

SINCE
1987

LET THE SUN IN! ATTACHED SUNSPACES THAT CURB HEATING COSTS

home power

SOLAR ▸ WIND ▸ HYDRO ▸ DESIGN ▸ BUILD

Fresh Perspective

Bold Design, Energy-Neutral



Better Solar Site Surveys

Maximize Your System's Performance & Payback

Keys to Wind Power Success

Critical Factors That Can Make or Break Your Project

Dec '13 & Jan '14, Issue 158

\$5.95 US • \$5.95 CAN



homepower.com



SUN XTENDER® STANDS ALONE



PVX-3050T | 6 Volt
305 Ah (24 Hr Rate)
GC2 Tall case

PVX-12150HT | 2 Volt
1215 Ah (24 Hr Rate)
L-16 case

PVX-1290T | 12 Volt
129 Ah (24 Hr Rate)
31 case

AGM Deep Cycle Sun Xtender® Batteries offer superior reliability and extended cycle life for renewable energy storage systems. Since 1987, the Sun Xtender renewable energy line has been manufactured with the same proven technology and rigorous quality standards used to produce Concorde Battery's military and civilian aircraft battery lines. Sun Xtender's robust build is designed for grid tied or off grid systems in residential, industrial, and commercial environments.

Processes and materials unique to Sun Xtender® that set them apart from the competition:

Protection against shorts: PolyGuard®, a proprietary, microporous separator around the positive plates.

Extended battery life: Plates are thicker than the industry standard for excellent cycling and improved float life.

Lower resistance: Over the partition intercell welds are broader for more current carrying capacity and stronger, compared to through the partition spot welds that are frequently used and are a common cause of early battery failure.

Maximum conductivity: Copper alloy terminals remain corrosion free.

Excellent charge acceptance: There is no current limit using controlled voltage charging.

Safe: Sun Xtender's reliable AGM design prevents acid spilling or spewing.

Maintenance Free: Ideal for locations where initial formation and electrolyte level maintenance is inconvenient or impossible. With no free electrolyte, Sun Xtender® also ships Hazmat Exempt.

With sizes and capacities to meet a variety of renewable energy requirements, Sun Xtender can customize any battery bank. Choose Sun Xtender for your system: premium, reliable batteries Crafted for Quality in the USA.



3

4

5

6

Dual-MPPT · 97% Efficiency · HALT Tested -50F to +200F · Order Now

Value.

Performance and innovation that will surprise you. **Cost** leadership driven by value engineering and world class supply chain efficiency. **Bankability** from a diversified, global company that is here to support you and your investment.



chintpower.com/na

AmericaSales@chintpower.com

855-584-7168

MIDNITE SOLAR

The KID

*The finest 35 amp MPPT charge controller for Solar, *Wind or *Hydro!*

The KID is the most versatile medium sized charge controller on the market. Ideal for small renewable energy systems. The KID allows for true input paralleling. As your power needs grow, add more modules to the array and a second KID. This will give twice the power from a single array.

The KID's PV power handling capacity is from 50 to 2000 watts depending on your configuration.

With three different mounting methods: flush mount surface mount or free standing, the KID will be the sharpest looking electronics in your home, cabin, boat or RV.

PRODUCT FEATURES

- Solar, *Wind or *Hydro modes
- Advanced MPPT tracking
- True paralleling - Inputs and Outputs
- MidNite's exclusive HyperVOC extends the max safe non operating input voltage to 162VDC
- Supports 12, 24, 36 and 48 volt batteries
- Load/Clipper function: Clipper function is used on wind or hydro and requires an additional *MidNite KID Clipper
- Lighting Controller: dusk-dawn, hourly, day, night settings
- Upgradable firmware so it is never out of date
- Up to 35 amps output
- Three LED bar graph plus 5 status LEDs
- Two line LCD display with keypad access for easy programming and data display/data logging

Marine version available in black or white.

- No fan
- Reverse polarity protected
- Battery temp sensor included on marine versions
- Front panel supplementary fuses for battery, input and load/clipper
- Includes wall mount adapter
- **Marine/RV versions include load circuit breaker, boat mount kit, battery temp sensor, extended conformal coating - available in black or white**
- Built in Arlington, WA USA

* Wind & Hydro available second quarter of 2014 with firmware updates

www.midnitesolar.com

17722 67th Ave NE Arlington, WA 98223 PH. 360-403-7207 Fax 360-691-6862



WE HAVE THE PRODUCTS YOU NEED TO MAKE RENEWABLE DO-ABLE



Solve & Janet are making renewable do-able, are you?

altE customers Solve and Janet are now happily living completely off-grid in San Antonio, NM.

EASY TO GET STARTED!



Off-Grid Cabin Packages
Starting at: **\$2,479**

CUSTOMER FAVORITE!



Xantrex XW MPPT 60A Charge Controllers
Only: **\$497**

MADE IN USA!



Air40 Wind Turbines - Available in 12V, 24V, 48V
Only: **\$849**

GREAT PRICE!



altE Solar Panels Available in 5W to 200W For Off-grid Systems

FREE WINTER TIME HEAT!



Your Solar Home Air Heaters
Starting at: **\$1,149**

PERFECT FOR RVs & BOATS!



ApolloFLEX Flexible Solar Panels
Starting at: **\$345**

MADE IN USA!



MK/Deka Solar Sealed Lead Acid Batteries
100% Maintenance Free

SAVE UP TO \$40!



Shurflo Submersible Pump/Controller Kits

PROTECT YOUR SYSTEM!



MidNite Solar Surge Protection Device
Only: **\$89**

ALL-IN-ONE SYSTEM!



OutBack FLEXpower ONE Pre-wired Off-grid System
Only: **\$3,995**

Call us at **800.320.9458** or visit us online at **www.altEstore.com**

Get an Extra Discount! Mention this code: **HP158** when you order today!



making renewable do-able™ for over 10 years!

AltE® Store is the Do-It-Yourselfer's supplier of renewable energy gear. We provide you the products, tools, education, expertise and the technical service you need to safely and successfully put together your own system. Join our fun and enthusiastic community of DIY'ers today!

Call us at **800.320.9458** or **978.562.5858**
or visit us online at **www.altEstore.com**



Offering You Quality Brands Such As...

42



On the Web



Like us on Facebook!

Easily browse and share our content with your Facebook friends. Enjoy special subscription offers, promotional discounts, reader comments, editors' notes, and much more: facebook.com/homepower



Follow us on Twitter!

Watch for bite-size article teasers, renewable energy event information, sneak peeks at upcoming coverage, subscription specials, and topical retweets: twitter.com/homepowermag



Share us everywhere!

Share an inspiring *Home Power* article on Facebook, Twitter, Digg, StumbleUpon, and many other services: homepower.com/articles

Events & Training

Search, browse, or post an RE event or training in your area. homepower.com/events

Contractors Directory

Search more than 1,000 local service providers to help with your project. homepower.com/contractors

Back Issues

Many print-edition back issues are still available for purchase. To check availability, contact us by phone or email. A three-year subscription to *Home Power* includes download access to the complete back issue archive—150+ back issues in PDF. homepower.com/subscribe



On the Cover

A 7.02 kW grid-tied PV system with battery backup was designed to provide all of the electricity for Kitty Brigham's ultramodern home in Longmont, Colorado.

Photo: Tophier Donahue

54



Main Features

34 **pre-owned** PV Zeke Yewdall & Orion Thornton

If you're considering buying a home or property with an existing PV system, here's what to check before you make an offer.

42 **platinum** PV Kelly Davidson

A Colorado home incorporates passive solar design, energy-efficiency measures, and a PV system to meet its energy needs and earn a LEED Platinum certification.

54 **site** evaluation Jeff Tobe

Taking the right steps to complete a thorough solar site survey can save you installation time and headaches later on.

Photos, clockwise from upper left: Kelly Davidson, Harry Martin, Courtesy William Sikora, Chuck Marken, Orion Thornton, Jeff Tobe

34

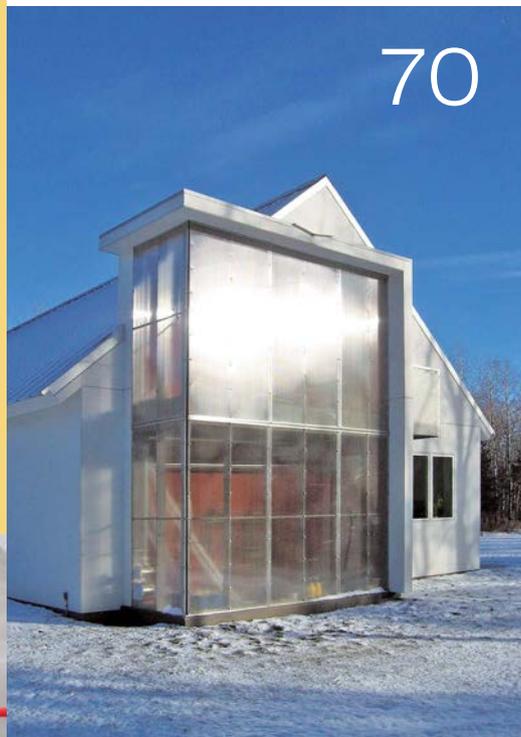
Up Front

- 6 from the crew**
Home Power crew
Energy lessons
- 10 news & notes**
Kelly Davidson
Efficient lighting
- 14 gear**
Sunnovations
The Ohm solar water heating monitor
Morningstar
TriStar MPPT 600 V charge controller
- 16 returns**
Kelly Davidson
Black Rock Solar
- 20 solutions**
Whitney Painter
Solar car-charging in Colorado
- 24 methods**
Jeff Tobe
Measuring roof azimuth
- 26 mailbox**
Home Power readers
- 28 ask the experts**
RE industry pros
Renewable energy Q & A

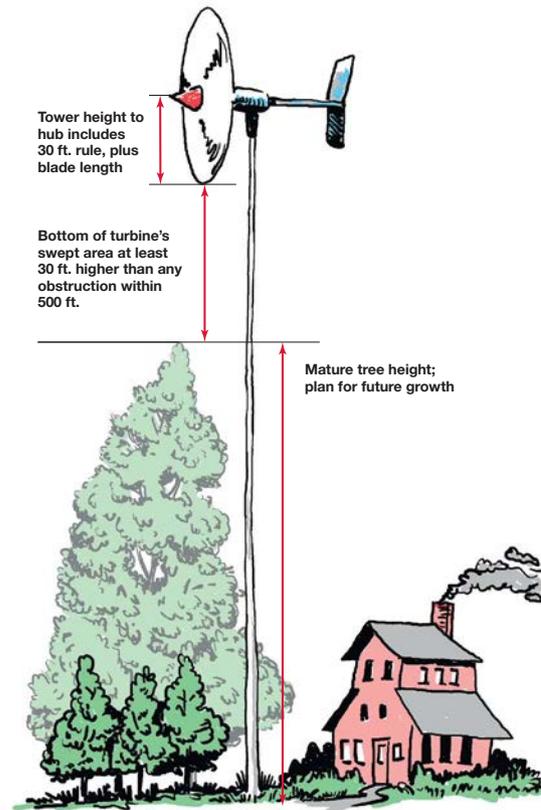


More Features

- 62 wind matters**
Mick Sagrillo
What matters when it comes to siting and designing a reliable and well-performing wind-electric system.
- 70 low-mass sunspaces**
Gary Reysa
Tap into the sun's free heat with a low thermal mass sunspace.
- 80 SWH troubleshooting**
Chuck Marken
Part two of this three-part series examines how to address problems with solar water heating controls, sensors, and tanks.



