapor resistant, they should choose a closed-cell product like Corbond.

Martin Holladay • Sheffield, Vermont

Hello Martin, Your keen observation spurred me to do some additional legwork to get to the bottom of this issue. I contacted Mason Knowles, executive director at the Spray Polyurethane Foam Alliance, who offered the following perspective. Thank you for your critique and comment.

Claire Anderson • Home Power

Hi Martin, There is some confusion in the marketplace about low-density open-cell SPF and medium-density closed-cell SPF. Much of it is based on competitive claims by both sides selling to their benefits and to the other's perceived weaknesses.

I published a few articles on the differences between low-density and medium-density SPF that can be found on our Web site (www.sprayfoam.org) under the News and Media section.

To specifically address this issue, the physical property differences are listed in our technical guideline, AY 112. Perm ratings of low-density SPF average from 8 to 10 per 3.5 inches of foam, so it does not slow water vapor flow as much as the 2-pound foam, which has a perm rating of less than 1 per 3 inches. However, because both seal against air infiltration (which accounts for most condensation problems in buildings) exceptionally well, low-density SPF can be used in warm and mixed climates without additional vapor retarders in typical applications. In colder climates, due to the increase vapor drive in one direction, low-density SPF typically requires an additional vapor retarder. In addition, even the 2-pound foam requires vapor retarders in extreme conditions where there is a constant vapor drive in one direction, such as freezers, swimming pools, mushroom farms, and so on.

The best way to assess this need is to perform a hygrothermal model on the specific application using software tools such as WUFI (downloadable at www.ornl.gov/sci/btc/apps/moisture/). WUFI allows a designer to select specific climate data, building materials, etc., to determine if moisture condensation would be a problem in a specific design. Sometimes it is not just the foam, but other materials as well. For example, one WUFI simulation (based on a real-life project) predicted that 3-pound foam (installed to the roof of a building with 5 inches of fiberglass insulation on the underside of the roof deck) with an interior humidity of 80 percent would create a condensation problem. When the fiberglass was removed, the condensation stopped. The WUFI program correctly predicted this condition and solution.

Mason Knowles • Spray Polyurethane Foam Alliance

RE in Disasters

Dear Mr. Owens and *Home Power*, I loved your article in *HP111*! It is exactly the article I've been waiting for. As a fellow Florida resident, it's remarkable that the "sunshine state" has so little PV in use compared to California and Arizona.

I have contemplated a design similar to the one noted in your article, with the same objectives: (1) start small, (2) emergency power supply for hurricanes, and (3) use battery-powered yard tools. Following Hurricane Wilma in October 2005, we were without electricity for several days. Fortunately, the hurricane coincided with a cold front (which caused additional damage), so we didn't have the sweltering heat to deal with. This coming hurricane season, a battery-powered emergency power supply as you describe would be useful for fans, small refrigeration, and even television to keep up with the news. I have purchased battery-pack yard tools—hedge trimmer, weed trimmer, and leaf blower—that all use the same 18 V batteries as my cordless drill. My additional criteria would be that the solar-electric panels could be easily removed from the roof and stored in case of an impending hurricane. Not only might they be destroyed in a storm, but they could also become dangerous projectiles.

Finally, the sidebar "Legal Protections in Florida" is very useful. The next step is to find Florida grants or tax incentives for renewable energy. Here's grid-tie information for readers who use Florida Power & Light: www.fpl.com/home/services/contents/small_photovoltaic_systems.shtml. Thanks again for the article. With a little more knowledge (and confidence), I hope to join you soon in the ranks of small-scale solar energy users.

Charles Willits • Naples, Florida

Hello Charles, Thanks for your kind words and useful observations on how to expand the use of a small solar-electric system with battery-powered hand tools. They could prove quite useful during any emergency. I worked for the Red Cross in Key West after Hurricane Wilma and saw firsthand the damage it caused. In the future, we will all need to better prepare for disasters. Small-scale solar electricity is well suited for this, and Florida can lead the way. Regards,

Bob Owens • Brandon, FL

Hi Charles, We are glad to see you are moving into RE and it seems like you are on the right track. The only thing I'd like to add is that you probably do not need to make your solar-electric panels removable from the roof. Modern racking systems should hold them down just fine, as long as your roof racks are appropriately rated and you mount the modules parallel to the roof plane. Just make sure that your roof is secured to the walls. We have not heard of parallel-mounted PVs flying off of roofs in high winds, and the glass on PV modules is capable of surviving a lot of projectile abuse.