80



62

In Back

- 86 code corner**
Brian Mehalic
2014 Code changes
- 88 home & heart**
Kathleen Jarschke-Schultze
Pig + Women + Knives
- 91 advertisers index**
- 92 back page basics**
Kelly Davidson
Window shopping

Home Power (ISSN 1050-2416) is published bimonthly from offices in Phoenix, OR 97535. Periodicals postage paid at Ashland, OR, and at additional mailing offices. POSTMASTER: Send address corrections to *Home Power*, PO Box 520, Ashland, OR 97520.

Energy Lessons in Action

I'll admit it—I'm a data geek. So when we installed our TED (The Energy Detective) 5000 whole-house electricity meter, I found myself checking the numbers several times a day—both our electricity consumption (yikes: dishwasher, water heater, and drying diapers!) and PV production (yep: sunny, cool days!).

Although my energy-miser habits are ingrained, there's something about watching a live report of your usage that's even more validating—or eye-opening. Invisible electricity becomes visible when you have a real-time monitoring system reporting on your habits.

I say that we're a household of energy-savers, but that comes with a caveat: My husband and I are, but my young son is in training (and his baby sister will be, too, as soon as she can reach a light switch). Like most frenetic 8-year-olds, flitting from activity to activity, he tends to leave a trail of lights behind him wherever he goes. No matter our remonstrations and reminders, we can trace his path through the house based on the lights that remain blazing, and are forever retracing that trail, flipping off switches as we go.

One evening, though, as the washing machine's cycle ended and I was watching the watts drop on the display, it dawned on me—my son might also be a number-nerd, and watts might speak to him more powerfully than words.

For the umpteenth time, I informed him that the guest bathroom's light and his four bedroom lights were on. But this time, before he darted down the hall to address his conservation responsibilities, I had him check out the energy monitor's reading: 784 W.

After he shut off all of the lights, I had him take another reading—and do the math. One hundred watts might seem like small potatoes to us adults, but to an 8-year-old, 100 *anythings* are a staggering sum. His eyes widened, and he ran back to his room to see which fixtures were the biggest energy users. As he switched one light on, he called out to me so I could report TED's reading. He did this for all four bedroom lights, hypothesizing that the little fan light was drawing the most power (it was), but wondering why the closet light, drawing the least amount of power, was the brightest (it's a tube fluorescent, unshielded).

These energy experiments were far more powerful in convincing him than any conversation we could have had.



Claire Anderson

Seeing was believing—and baby sister will also be learning by watching what her big brother does.

Yesterday, after he left for school, I opened his bedroom door and braced myself for the expected blaze of lights in his room. Not a single bulb was burning.

—Claire Anderson, for the *Home Power* crew

Think About It...

"The vision must be followed by the venture. It is not enough to stare up the steps—we must step up the stairs."

—Vance Havner

The Right Mount



Using the right mount for the job can make the difference between a happy customer and a callback. Quick Mount PV, the leading supplier of solar roof mounting products, has mounts for composition/asphalt shingle roofs to cover your every need.



QBase Comp Mount - Ideal with new roof construction

Reinforced base-and-post technology for the strongest mounting platform. Installs smoothly with re-roofing or new roof construction.



Classic Comp Mount - Premium mount for existing roofs

Our original mount that revolutionized solar rooftop installation with its patented QBlock Elevated Water Seal. When the highest quality is demanded. 20-year warranty.

NEW!



E-Mount - Superior protection and value

Our QBlock Elevated Water Seal technology with a smaller, lighter flashing. Affordably priced for competitive markets.

With proven, made-in-America quality, Quick Mount PV helps you make every installation a success.

Sell more solar with Quick Mount PV.

To get a **FREE SAMPLE** -
and see all of our roof mounts -
visit www.quickmountpv.com

Quick Mount PV[®]
RESPECT THE ROOF

925-478-8269

Make your AC Coupled System Less Complex



The MS-PAE is ideally suited for use with Magnum MP and MMP Panel Systems for easy installation and a five-year warranty that covers the inverter and all Magnum accessories.

MAGNUM

E N E R G Y

www.magnumenergy.com

contact us

Home Power—Independently published since 1987

Publishers Richard & Karen Perez

Executive Editor & CEO Joe Schwartz

Managing Editor Claire Anderson

Art Director Ben Root

Senior Editors Michael Welch, Ian Woofenden

Senior Technical Editor Justine Sanchez

Technical Editor Erika Weliczko

Associate Editor Kelly Davidson

Graphic Artist Dave Emrich

Building Technology Editor Rachel Connor

Solar Thermal Editor Chuck Marken

Transportation Editor Bradley Berman

Columnists Kathleen Jarschke-Schultze

Ryan Mayfield, Brian Mehalic

Advertising Directors Kim Bowker, Connie Said

Operations Director Scott Russell

Data Manager Doug Puffer

Customer Service & Fulfillment Jacie Gray, Shannon Ryan

Home Power magazine

PO Box 520 • Ashland, Oregon 97520 • USA



homepower.com



facebook.com/homepower



twitter.com/homepowermag

Subscriptions

To subscribe, renew, change, or inquire about a subscription:

800-707-6585 or 541-512-0201

subscription@homepower.com

homepower.com/subscribe

Back Issues

Many of our back issues are available in print and/or online in Adobe PDF. Our first 131 issues are also compiled on DVD-ROM. More information at:

homepower.com

Order online or by phone:

800-707-6585 or 541-512-0201

Submissions

For inquiries and information related to editorial submissions, write to us at:

submissions@homepower.com

homepower.com/writing

Website

homepower.com

Send your comments regarding the site to:

web@homepower.com

Ask the Experts

To have your technical questions considered for publication, send them to:

asktheexperts@homepower.com

Letters to the Editor

Email your comments and suggestions to us at:

mailbox@homepower.com

or write to the address above.

Marketing

Promotional opportunities and offers:

marketing@homepower.com

Advertising

For inquiries and information related to advertising in *Home Power* or on homepower.com:

Western States:

connie.said@homepower.com

541-326-5773

Eastern States:

kim.bowker@homepower.com

541-858-1791

homepower.com/advertising

©2013–2014 Home Power Inc. All rights reserved. Contents may not be reprinted or otherwise reproduced without written permission. While *Home Power* magazine strives to publish only safe and accurate content, we assume no responsibility or liability for the use of this information.

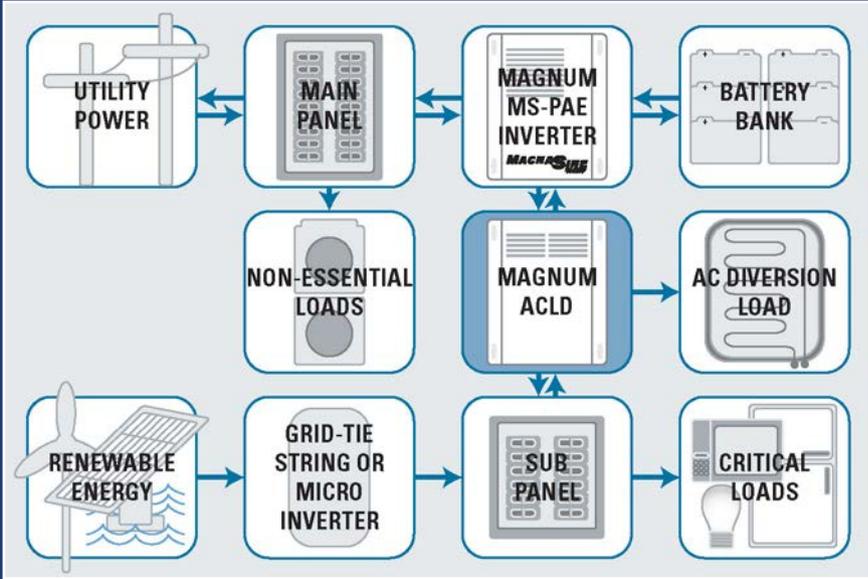
Interior paper is made from 85%–100% recycled material, including 20%–30% postconsumer waste.



Create a Diversion with Magnum's New ACLD

Introducing the First AC Load Diversion Controller on the Market (Patent Pending)

You're offsetting your electrical usage with a grid-tie solar system. You've gone a step further to protect yourself against blackouts or grid instability with an AC coupled system that provides a battery backup. Protect that battery backup system with Magnum's ACLD (AC Load Diversion). The ACLD will prevent battery overcharging by diverting power away from the batteries when they're fully charged to an AC diversion load – typically a water heater.



- ACLD works with the Magnum MS-PAE Series. One ACLD required for each MS-PAE Inverter
- Diverts up to 4000 Watts per unit

- Parallel stack up to four ACLDs
- UL1741 and CSA approved
- Works with most string and micro grid-tie inverters

- No backfeeding - the grid-tie inverter can remain connected (connected to the loads, but not the grid)

To learn more about Magnum products visit www.magnumenergy.com



LED vs. CF vs. Incandescent

Which light source has the smallest total life-cycle impact?



Number-nerds will rejoice in the graphs and data-crunching of an August 2012 U.S. Department of Energy (DOE) study—*Life-Cycle Assessment of Energy and Environmental Impacts of LED Lighting Products*—which assessed the results of 10 other studies and compared the total life-cycle impacts of LED, CF, and incandescent lamps. The results weren't surprising—spoiler alert! LEDs came out on top—but the slim margin between the top two efficiency contenders was.

The three-part study looked at the energy required for lamp use, manufacturing, transport, and disposal. Since the lumen output and lifetime for each lamp type are not equivalent, the study measured each lamp's energy use with a "functional unit" of 20 million lumen-hours—the estimated service life of a single 12.5 W LED lamp (60 W incandescent replacement) over its lifetime. An incandescent or CF lamp provides less lighting service than the functional unit value, so in order to make an apples-to-apples comparison, life-cycle energy estimates are multiplied by the number of lamps needed to reach this equivalence.

According to the analysis, the "use" phase of incandescent, CF, and LED lamps is the most energy-intensive portion, accounting for approximately 90% of a lamp's total life-cycle energy. The manufacturing and transport phases follow, respectively—with energy use due to transportation representing less than 1% of life-cycle energy for all lamp types. The uncertainty with LED life-cycle assessment centers on the manufacturing of the LED package (including substrate production, LED

die fabrication, and the LED assembly). Low estimates indicate that the LED package contributes to 0.10% of life-cycle energy use, while high estimates show it could be as much as 27%. The average indicates that LED package manufacturing is likely at about 6.6% of total life-cycle energy use.