Michael Welch • Home Power

RE in the Developing World

My wife and I are considering going into the Peace Corps when we retire in three to five years. I am wondering about learning the skills necessary for building RE systems in Third World countries. As I go through *Home Power*, I see a fair number of ads for programs that would help me learn these skills. Can you help me begin to sort out such issues as what would be the basic skills I might need to be of value in a Third World country? I'd appreciate any direction you could provide me. And, as always, I love your magazine and still get a thrill when I see it in my mailbox.

Steven Barry • Portland, Oregon

Steven, It's great that you are considering the Peace Corps. I know many folks who have had incredible experiences with the Peace Corps. As far as the basic skills you need to be of value in a Third World country, I'd say the most important are patience, open-mindedness, and understanding.

As far as technical knowledge goes, most groups that we work with seem to be working in PV for rural electrification. However, many organizations in the developing world do not know how to assess what the best technology would be for them to use, so a good overview of the different technologies is important as well. Often the technology is the easy part of doing a project, and all the other issues of working in the developing world are the hard (and more crucial) parts. I hope this answers some of your questions, and please feel free to contact me if you have any further questions.

Laurie Stone • Solar Energy International

Errata

The article, "Get Energy Smart—Insulation Options," published in *HP111* stated that "IARC [the International Agency for Research on Cancer] puts mineral wool (rock and slag wool) in its Group 2B class: 'possibly carcinogenic to humans.'"

IARC retreated from its former position and now states that "the more commonly used vitreous fibre wools including insulation glass wool, rock (stone) wool and slag wool are now considered *not classifiable as to their carcinogenicity to humans (Group 3).*"

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RE happenings

U.S.A.

Info on state & federal incentives for RE. NC Solar Center • www.dsireusa.org

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

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

ARIZONA

Scottsdale, AZ. Living with the Sun energy lectures, 3rd Thurs. each month, 7 PM, City of Scottsdale Urban Design Studio • 602-952-8192 • www.azsolarcenter.org

ARKANSAS

Jun. 21–25, '06. Fayetteville, AR. 2006 Solar Splash. World championship of solar and/or electric boating. Displays, solar slalom, sprint & endurance events. Info: Fayetteville Visitors Bureau • 800-766-4626 • www.solarsplash.com

CALIFORNIA

Jun. 27–28, '06. PV Summit 2006: San Diego. Assessing emerging markets & advancements in solar. Info: Doug Sanborn • dsanborn@intertechusa.com • www.intertechusa.com/photovoltaics.html

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

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

COLORADO

Aug. 7–14, '06. Paonia, CO. Camp-Us, RE camp for teens. Discover relationships between energy, nature, spirit, technology & social diversity. Hands-on activities, lectures & recreation. Info: 970-921-5529 • hareef99@yahoo.com • www.youthcamp-us.org

Sep. 16–17, '06. Fort Collins, CO. Rocky Mt. Sustainable Living Fair. Exhibits, workshops, RE, alternative fuel vehicles & more. Info: Rocky Mt. Sustainable Living Assoc. • 970-224-FAIR • kellie@poudre.com • www.sustainablelivingfair.org

Carbondale, Paonia & Denver, CO. Workshops & online courses on PV, solar pumping, wind power, RE businesses, microhydro, solar hot water, radiant heating, alternative fuels, green building & women's courses. Solar Energy Intl. • 970-963-8855 • sei@solarenergy.org • www.solarenergy.org

FLORIDA

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

IOWA

Jun. 16–18, '06. Mechanicville, IA. Thermal Solar Installation workshop. Info: see I-Renew below.

Iowa City, IA. Iowa RE Assoc. meets 2nd Sat. every month at 9 AM. Call for changes. I-Renew • 319-341-4372 • irenew@irenew.org • www.irenew.org

MICHIGAN

Dimondale, MI. '06 RE workshops. Jun. 3: Intermediate Solar Heating; Jun. 21–23: System Integrator Certification Course. Info: see GLREA below.