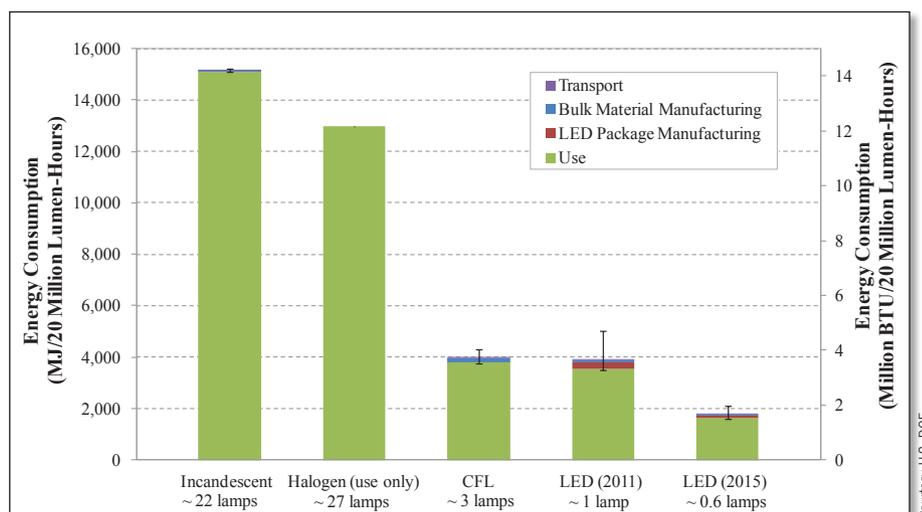
The analysis concluded that LED replacements and CF lamps are similar in their life-cycle energy consumption, with the difference largely determined by the manufacturing aspect. During their lifetime, LEDs and CF lamps consume 3,890 and 3,950 megajoules (MJ) per 20 million lumen-hours, compared to an incandescent lamp's energy consumption at 15,100 MJ per functional unit. The energy used to manufacture can be from four (CFs) to eight (LEDs) times as much as an incandescent.

By 2015, if LED lamps meet performance targets, their life-cycle energy use is expected to decrease by approximately 50%, which will give them a big efficiency gain over both CF and incandescent lamps. Improvements to current manufacturing methods and procedures are expected to reduce the manufacturing energy use, but the biggest gain will likely be due to an increase in LED lamp efficiency, resulting in fewer watts required to provide the same amount of lumens.

By 2030, the DOE forecasts that LED lighting will represent 74% of lumen-hour sales in the U.S. general illumination market. From 2010 to 2030, the cumulative energy savings is estimated to be 2,700 terawatt-hours, which at 2010 energy prices and

continued on page 12

Life-Cycle Energy of Incandescent, CF & LED Lamps



Courtesy U.S. DOE



Reliability runs in the family

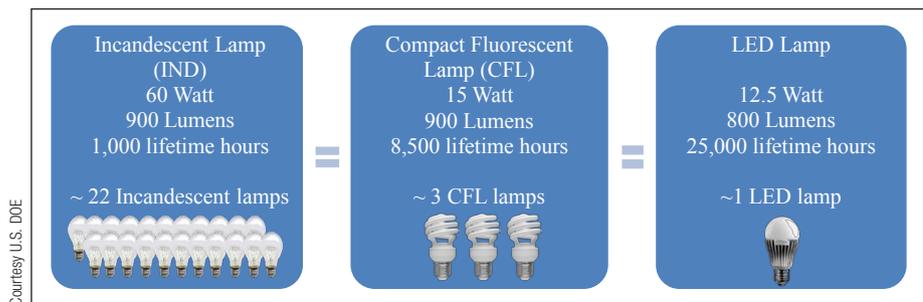


The Sunny Boy 240-US Micro Inverter
NOW AVAILABLE!

www.SMA-America.com

continued from page 10

Number of Lamps to Supply 20 Million Lumen-Hours



Courtesy U.S. DOE

electricity-generation-mix conditions represents approximately \$250 billion in savings and a greenhouse-gas emission reduction of roughly 1,800 million metric tons of carbon dioxide.

The environmental impact of the incandescent lamp's energy use were markedly more significant than for CF and LED lamps because of its low efficiency. The CF lamp is slightly more harmful than the 2012 LED lamp against all but one criterion: hazardous waste sent to the landfill. The energy and environmental impact of the manufacturing of the aluminum heat sink used in LEDs causes the impacts to be slightly greater for the LED than for the CF. The study notes that heat sinks should diminish in size for succeeding generations of LED lamps as efficiency gains are made. Environmental impacts of

a 2017 LED, for example, are predicted to be about 50% lower than the 2012 LED and 70% lower than the CF.

A variety of LED, CF, and incandescent lamps—a total of 22 samples, representing 11 different models—were tested to determine whether any of 17 elements were present at levels exceeding California or federal regulatory thresholds for hazardous waste. Most of the lamps were found to be well above the California threshold for copper, regardless of technology,

and some approached or exceeded the threshold for nickel. The selected models were generally found to be below thresholds for federal regulation. The study noted that the greatest sources of hazardous waste were the metal screw bases, drivers, ballasts, and wires or filaments—the diodes themselves generally did not cause LED lamps to exceed thresholds

—Compiled by Kelly Davidson

web extra

Read the full report at bit.ly/LampTech.



Trust is good – control is better.

Monitor your system quickly and effectively any time of day or night through a maintenance contract with your installer or portal operator. It provides both with access to our Solar-Log® WEB "Commercial Edition" - the simplest and safest way to monitor your solar-panel plant.

The Commercial Edition features the Solar-Log® Dashboard that displays yields, CO₂ savings and plant performance at a glance.

For more information, please visit: www.solar-log.net



Toronto
December 9 - 10, 2013
Booth number: 828



Solar Data Systems, Inc. • USA • north-america@solar-log.com • www.solar-log.net

U.S. Battery Provides Simple-Clean-Reliable Energy Storage Solutions.



U.S. Battery's American Made batteries have been energizing the industry since 1926.



6-volt
100 hr. rate
Amp Hours
441

2-volt
100 hr. rate
Amp Hours
1250

6-volt
100 hr. rate
Amp Hours
266

U.S. Battery Manufacturing Company is providing you with the highest rated batteries available today. With the addition of XC™ Diamond Plate Technology®, Outside Positive Plates OSP™ design, and an all new Defender™ Moss Shield specifically designed to prevent topside mossing. Our batteries will last longer and outperform the competition, saving both time and money.

U.S. Battery offers you both flooded (wet) and AGM (sealed) deep cycle batteries making us your one-stop-shop for premium lead acid batteries. Our new line of AGM maintenance-free batteries offer ease and convenience, minimal gassing and no leak applications.

We LOVE our Facebook fans!



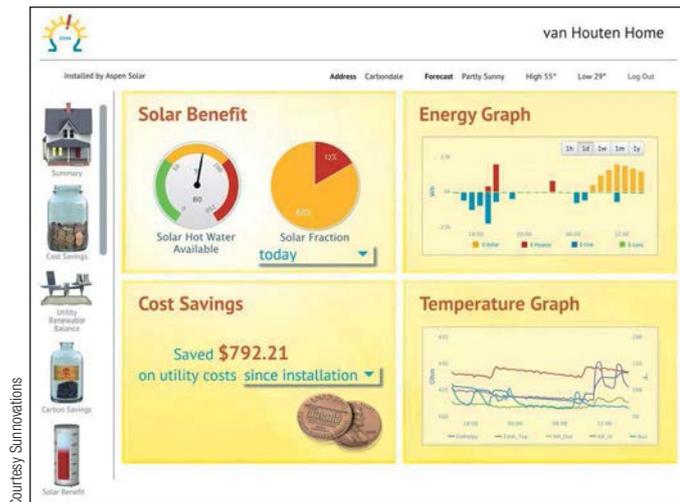
"Like" us and be automatically entered in our Facebook Give-A-Ways



See our entire line of American made products at: WWW.USBATTERY.COM

Sunnovations' Ohm

SWH Production Meter



Courtesy: Sunnovations

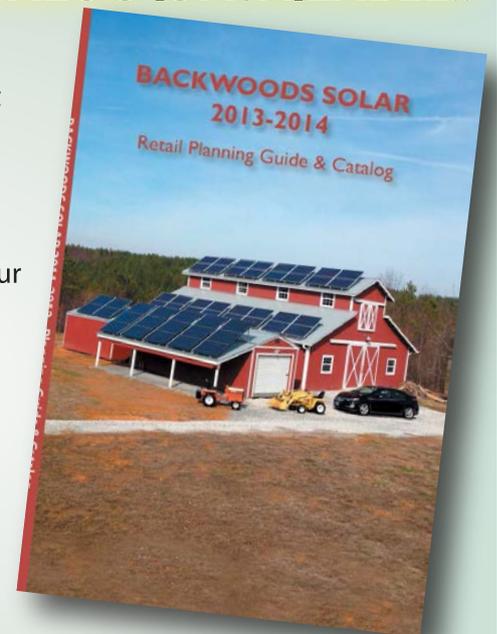
The ohm is a familiar unit for measuring electrical resistance. It's also a new solar heating monitor from solar water heating manufacturer Sunnovations (ohm.sunnovations.com). The Ohm is a production meter for residential use that eliminates the need and costs of an inline flow meter. The Ohm uses a resistance temperature device to measure the tank temperature and calculate the gain for each day. The Ohm requires Internet access at your home and uses a third-party website to access monitoring data. The company has published on its website the results of independent testing of the unit's accuracy.

—Chuck Marken

OUR NEW 2013-2014 FULL COLOR CATALOG IS AVAILABLE!!

The time has never been better to consider reducing or eliminating your dependence on the electrical grid. Let us help you plan the best system for you and your family. At Backwoods Solar we know what we're talking about because we live with it every day! Whether it's solar, hydro or wind power, at least one of us has it running our own home! We're a small company that cares about our customers and we've been doing so over 35 years. You can count on us to design your system using the products we've tested from the manufacturers we trust.

Check out our NEW 2013 Planning Guide & Catalog. It has a ton of great information about the basics of installing solar, wind and hydro systems. It's FREE to readers of Home Power if you mention this ad!



1589-HP Rapid Lightning Rd
Sandpoint, ID 83864
phone: 208.263.4290

AMERICA'S MOST TRUSTED OFF-GRID SUPPLIER FOR OVER 35 YEARS

Morningstar's TriStar

TS-MPPT 600 V Charge Controller



Courtesy Morningstar

Morningstar (morningstarcorp.com) has introduced its TS-MPPT-600V charge controller for PV array open-circuit voltage (Voc) of up to 600 VDC; a nominal battery voltage of 48 VDC; and a 60-amp maximum output current. High-voltage input can yield many advantages, such as smaller-diameter (less expensive) wire for long wire runs between the array and controller. Since more PV modules can be wired in series before reaching 600 VDC, the controller can eliminate parallel wire runs and a combiner box. Additionally, adding battery backup to a typical high-voltage grid-tied system can be accomplished without having to rewire the array. The TS-MPPT-600V has four-stage charging (MPPT, absorption, float, and equalize), utilizes open communications protocols, and has several options for communication ports (Ethernet, EIA-485, RS-232, and MeterBus).