Jun. 16–18, '06. Onekama, MI. Michigan Energy Fair. Exhibits, vendors & workshops on green building, solar architecture, wind energy, energy efficiency, alternative fuel vehicles & more. Music & food. Info: Great Lakes RE Assoc. • 800-434-9788 • info@glrea.org • www.glrea.org

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

MISSOURI

Jul. 15–16, '06. New Bloomfield, MO. Missouri RE Fair. Wind power, PV, dome housing, greenhouses, hydrogen & more. Mid-America RE Center, 9810 State Rd. AE, New Bloomfield, MO 65063 • 800-228-5284

Jul. 29–30, '06. Hermann, MO. Ozark RE & Sustainable Living Expo. Presentations, workshops on PV, wind power, etc. Guest speakers, exhibitors, food vendors, music, kids' activities & more. Info: Rick Rodriguez • 314-993-9047 • rrickrod@charter.net • www.ozarkre.org

MONTANA

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

NEW HAMPSHIRE

Jun. 17, '06. Dorcester, NH. Solar Workshop. Home heating, PV, SDHW & solar cooking. Info: D Acres of NH • 603-786-2366 • dacres@cyberportal.net • www.dacres.org

NEW MEXICO

Oct.–Nov. & Feb.–Mar. each year. Deming, NM. Intro to Homemade Electricity. Meets 5 Thurs. eves. Mimbres Valley Learning Center • 505-546-6556 ext. 103 • www.mvlc.us/MVLC-DABCC.htm

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

NEW YORK

Jun. 21–22, '06. New York, NY. RE Finance Forum. For bankers & investors. Info: ACORE & Euromoney Energy Events • www.euromoneyenergy.com

Aug. 7–11, '06. Olivebridge, NY. Workshop: Designing & Building Natural Homes. Info: See SEI in Colorado listings.

NORTH CAROLINA

Beech Mt. & Fletcher, NC. '06 Wind workshops: Jun. 24–25, PV/Wind Installation; Aug. 27 & Sep. 9, Intro to Small Scale Wind Energy; Sep. 22–23, Wind Resource Assessment; Oct. 21–22, Small Scale Wind Energy. Info: NC Small Wind Initiative, Appalachian State Univ. • 828-262-7333 • wind@appstate.edu • www.wind.appstate.edu

Pittsboro, NC. RE, biofuels, green building, etc. Piedmont Biofuels Coop • 919-542-6495 ext. 223 • www.cccc.edu or www.biofuels.coop

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

OHIO

Sep. 30–Oct. 1, '06. Athens, OH. Athens Area Sustainability Festival. Workshops on alternative building & energy & sustainable living lifestyles. Arts & crafts, music & children's program • 740-674-4300 • fun@susfest.org • www.susfest.org

OREGON

Jun. 22–25, '06. Detroit, OR. Breitenbush Hot Springs RE Conf. Presentations on PV, solar thermal, biodiesel, efficiency, regs & codes, financing & big picture presentations. Info: Breitenbush Hot Springs • 503-854-3320 • office@breitenbush.com • www.breitenbush.com

Jul. 26–27, '06. John Day, OR. Pre-SolWest hands-on installation workshop. Info: see below.

Jul. 28–30, '06. John Day, OR. SolWest RE Fair. Exhibits, workshops, keynote speaker, family day, speakers, music, alternative transportation & Electrathon rally. EORenew • 541-575-3633 • info@solwest.org • www.solwest.org

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

PENNSYLVANIA

Jun. 23–25, '06. Portage, PA. East Coast Alternative RE Fair. Exhibits, vendors & education on RE & sustainable living. ECARE • 814-736-8818 • info@ecarefair.com • www.ecarefair.com

Philadelphia, PA. Penn. Solar Energy Assoc. meetings. Info: 610-667-0412 • rose-bryant@erols.com

RHODE ISLAND

Jun. 3, '06. Coventry, RI. Sustainable Living Festival & Clean Energy Expo. Exhibits & workshops on solar, wind, biofuels, alternative vehicles & building. Music & food. Info: Apeiron • 401-397-3430 • info@apeiron.org • www.apeiron.org

TENNESSEE

Oct. 19–22, '06. Summertown, TN. Personal oil independence course. Grow your own fuels; put PV on your roof. Info: The Farm • ecovillage@thefarm.org • www.thefarm.org

TEXAS

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

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

WASHINGTON

Oct. 7, '06. Guemes Island, WA. Intro to RE workshop. Solar-, wind- & hydroelectricity, solar cooking & hot water. Classroom & tours. Info: see SEI in Colorado listings. Local coordinator: Ian Woofenden • 360-293-7448 • ian.woofenden@homepower.com

Oct. 9–14, '06. Guemes Island, WA. Solar-Electric Design & Installation workshop. Comprehensive classroom and hands-on training on photovoltaics. Info: see above listing.