—Justine Sanchez

SOLARWORLD MODULES ARE MADE IN THE USA



**SolarWorld.
US Solar.
Winning Combination.**



**We have your modules in stock
and available now - give us a call!**



(916) 679-4044 • www.ussolardistributing.com/solarworld

Black Rock Solar Shines

In 2007, when the Nevada state legislature established the SolarGenerations rebate program for customers of NV Energy, the state's largest utility, entrepreneurs Tom Price and Richard Scott saw an opportunity. SolarGenerations provided upfront rebates for installations on public buildings, including nonprofits, churches, schools, and tribal offices.

The duo devised a plan to provide free or low-cost PV systems through the rebates and other public funding. They founded the Reno-based nonprofit Black Rock Solar (BRS, blackrocksolar.org), assembled a crew of volunteers, and began knocking on doors and cold-calling prospective clients. Six years later, BRS's 25-person crew has installed more than 3 megawatts of PV throughout the state—including 201 kW at Western Nevada College in Carson City; 45 kW at the Children's Cabinet Youth Center in Reno; and 91 kW for buildings operated by the Fallon Paiute Shoshone Tribe.

"Many schools, nonprofits, and tribes don't consider solar because they think they cannot afford the upfront costs. We help them take advantage of all the available incentives and raise additional funds through donations," says Patrick McCully, BRS executive director. "In the end, our clients pay very little, if anything, for the installation, and they save hundreds, even thousands, in electricity costs each year. That's money they can use to support their missions."

Pyramid Lake School in Nixon, Nevada, is partially powered by a solar array installed by Black Rock Solar.



Courtesy Black Rock Solar & Candice Nyando

The "Burning" Backstory

The idea that sparked Black Rock Solar came at the 2007 Burning Man festival, an eight-day counterculture arts festival held annually in Nevada's Black Rock desert. The festival—themed "The Green Man" that year—attracted a company looking to promote their green and clean-tech wares. Renewables Ventures, a San Francisco renewable energy company, donated a 30 kW PV system to help power lights for the festival. A crew from Burning Man's Department of Public Works installed the array, in the shape of the Zuni sun, on the desert floor.

After the festival, the Burning Man crew—which included employees Tom Price and Richard Scott—moved the donated array to an elementary school in the neighboring town of Gerlach. With state rebates, the original array was expanded to 90 kW, providing the school with 30% of its electricity needs and saving the town government more than \$15,000 per year. The success of the Gerlach school project led Price and Scott to develop another 30 kW project at Pershing General Hospital in the town of Lovelock.

At the end of 2007, the two established Black Rock Solar. In those early days, Burning Man and its board provided key advice, technical assistance, and financial support to help BRS get off the ground. The festival continues to show its support for BRS—customers who buy Burning Man tickets online can also donate funds to BRS. Additionally, Burning Man allows BRS to use space in its San Francisco office rent-free.

True to its roots, BRS returns to Burning Man every year. In 2014, look for them in the Everywhere Pavilion, where the Burning Man outreach groups gather and host events.

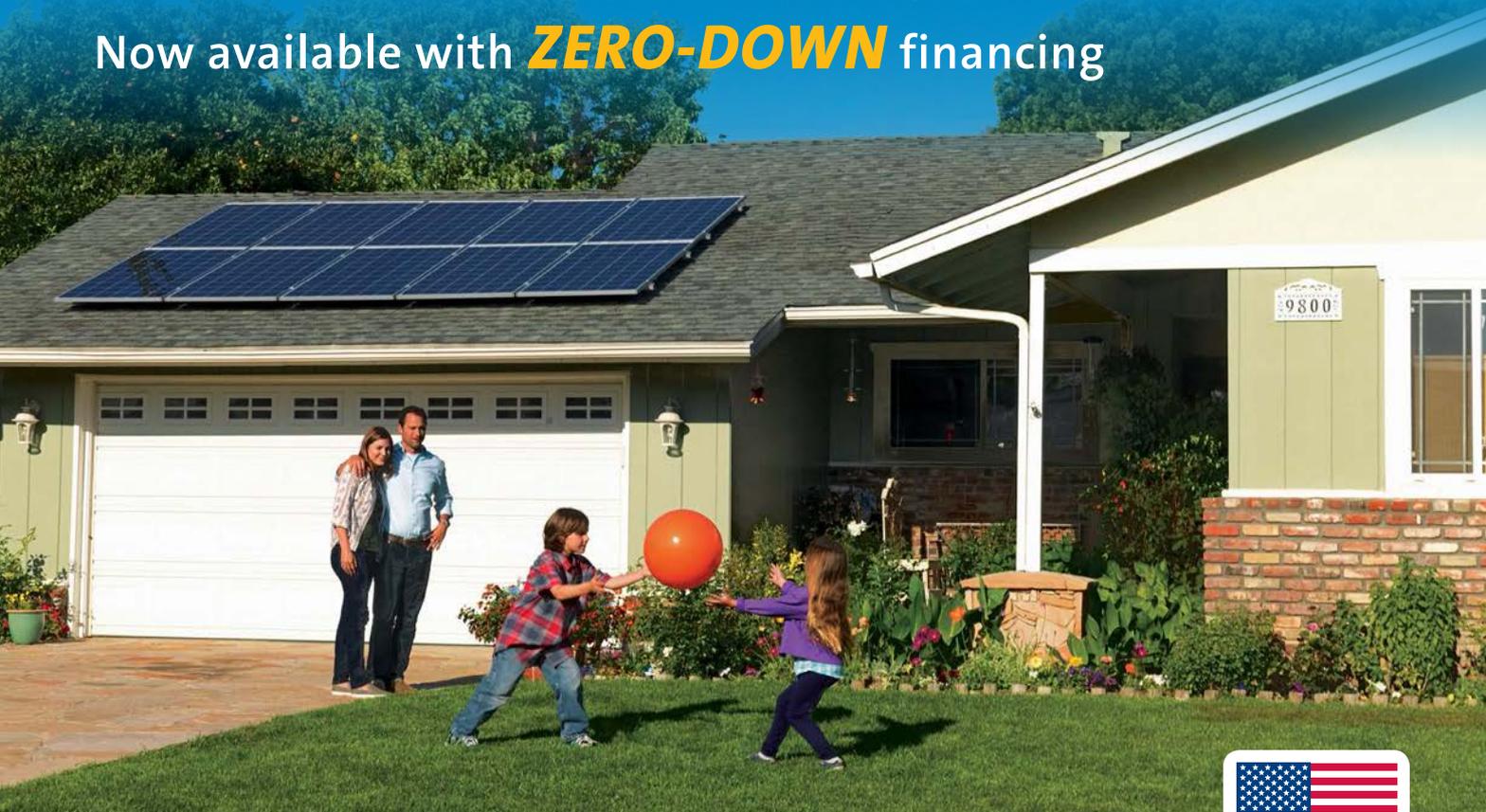
Once funding is in place, BRS's crew installs the system. In return, clients sign over all or a portion of the rebates they receive. This amount is typically equal to one to three years of the estimated electricity savings from the system output, says McCully.

In the past, the majority of BRS's funding to pay its staff and support its administrative operations came from the SolarGenerations rebates collected from clients. Funded through a small surcharge on NV Energy's customers, the rebates paid as much as \$5 per watt at one point for PV systems installed on public buildings. Since government agencies, nonprofits, and schools are tax-exempt and unable to take the federal tax credit, the NV Energy rebates have been especially important for promoting Nevada's solar growth in this sector, McCully says.

continued on page 18

AMERICAN-MADE SOLAR

Now available with **ZERO-DOWN** financing



Don't settle for less

With the SolarWorld Freedom™ Plan, making the smart decision to go solar has never been easier—or more affordable. Solar panels made in America, by Americans are now available with flexible financing options. Don't spend more for lower quality solar.

The Freedom Plan from SolarWorld Gives You ...

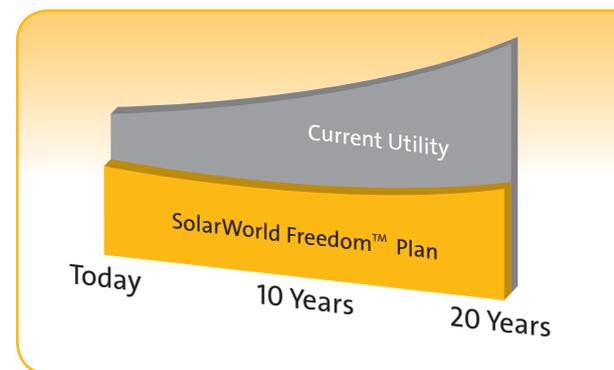
- Freedom to lower your energy bill every month
- Freedom from rising energy costs
- Freedom to choose American-made solar and support American jobs

Plus...

- NO high up-front capital costs
- NO system maintenance
- NO performance risk

To sign up for a free solar consultation, visit us at SolarWorld.com. Or if you are an installer and want to see if the SolarWorld Freedom Plan is available in your area, contact us at freedom@solarworldusa.com or call (866) 228-8756.

We're SolarWorld – America's Authority on Solar™



continued from page 16

But as the price of PV has dropped, so have the rebates. In 2013, the state's public utility commission approved NV Energy's proposal to reduce the solar rebates for public buildings to \$1 per watt, down from \$2.80 per watt during the previous phase. Now, NV Energy is proposing that rebates be cut even more, down to \$0.1724 per watt for public buildings. The utility had plans to reopen the program for applications starting November 1, 2013. Though this release is scheduled to be the utility's last round of upfront incentives, McCully doubts that such low-level incentives will be enough to make the initial costs of a new solar project affordable for nonprofits and schools already facing budget challenges.

Courtesy Black Rock Solar



Students from Hunter Lake Elementary School in Reno visit the Pyramid Lake Paiute Tribal Museum and Cultural Center. Students learn about renewable energy and Paiute culture at the museum, which is partially powered by a Black Rock Solar array.

BRS Project Snapshots

The Shade Tree • theshadetree.org On any given day, roughly 350 women and children may reside at The Shade Tree shelter in Las Vegas. The shelter provides beds, meals, and support services for women, children, and their pets who are escaping domestic violence and other difficulties. For the donation-reliant shelter, every dollar counts. Last year, BRS installed a 31.1 kW PV array atop a carport built on the shelter's campus, helping the shelter save more than \$5,000 annually. "BRS was so compassionate about our mission that they performed the installation at night so all the workers were off-site during the day, when our victims are awake and moving about the campus. This approach allowed the project to be completed without even one client feeling fearful that her identity may be discovered," says Marlene Richter, The Shade Tree executive director.

Boys & Girls Club of Truckee Meadows • bgctm.org In May 2011, BRS completed a 75 kW PV array on the club's roof, saving about \$12,500 annually. "The [savings are] put into our programs and services for Reno kids," says Rick Stevens, director of operations for the club. "Perhaps most importantly, it shows our members and the kids that clean energy is something that can be practical."

Yerington Paiute Tribe • ypt-nsn.gov BRS installed three PV arrays for the Yerington tribe in 2011, melding technology and artistry. One 30 kW ground-mounted array at the tribe's medical clinic resembles a stylized sun. Another 30 kW ground-mounted array at the tribe's administrative building takes the shape of a gavel, the tribe's emblem. A 15 kW ground-mounted array at the tribe's commodities building is in a basket-weave pattern, representing an important element of the Tribe's culture. But the arrays are much more than static sculptures. All told, these three arrays save the Tribe an estimated \$14,300 every year—more than \$350,000 over the next 25 years of their estimated service life.

With the proposed cuts, BRS's time in Nevada may be coming to an end. The nonprofit is exploring several options, including moving its operations across state lines to California, where incentives are still available. However, the group remains hopeful that this summer's acquisition of NV Energy by Warren Buffett's MidAmerican Energy may be a game-changer in the long run, given that MidAmerican is a major owner and developer of solar projects.

In the meantime, BRS is wrapping up what may be its last SolarGenerations rebate-funded installation—a 31 kW rooftop PV system for Friends In Service Helping (FISH), one of northern Nevada's biggest charities, which serves more than 200,000 free meals a year. Rebates covered most of the system cost, and BRS partnered with the Las Vegas-based charity Green Our Planet to raise \$12,000 via an online crowd-funding campaign. The system, due to be operational by early 2014, will be installed on the roof of FISH's thrift store in downtown Carson City.

For now, BRS is sustaining its operations by relying more heavily on donations and grants for its education work, which includes a field-trip program where grade-school students learn about renewable energy and energy conservation while visiting BRS project sites. Funding from clients, as well as in-kind and subsidized donations of solar goods from the industry, has grown in importance as the incentives have declined.

—Kelly Davidson

Deka Solar Saves The Day

The proven, reliable solar battery choice for off-grid power needs in harsh conditions... and other remote possibilities!

Power when you need it. From the Caribbean to the glaciers of Antarctica, Deka Solar Gel/AGM or flooded batteries are the proven choice for all your renewable energy applications.



Deka
SOLAR
PHOTOVOLTAIC BATTERIES



Available through MK Battery distribution centers across North America, Europe and the Asia Pacific region • U.L. Recognized Components • Competitive Warranty • ISO9001 Quality System Certified • Made In The USA



www.mkbattery.com

© MK Battery 2013

MK Battery - An East Penn Manufacturing Co., Inc. Subsidiary



Solar Car-Charging

in Colorado

In anticipation of an electric vehicle purchase, this PV charging station was constructed in 2009. Due to a lag in availability, the all-electric Mitsubishi i-MiEV arrived in 2012.

The home was already equipped with a 2.88 kW batteryless grid-tied system on its detached garage, which offset more than 100% of the household's annual electricity use. However, with increased usage anticipated for charging an electric vehicle, a suitable location was needed for an additional array.

The carport was designed to provide covered parking and the EV charging station. Because the carport is visible from the street, its appearance was a priority. Custom-designed

and engineered, the structure was built with hand-notched beetle-kill Colorado pine from a local family's forestry operation. The cobblestone-style driveway was constructed with remnants from the slab driveway removed to make way for the project, as well as construction debris from a neighboring property.

Sanyo Double-HIT modules were chosen for the batteryless grid-tied array, both for their aesthetic and production benefits. The semi-transparent cells allow some light to pass through, gently illuminating the carport during the day. The underside of the modules collect reflected sunlight, boosting the array's production by about 5%. This increased productivity would help make up for increased afternoon shading from a large conifer on the west side of the property that reduces annual production by about 9%.

The car-charging system generates about 2,750 kWh per year—providing enough energy for 11,170 miles of driving. In the past 18 months, the vehicle has logged about 16,800 miles—and the electricity it uses for recharging is well-matched with the PV system's generation capacity.

Utilized for day-to-day business travel along Colorado's Front Range, the electric vehicle is equipped with a 16 kWh battery. Although a full charge is rarely required, the carport's level 2 charger (240 VAC) can provide a full charge in about five hours; a level 1 charger (120 VAC) performs this task in about 16 hours. The same port is used for either type of charge. Most EV owners have level 2 chargers at home, and some public charging stations are level 2 as well. However, with the same port, the level 1 charge can be delivered from any standard outlet, as well as some charging stations, which increases options and flexibility for the EV driver.

Vehicle range is variable, depending on seasonal temperatures and terrain traveled. A mountainous

continued on page 22



Courtesy Buglet Solar Electric



One size doesn't fit all, but one company does.

Built for the real world

continued from page 20

60-mile summertime one-way trip from Golden (elevation 5,675 feet) over the Continental Divide at Berthoud Pass (elevation 11,306 feet) and into Winter Park (elevation 10,578 feet) is not unusual, but during colder months the battery's decreased capacity makes such a trip impossible.

Experience indicates an average battery bank range of about 85 miles during warmer months to about 50 miles in the coldest months, depending upon terrain. Regenerative braking noticeably increases battery capacity—and vehicle range—in downhill driving or stop-and-go traffic, compared to highway travel. Familiarity with the vehicle's performance in various conditions grows with time—similar in many ways to the experience of a household adjusting to an off-grid PV system. You learn to adjust energy consumption habits as energy production allows.

The household couples the EV with a biodiesel-powered Volkswagen Jetta TDI wagon for longer travel. "Most households have two cars, and it makes sense that one of the vehicles is mostly for trips closer to home," says homeowner Bart Sheldrake. "It's really convenient to charge our car at home, and we're glad to know that we're fueling our transportation with solar energy." Since adding the electric vehicle in 2012, the household continues to accrue credit on its bidirectional meter despite recharging the car daily.

—Whitney Painter

Overview

System type: Batteryless grid-tied PV

Owners/installer: Whitney Painter & Bart Sheldrake / Buglet Solar Electric

Date commissioned: August 2009

Location: Golden, Colorado

Latitude: 40°

Average daily peak sun-hours: 5

System capacity: 2.3 kW STC

Average annual production: 2,750 kWh AC

Average annual utility bill offset: 100%

Equipment Specifications

Modules: 12 Sanyo Double-HIT HIP190DA

Module rating: 190 W STC

Inverter: Fronius IG2000

Inverter rated output: 2 kW

Array installation: Custom carport

Array azimuth & tilt: 154°, 12°

The TriMetric Basic Battery System Monitors

Display vital battery system data to help users provide better battery care, conservation awareness and aid system maintenance: • **Volts** • **Amps** • **Amp-hours** • **Watts** • **Battery% full** • **Days since charged**. Newer TM2025 records recent data to check proper battery charging voltage and amps.



TriMetric TM-2025-RV
includes enclosure



TM2025-A
Shown in (optional) double gang electrical box.

Trimetric-2025 comes in two versions: Different look, but operate the same. 12-48V operation standard. Lightning resistant. About....\$180

The PentaMetric Battery System Monitor with More Capability

The choice for advanced system analysis and maintenance.



- **Data Logging** - records last 3 weeks of system data.
- **System Troubleshooting** by comparing to previous data.

NOW - 3 Computer Options:

- PM101-CE:** Ethernet computer or internet access
- PM102-USB:** USB access
- PM100-C:** RS232 access

The PentaMetric System with USB or RS232 interface: ...\$320
Optional LCD Display unit (shown above) additional....\$199

details at: www.bogartengineering.com
BOGART ENGINEERING (831) 338-0616
Boulder Creek, CA 95006

Learn Solar, Buy Solar, Accelerate Your Solar Business



Solar Training



Solar Products



Support Services

Now it's as easy as 1-2-3 to power up your solar business with ONTILITY.
With our solar training, products and services, accelerate your business today.



ONTILITY Announces New Partnership Program!

We bring you the best of the best in the solar industry.

Visit us at www.ontility.com for our full list of Platinum & Gold Partners



To learn more, please contact us toll-free at **1.877.858.7479** or visit us at www.ontility.com
Solar Training · Solar Products · Solar Design · Solar Consulting · Solar Logistics · Solar Marketing

Measuring Roof Azimuth

Knowing what direction a roof faces (its azimuth) is important to accurately estimate a roof-mounted PV array's generation potential. With the use of a compass and magnetic declination, a roof's orientation can be determined using these few simple steps.

1. Align the base of the compass with the edge of the roof. Most compasses will have an indicating arrow that will be perpendicular to the roof edge.
2. Rotate the compass dial so the needle is aligned to the magnetic north-and-south axis.
3. Adjust the compass dial to compensate for the local magnetic declination. You can find your magnetic declination at bit.ly/CalcDeclination.
 - a. For eastern declinations, the dial is rotated counterclockwise, *subtracting* the declination value from the current compass reading.
 - or-
 - b. For western declinations, the dial is rotated clockwise, *adding* the declination value to the current compass reading.
4. The compass bearing that aligns with the indicating arrow is the roof's azimuth. The photos demonstrate finding roof orientation with an eastern declination of 8°.

—Jeff Tobe

Online Siting

Solmetric provides a free online tool that can determine your roof's azimuth. Just enter your address and use a screen cursor to point to the edge of your roof (see bit.ly/SolmTools). To use the tool, you will need to register on Solmetric's website.

Select "Roof Azimuth Tool" from the drop-down menu under the "Support" tab at the top of Solmetric's home page. Log in with your username and password, and a map of the United States will appear with a text box at the top to enter the property address. Once the address has been entered, an overhead image of the property will appear for viewing. Next, click on the "Azimuth Tool" button located at the top of the satellite image just to the right of the address text box. A crosshair will appear for you to move and establish a reference point for measuring the roof azimuth. Use the crosshair to click on two points at either end of the roof edge. Once the two points have been established, the tool automatically draws a line along this roof edge indicating the orientation to true south, which is also shown in the "Azimuth (true)" text box. (See "PV Site Evaluation" on page 54 for an example.)

Smartphone Siting

If you have location services enabled, the compass app on your smartphone likely corrects for magnetic declination automatically. Just align the phone with the roof edge and read the value. However, be aware that interference can create inaccurate readings.

Align the bottom edge of the compass with the roof's edge.



Rotate the dial to align the black needle with the north arrow.



Adjust for declination (8°E), and read the value at the arrow (152°).



Jeff Tobe (3)



The new look of quality.

NABCEP Certification has a fresh new look. But its meaning hasn't changed. The industry's most respected mark of excellence is your assurance of expertise, ethical sales practices, and quality workmanship.

Experience. Quality. Professionalism. Buy with confidence. Choose only NABCEP certificants for your solar installation.