Oct. 16–21, '06. Guemes Island, WA. Solar Home Design & Natural Home Building workshop. Learn to design healthy, energy-smart homes. Classroom, labs, tours. Info: see above listing.

WISCONSIN

Jun. 23–25, '06. Custer, WI. RE & Sustainable Living Fair (aka MREF). Exhibits & workshops on solar, wind, water, green building, alternative fuels, organic gardening, energy efficiency & healthy living. Home tours, silent auction, Kids' Korral, entertainment, speakers. Info: see MREA listing below.

Custer, WI. MREA '06 workshops: Basic, Int. & Adv. RE; PV Site Auditor Certification Test; Veg. Oil & Biodiesel; Solar Water & Space Heating; Masonry Heaters; Wind Site Assessor Training & more. MREA • 715-592-6595 • info@the-mrea.org • www.the-mrea.org

INTERNATIONAL

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

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

CANADA

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

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

CHINA

Jun. 28–30, '06. Beijing. Wind Power Asia 2006. Wind energy conf. & exhibition. Info: Unique Intl. Exhibition Ltd. • 86-10-88-145-170 or 86-10-88-145-171 • sonya.xia@windpowerasia.com • www.windpowerasia.com

Oct. 24–27, '06. Beijing. Great Wall World RE Exhibition. Networking to bring together power executives, regulators, RE experts, suppliers & investors. Info: Skizttly Zhu • 86-10-62-180-145 • registrar@gwref.org • www.gwref.org

Oct. 31–Nov. 2, '06. Beijing. China Intl. RE Equipment & Technology Exhibition & Conf. Promotes RE & technology in China. Info: Goodwill International Conference & Exhibition Co. • 86-10-84-518-321 • bjgoodwill@263.net

FRANCE

Jun. 19–23, '06. St. Laurent de Cerdans. Intro to RE & solar energy. Incl. system design, electricity basics, lights & appliances, components & visits to working systems. Info: Green Dragon Energy • courses@greendragonenergy.co.uk • www.greendragonenergy.co.uk/courses.htm or Les Amis de Numero Neuf • 33-0-468-39-28-37 • lesamis9@gmail.com • www.lesamis9.org/solarcourse.htm

GERMANY

Sep. 4–8, '06. Dresden. European PV Conf. & Exhibition. Info: WIP-Munich • 49-89-720-12-735 • pv.conference@wip-munich.de • www.photovoltaic-conference.com

ITALY

Nov. 16–18, '06. Milan. PV Tech Expo. Conf. & exhibit for the PV manufacturing industry. Info: ArtEnergy Publishing • 39-02-66-306-866 • info@pvtech.it • www.pvtech.it

NEPAL

Kathmandu. School of Renewable Energy Ltd. • 97-701-424-4003 • sre@nepalmail.com • www.sre.org.np

NICARAGUA

Jun. 30–Jul. 11, '06 (again Jan. 8–19, '07). Managua. Solar Cultural Course. Lectures, field experience & ecotourism. Richard Komp • 207-497-2204 • sunwatt@juno.com • www.grupofenix.org

SCOTLAND

Jun. 7–9, '06. Crieff. Hidroenergia '06. Info: European Small Hydro Assoc. • 01-202-886-622 • info@british-hydro.org • www.british-hydro.org

Jun. 27–30, '06. Glasgow. EuroSun 2006. Intl. RE Conf. & Trade Exhibition. Latest research results, technological developments & business opportunities in solar & other RE. Info: The Solar Energy Society (UK-ISES) • 44-0-77-60-163-559 • info@uk-ises.org • www.eurosun2006.org

SPAIN

Jul. 12–16, '06. Granada. Solar Cookers & Food Processing Intl. Conf. For researchers & practitioners. Spread access to solar cooking, water purification & solar food processing. Info: Terra Foundation • solar@terra.org or Solar Cookers Intl. • bev@solarcookers.org • www.solarconference.net

UNITED KINGDOM

Jul. 21–23, '06; Buckinghamshire. Self-Build Solar Hot Water workshop. Build your own & learn to install a SDHW system. Info: Low-Impact Living Initiative • 44-0-12-96-714-184 • lili@lowimpact.org • www.lowimpact.org

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