PV Installation Professional
PV Technical Sales Professional
Solar Heating Installer



**Meet the faces of NABCEP:
Kelly Provence**

*Owner of Solairgen School of
Solar Technology*

"My NABCEP certifications tell customers I have achieved high-level skills, and let them know I didn't get into this yesterday. NABCEP certification distinguishes individuals within the industry."

Find a NABCEP Certified Sales or Installation Professional

Visit nabcep.org

NABCEP™

Raising Standards. Promoting Confidence.

Solar Hot-Tub Controls

In *HP157*, Karim Wingedheart asked how to keep his solar-powered hot tub water at a constant 103°F. We had this same challenge with our open-loop, solar-heated, 550-gallon cedar hot tub. We live in Arizona, and without regulation of such a heating system, the water would often be too hot for comfort.

To regulate water temperature, we purchased a differential temperature controller from Art-Tec Solar. The controller compares the temperature set point to the water temperature of the hot tub and the temperature in the solar collector, turning the circulation pump on only if the water temperature in the collector is higher than the tub water's temperature, and the hot tub water is lower than the temperature setpoint.

The controller remains the brains of our solar-heating system. Without it, we were faced with the same challenges as Karim. We hope this helps.

Dominick McCutcheon •
San Tan Valley, Arizona

Minisplits in China

I read about ductless minisplit heat pumps in *HP157*. I was both surprised and intrigued to see this heating system mentioned in *Home Power*. I have been to China twice in the last two years. These units are in service in many thousands—probably millions—of homes in China. In 2011, I used a minisplit unit to keep my hotel room cool in July. This year, I used a minisplit to heat and cool the apartment I lived in for five months. The writer says these units can be installed on exterior walls. In China, they are installed on whatever wall the installer chooses. One can hope the unit is powerful enough to distribute hot or cold air throughout the home no matter where in the home it is placed, but this is not always the case.

Retrofit minisplits on apartments in China.



Courtesy Robert Boardman

In 2011, you published my letter about the widespread use of electric bicycles and tricycles in China. Minisplits are another example of technology that has been used in developing countries for a long time, but which are now being discovered and used in developed countries.

Robert Boardman • via email

Solar Sisters

Many thanks to *Home Power* for providing the space and to Justine Sanchez for writing "Support Solar Sisters" in *HP157*. I thought I was alone in feeling disgusted by "booth babes" at recent solar trade shows. People told me that it's even worse at European shows, but that sure does not make me feel better. Justine highlighted how disheartening it is as the mother of a young girl, and I wholeheartedly agree! She also noted that she avoids these booth areas when attending a conference; I would add that I refuse to do business with those vendors.

I have been a successful business owner and NABCEP-certified installer for seven years. It continues to amaze me how surprised people are that I—a woman—choose to engage in intelligent technical conversation. The solar industry has enough entrenched ideas to deal with as we offer options to replace fossil fuel and old ways of doing things. Let's work together as an industry to shine when it comes to such gender stereotypes and bias. Support solar sisters!

Rebecca Lundberg • via email

Compressed Earth

I read Josh Denney's letter about compressed earth buildings in *HP155* with interest. I think he's confusing the high R-value wall structures (what the original article was talking about), with high thermal-mass wall structures. While there are benefits to both, the high-R-value wall has a much wider applicability. A wall with high levels of insulation is able to resist the temperature difference between inside and outside. This is valuable for a high-performance home in nearly all climates, and is really just an extension of the well-understood design of a modern home.

On the other hand, a high-mass wall (masonry, concrete, water, etc.) is completely different. It has very little insulation value, which means that it can't support a temperature differential across it for very long. What it can do, though, is absorb a lot of energy, very slowly, with a fairly small temperature change. A properly built and designed high-mass wall, in the

right climate, will warm up slowly during the day, when the outside temperature is warmer than the interior temperature, and will then radiate that heat in both directions (inside and outside) at night, when the outdoor temperature is cooler than you'd want inside.

In short, high-mass walls provide a temperature-moderating effect. For an exterior high-mass wall to work well, this means that the average outside temperature over the course of the day be close to an acceptable indoor temperature—i.e., your climate must have a fairly wide temperature swing. In some parts of the United States, such as the desert Southwest, this is fairly common.

But if you're talking about the humid Southeast (like Florida), I don't think the nighttime temperature gets cold enough in the summer for the average temperature to be acceptable. Similarly, in many parts of northern United States, the average wintertime temperature is far too cold to be acceptable. Even in those regions, though, you could be clever and put a high-mass wall *inside* a well-insulated building envelope. That way they work together to naturally keep the indoor temperature acceptable. High-mass walls are valuable, but please don't try to make them be something that they're not.

Lloyd Brown via homepower.com

Amnesty for Solar Guerrilla

In 1999, I was Solar Guerrilla #0006 (see *HP73*). A few months ago, I got a call from a representative of my electric utility (it's a public utility district; PUD) telling me that the new smart meter installed at my house last summer detected "reverse energy." When they asked if I knew of a reason for this—and asked if I have solar panels—I saw no point in trying to hide (plus, the PVs are mounted out in the yard). I said, "Yes, but my charge controller was supposed to prevent that from happening."

The caller, who turned out to be the energy services manager, asked if he could see the installation the next afternoon and drop off a net-metering application. I agreed, expecting that he'd turn around and get back in his car when he found out that it wasn't a county-permitted, licensed-electrician-installed, AHJ-inspected system. During his visit, he asked about the system generation capacity and anti-islanding protections, and dropped off the six-page application, all the while talking like it was a done deal—just fill out the forms and send them in and he'd rubber-stamp them.

I filled out the application, including a one-line system diagram and a layout drawing showing the spatial relationship of the ground-mounted array, house, utility meter, and service drop, and sent it in via email the day after his visit. The next afternoon, I got an email from him telling me the application was approved. The email also included a copy of the signed contract.

It's done—my system is legit with the utility! All I can figure is that the last 14 years wore them down. I ran out the clock, and now that they have all these darned smart meters that are ringing bells and flashing red lights down at the administration building, they are bringing everyone they can into the fold so that they can concentrate on more important stuff. Amazing! No permits, no inspections, no electricians, and most mind-blowing, no lockable disconnect!

Exactly one week from the initial phone contact, a crew of two workers from the utility's meter shop installed a newer smart meter that can recognize reverse energy as net production. Afterward, I turned off my Frankenstein dump load controller and just let their meter sort it all out. I was catching 99% of the PV surplus before, so I didn't expect to see a big advantage. Now, I'm entering the fourth month of net metering with a 38 kWh surplus.

Of course, I've also spent a fair bit of time since fiddling with my newly installed hydro project. If I'm going to get paid for stuffing electrons back into the grid, I'm going to get good at doing it. (They pay wholesale rate for any production over parity at the year-end even-up time.)

So, back in 1999, I was Solar Guerrilla #0006, and in 2013, I'm Owner-Generator #19 for the local PUD.

Solar Guerrilla #0006 • via email

The old guerrilla PV array and new legit net meter.



Courtesy Solar Guerrilla #0006

Monetizing Sunshine

I enjoyed Andy Kerr's "Monetizing Sunshine" in *HP154*.

There is one very major factor that is not considered with solar as an "investment." If you have money to invest in solar, you then subtract utility costs from other investment returns you are considering. In other words, if you choose to invest in a mutual fund instead of solar electricity, you subtract your utility cost from your mutual fund returns. If a solar-electric array costs \$15,000 out of pocket and returns \$80,000 in savings—that's good. The same \$15,000 invested in a mutual fund may return \$100,000, but you've still paid the \$80,000 in utility costs.

Now consider what you *do* with the savings. If you pay off your array in five years, and then *invest* the savings in an individual retirement account—well, now you're talking. Because—work with me now—to pay a \$100 electric bill, you have to *earn* almost \$150 in order to also cover taxes. Which means you can now save roughly 150% of your utility cost, tax-deferred. Your out-of-pocket is the same, but you are paying yourself \$150 instead of \$100 to utility and \$50 to Uncle Sam.

R. Schorert via homepower.com

DIY PV System

Living in Hawaii means great year-round weather, but one of the downsides is that I like my air-conditioning, and the cost I pay to keep my house at a comfortable 80°F is high. With a good solar insolation rate here on Oahu, and specifically in Ewa Beach, I started pricing solar-electric systems so I could save on my electricity bill. Prices ranged from \$30,000 to \$60,000, installed. Leases tied me to a contract for 20 years. Frustrated, I asked the question that many DIYers ask—is there a cheaper way to do it, and are there others who have tackled this themselves?

After some Internet research, I found *Home Power* magazine (which I promptly subscribed to) and links to solar suppliers. My research began in February 2013, and my system started producing energy on July 27, 2013. I have 26, 250-watt polycrystalline modules with Enphase M-215 microinverters. The system cost—including shipping from California to Hawaii—was about \$15,000. Additional costs (drawings, electrician, permit, parts) amounted to \$2,500. After my tax credits, the total cost should be around \$6,000. That's a big difference from the low-end \$30,000 quote I got for a turnkey installed system.

Courtesy Joe Marshall



A DIY-installed grid-tied array in Hawaii.

Using my average electricity bill for the past 12 months, my system will be paid for in about 1.5 years. My first month of production was a touch over 1 MWh. When I tell people I installed the system myself, the response is always: "Really?" Yes, really. This was not that difficult. It did take some planning and learning. There are tons of free online videos to help with the learning curve. My equipment supplier had answers to any question I asked. I tell people, "If you can hang a picture and insert a plug into an outlet, you should be able to do this. The only difference is that you're doing it on a roof."

Thanks *Home Power* magazine for your great articles that encourage DIYers to take on projects such as this. My next project is to convert an early Mustang to full electric—a perfect island solution to our high gasoline prices. Thanks again.

Joe Marshall • Ewa Beach, Hawaii

write to:

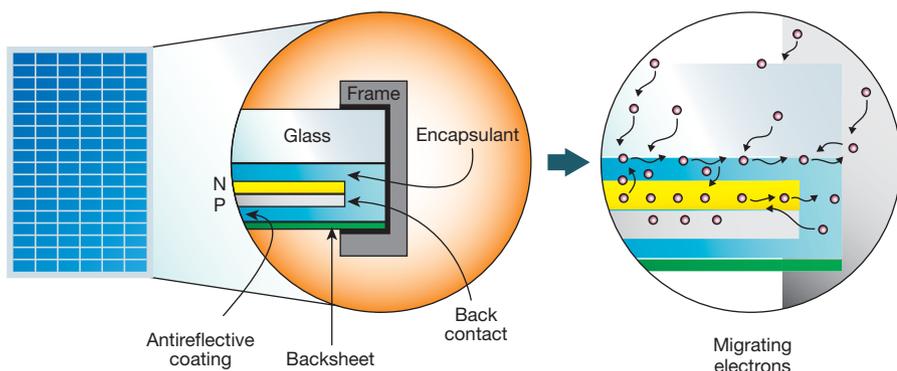
mailbox@homepower.com

or Mailbox, c/o Home Power
PO Box 520, Ashland, OR 97520

Published letters are edited for content and length. Due to mail volume, we regret that unpublished letters may not receive a reply.

Potential-Induced Degradation

Reduction of a Solar-Electric Module's Efficiency Over Time



Transformerless Inverters & PV Degradation

I read that potential-induced degradation (PID), the reduction of a solar-electric module's efficiency over its lifetime, is sped up by the use of transformerless grid-tied inverters, which allow the modules to cycle electrons at the grid's AC frequency. Module manufacturers are advertising PID-free modules, which supposedly counteract this problem.

Transformer-based inverters don't cycle and have a constant flow of electrons. So would using one allow my modules to last longer? Does anyone have real experience in this area, or is it all theoretical at this point?

Zachary Strassman • via email

PID is the result of PV modules being held at a high potential (voltage), which causes them to temporarily decrease power output. With high-voltage arrays, ungrounded inverters, and increasing module efficiency with antireflective coatings; PID is showing up in the field—not just the lab.

PID is due to leakage of electrons out of the silicon cells. These migrating electrons accumulate on the surface of the silicon cell, where they affect the ability of the P-N junction in the cell to convert sunlight. This power reduction can occur over days or weeks. It is seen at higher array voltages, higher temperatures, and, especially, under higher humidity conditions. Estimates of power losses due to PID range from 10% to 60%, although the most I've seen (on a negatively grounded SunPower array) is about 25%.

The type of encapsulant and backsheet used on the modules are factors that can influence PID. Some compounds are more prone to leaking current than others, and some are more affected by moisture than others.

Another factor is the antireflective coating—some types, while improving efficiency, also make modules more prone to PID. How the silicon's cells are layered (for example, back-contact cells in which the P and N layers are flipped) also affect the module's PID propensity.

The third major factor affecting PID is the array's polarization and voltage. Most negatively grounded arrays are not affected by PID. Historically, however, negatively grounded SunPower arrays could suffer PID. PID is generally only seen on high-voltage (100+ volts) arrays as well. Whether modules are PID-prone is largely dependent on the antireflective coating and encapsulant.

The good news is that, in crystalline silicon modules, PID is mostly reversible. By properly grounding the array, the extra electrons that have leaked to places they shouldn't are sent back, restoring the module to its normal state. By holding the cells at the proper high voltage for a few days (48 to 96 hours) with an external source of voltage, PID can be almost completely reversed. Properly grounding the array so it gets a few hours of the proper voltage every day will also reverse the effects of PID.

Electrical standards organizations are developing tests and standards to rate whether a particular module is susceptible to PID. Look for these certifications on modules in the future. If you do not have PID-prone modules, the type of inverter you use may not matter. But if you do have PID-prone modules, use an inverter that grounds the modules in the proper direction to avoid PID for those particular modules.

Zeke Yewdall • Mile Hi Solar



Reach new solar customers *anywhere.*

Now, connect off-grid customers to reliable power with our solar products and solutions.

Rely on proven performance.

People have relied on Schneider Electric™ for over 100 years to deliver quality residential products and solutions — lighting, security, medium voltage, and more. Today, everyone can rely on Schneider Electric for solar solutions whether tied to or completely off the grid.

A complete solution.

The Conext™ XW system consists of several devices, components, and optional accessories to create a renewable energy power system that can be customized to suit off-grid or backup applications. All system components are networked and communicate with each other out of the box.

- > Conext XW Inverter/Charger
- > MPPT Solar Charge Controllers with Fast Sweep Technology
- > Power Distribution Panel
- > Automatic Generator Start Module
- > System Control Panel



Your system, your way.

The Conext XW Inverter/Charger features unparalleled application flexibility. It is ideal for off-grid or battery backup systems. It can also be paired with an existing grid-tie inverter.



Learn how to meet any customer request today!

Watch this video to learn how the Conext XW system meets customer demand, plus enter to **WIN** a **Google Nexus 10 tablet!**

Visit www.SEreply.com Key Code **b465u**



Enphase Microinverters & Grounding

I read with interest Ryan Mayfield's "Code Corner" article in *HP157* about AC modules, and their unique treatment in the *NEC*. Enphase has just released its M250 microinverter, which has built-in, isolated DC grounding. Enphase claims this eliminates the requirement for a grounding electrode conductor (GEC).

Does this development signal a departure for future grounding requirements? Can this technology allow "any" module to be retrofit and then treated as a "factory" AC module?

Jody Herperger • Regina, Saskatchewan

This release from Enphase will undoubtedly change the method for grounding its new inverters, but will not change overall module-grounding requirements.

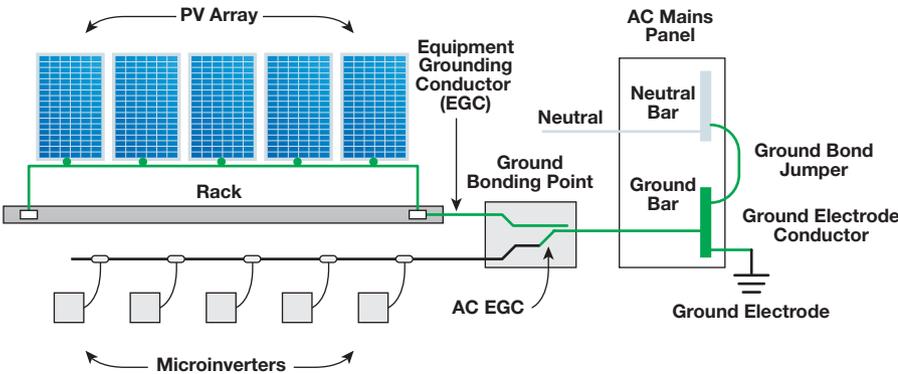
An inverter and module must be factory-supplied and listed as an AC module to qualify for that distinction. Attaching an Enphase M250 microinverter to a PV module doesn't qualify. *Code* still considers this setup two distinct pieces of equipment—and your installation will need to reflect that.

However, the new Enphase microinverter eliminates the need for a GEC between microinverters. The array and inverters still need proper bonding via an equipment-grounding conductor (EGC) but per Enphase instructions, a GEC is not required. The sizing and installation requirements surrounding an EGC are not as stringent as they are for the GEC, so this will likely result in installation-labor savings. The availability of an EGC in the cable system will play a big role in the installation. For example, Enphase microinverters contain an EGC in their cabling system, so bonding modules and inverters to the rack establishes the required bond. The cable system can carry that from the roof.

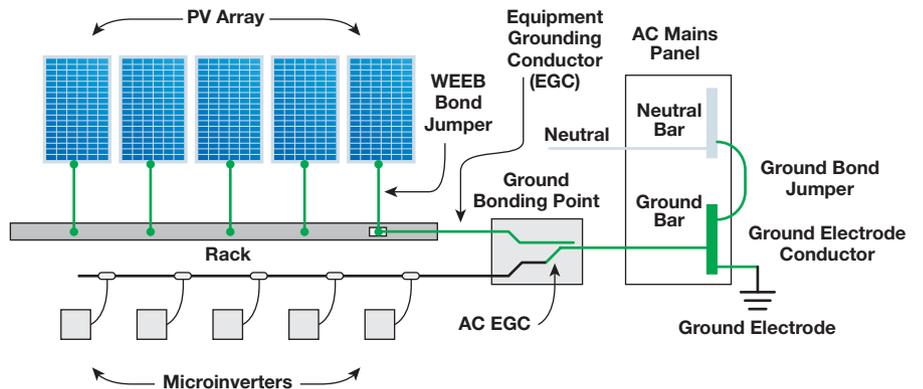
As with all grounding issues, this is not a slam dunk. There are varying opinions on this subject, so check with your authority having jurisdiction to make sure they agree with the manufacturer and your installation plans.

Ryan Mayfield • PV Systems Technical Editor, *SolarPro* magazine

Microinverter-Integrated Ground with EGC-Connecting PV Frames & Rack



Microinverter with WEGB Ground Jumpers



ENERGY STORAGE UNLEASHED



RE Renewable Energy / Hybrid Systems / Backup Power

Rely on Trojan Battery to unleash your storage needs. As a global company with local expertise, Trojan's wide range of deep-cycle flooded, AGM and Gel batteries for renewable energy, hybrid and backup power systems are backed by more than 85 years of battery innovation.

(800) 423-6569, +1 (562) 236-3000

WWW.TROJANBATTERYRE.COM



Courtesy Peerless-Premier Appliance Co.

For off-grid homes, the most efficient natural gas or propane ranges use an electric spark to light the gas flame.

Off-Grid Ranges

I am shopping for a new gas-fired range for my off-grid home. I know that I need one without an energy-wasting “glow bar” in the oven. Any suggestions?

David S. Martin • via email

Most gas ovens use either a pilot light—a continuously burning flame—or an electric element (aka glow bar) for lighting the gas flame. The downside of a standing pilot light is that, since it is always on, it uses a small amount of a fuel continuously, which can add up.

For an off-grid system, the *electrical* draw of a glow bar—which is about 500 watts—can eat up far more of your renewable energy than you’d want. Cooking a holiday dinner during the winter, for example, could easily consume 3 to 5 kilowatt-hours. For a 24-volt system, that’s up to 200 amp-hours or more for cooking alone—and that’s a lot of electricity to make up for during winter’s limited number of

All-Weather Power

Sunny Days or Stormy Nights - We Put the Power in Your Hands

- Self install packaged systems, fully programmed and ready for operation
- Over 10 years off-grid design and installation experience
- Not all solar power works when the grid goes down – ours does!
- Grid tie solar with emergency backup
- No maintenance, reliable hybrid systems



Get answers for solar, wind and remote power from folks who live off grid.

Apex Solar

Toll Free:
888-782-0706
www.apxsolar.com



A+ rating

sun-hours. If your family bakes a lot, such an oven would be a large, year-round draw.

For that reason, many off-gridders end up using ranges with pilot lights. But for folks who also want to minimize gas use, even that is a problem. Most ranges allow users to turn off the pilot light just for the cooktop, which can then be safely lit when needed with a simple, long-handled flint striker. You can turn off the pilot lights using the adjustment for pilot flame height, often deep inside each burner's knob shaft. (Check your range's documentation for adjuster location and how to do this.)

But it is more difficult, often impossible, to turn off the oven's pilot light. Unlike the cooktop burners, the oven burner needs to cycle on and off so it can regulate oven temperature—and needs to relight each on-cycle (either via a pilot light or glow bar). On my last oven, there was no way to turn off the pilot light completely.

The other alternative is to find a range, like a Peerless Premier, that uses an electric spark to light its pilot light when the oven is turned on, and turns the pilot off again when the oven is turned off. Some of these ranges also have an AA-battery-powered spark igniter, for completely cordless operation. For on-gridders, that means the oven can even be lit during utility outages.

If you go with a Premier or other spark-based range, see if you can get one from a local appliance dealer or your propane dealer. They are not as commonly available as many stove brands, but having a local source can be helpful when parts or service are needed.

Finally, be sure you specify the type of gas you have when purchasing your stove. Most off-gridders use propane, which requires different burner orifices than natural gas. If you cannot find a propane range, and the appliance store can't handle a conversion, you may be able to make the change yourself using instructions in the range documentation. Otherwise, make arrangements to stop at a local propane dealer on your way home from the appliance store—they can change the orifices and adjust all of the burners for you.

Michael Welch • *Home Power* senior editor

write to:

asktheexperts@homepower.com

Published letters are edited for content and length. Due to mail volume, we regret that unpublished letters may not receive a reply.

DuraRack™ AT > formerly the Seasonal Adjustable Rack

From 0° to 60° in seconds.

Finally there's an easy and affordable alternative to optimizing your array's tilt to compensate for the sun's seasonal changes. Easily assembled, this innovative adjustable-tilt rack system holds up to 16 standard PV panels and a single cordless drill adjusts the manual gear box and rotating bearing assembly from flat to 60° in moments, giving you maximum power year round.



wattsun
SOLAR TRACKERS
a division of Array Technologies

residentialsales@arraytechinc.com | 1.855.TRACKPV | arraytechinc.com

June



December



ARRAY
TECHNOLOGIES

Purchasing

a PV-Powered Home

WHAT YOU NEED TO
KNOW *BEFORE* YOU BUY

**Comment
& Discuss**
this article @
homepower.com/158.34



Orion Thornton (2)

Dealing with the climbing foliage is an easy fix, but be sure the shade on the modules is not masking any other production problems.

by Zeke Yewdall & Orion Thornton

More and more, it is common for houses on the market to include grid-tied PV systems. Depending on the design and condition of the PV system, it may or may not be a selling point. Here's how to evaluate an existing PV system and how to make sure it adds value instead of liability.

Is It Working?

Because the utility also provides energy to the home, it may not be evident when a PV system stops working. Problems may show up on your energy bill, but if the system only provides a small portion of the home's total electricity usage, or if the occupants (and load) of the house have recently changed, there may be no clear indication of a problem on the latest energy bill. How do you know if the system is operating properly and producing its full potential?

To check if it is producing power, look at the inverter during the daytime—at the very least, it should have a green light (or something equivalent) indicating that it is "online." Most will show how many watts are being produced on the AC side.

This paint on this 2001 model inverter has oxidized from being in the weather, but the inverter is still functioning fine.



Red lights that say “ground fault” or “off-line” indicate the system is not working—no power from the system is feeding the home (or the grid).

Even if the system is operational, is it producing as much power and energy as it should? Many older systems may be operational, but producing low power for various reasons—fuses blown, foliage grown in front of the array, or perhaps a poor design that’s been stifling system production from the beginning. If the inverter has a cumulative kWh meter, you can compare its overall energy production with PVWatts estimates based on module specs. (This may require disconnecting and removing a module from the rack to see its label.) You will also need to know when the inverter was commissioned to make an accurate comparison to PVWatts data. This comparison can tell you if the system has produced expected energy production since commissioning, but doesn’t tell you if the array is producing expected power now.

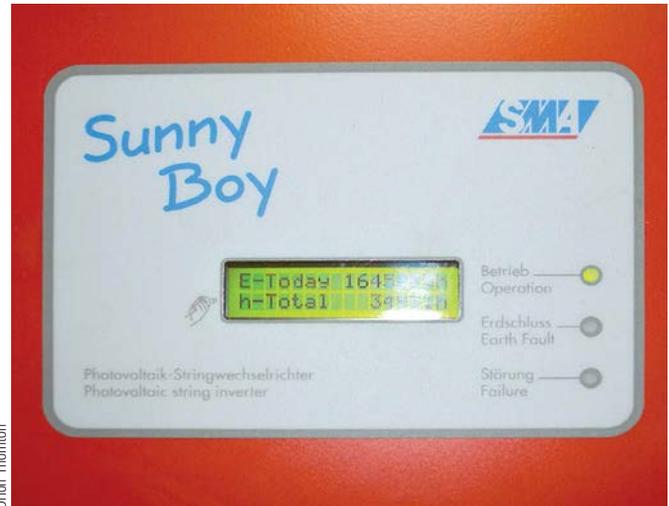
An inspection by a qualified PV installer who has the proper tools and know-how to analyze the system’s electricity output is a good idea. This requires special equipment that can measure several parameters as well as accounting for ambient temperature, irradiance, and system efficiencies. With the right tools and some math, a qualified PV technician can tell if the power output is too low, indicating a potential problem. (See “Grid-tied PV System Performance Factors” in *HP156* for more information.)

If system data collection includes historical data, it should be a lot easier to determine if the system is performing as it should. However, monitoring failures can be more common than PV system failures. Sometimes the monitor just fails

The glass face on this center module is shattered and may allow moisture to penetrate, leading to corrosion of the internal electrical connections. Also note the nonflushed feet, which should be inspected to make sure the sealant around them has not deteriorated.



Zeke Yewdall



Orion Thornton

Reading the inverter’s power and daily energy production can tell you a lot about how a system is performing.

(monitors are often much lower quality compared to other PV components) or a vital component (like the monitor’s network gateway box) is unplugged. Make sure to get any Web-based monitoring addresses (and passwords) from the former homeowner(s) so you can access the data.

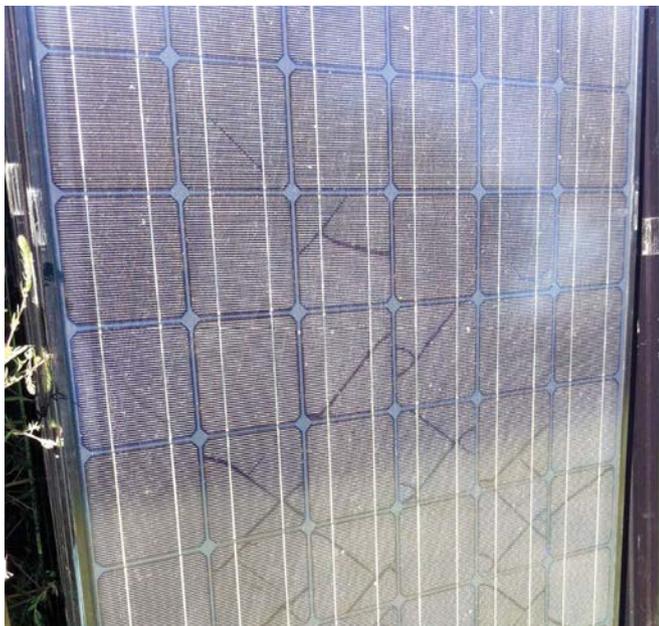
How much of the house’s energy use is the system expected to provide? It would be great if every PV system resulted in a net-zero energy home. But most PV systems are designed to provide only a portion of a home’s energy usage. For example, a 3 kW array on an all-electric, 3,000-square-foot house is unlikely to make a major dent in the electricity bill—production problems will be less noticeable, so it does make the need for monitoring slightly more important.

If it’s an older array that’s been installed for at least a year, the previous owners should be able to tell you whether or not the system has ever met the home’s monthly electricity usage. If it is a new system, find out how much electricity the array was designed to offset. It’s not uncommon to ask for historical energy bills when purchasing a home, so don’t be shy about requesting information about the PV array and its subsequent energy production. A small array may just be serving a battery backup system in the event of a power outage, keeping critical loads running—its main value is in the backup electricity rather than in utility bill reductions.

Check System Components

Are there obvious signs of damaged components? Modules with broken glass are not common, but can occur. Hail damage is rare, unless you get hailstones larger than two inches. A module with shattered glass may keep functioning for some time, but eventually, water will infiltrate and corrode internal electrical connections, causing shorts or ground faults.

You will eventually have to replace the broken module, and finding an identical replacement can be quite difficult—especially for systems that are more than a few years old—due to changes in solar module construction and frame sizes. The



Module failures are relatively rare, but they do happen. Although there are “snail trails”—perhaps due to a reaction with the encapsulant—this module still functions. Test modules that are different in appearance to assess their performance.

longer you wait to replace modules, the more difficult it will be to find the same model. If the exact replacement module is not available, it may be possible to integrate another make and model, but it will need to have very similar physical and electrical characteristics to integrate into the solar array, and may affect the overall array aesthetics.

Depending on the inverter’s operating voltage range, it may be possible to simply remove the damaged module and rewire the array at a reduced system capacity. This will result in lower energy production, but will avoid the problem of having mismatched modules. In the case of multiple damaged modules, a full replacement may be required. Any undamaged modules could be used in another project or sold to offset some of the costs of the new modules.

What is the inverter’s make and model? Inverters typically last between five and 20 years, depending on the make, model, and production date. But it’s safe to assume that you will need to either make a warranty claim or replace the inverter within

Trace Engineering began making these off-grid inverters in the 1980s, and many are still providing electricity to homes today.



Zélie Veyrdall (4)

five to 10 years. A qualified solar contractor can tell you the expected lifespan, warranty coverage, and reputation of your inverter. A quick call to the manufacturer, providing the serial number of the inverter, can also determine whether it is still under warranty and whether there are any recalls or service bulletins on it.

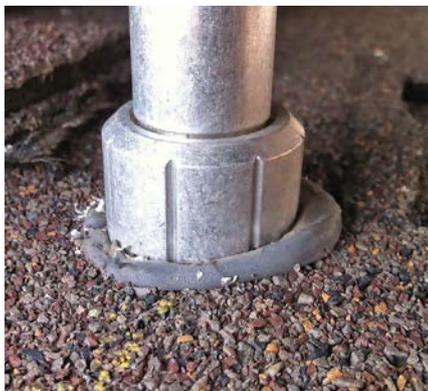
Were there any recent upgrades to the system? The modules may be 15 years old, but the inverter (or if the system is battery-based, the charge controller or batteries) may have been replaced recently. It is helpful to know if there’s a mix of newer and older equipment since some parts (such as modules) generally function longer than others.

If it’s a roof-mounted system, what is the roof’s condition? The PV system may be in perfect condition, but if the roof is worn out, you’ll need to replace it. To avoid a big budget surprise, get a cost estimate to have the array removed and then reinstalled on the new roof. If penetrations do not have flashings (as may be the case with some older installations),

The cupped and deteriorated shingles underneath this array are a cause for concern, as replacing the roofing material necessitates removing, and then reinstalling, the entire array—a pricey proposition.



This PV module’s electrical traces were burned from a lightning strike, but testing showed that the module still functioned.



Older arrays may not have flashed roofed attachments, and rely only on sealant to keep water from penetrating the roof.



Zeke Yewdall ©

The rubber boot around this flashed conduit has disintegrated, creating a route for water to easily enter the home. This is an old solar thermal installation, but the same rubber boots are often used on PV installations.

the extra cost of adding flashing will need to be considered when reinstalling (see “Evolving Installation Methods” sidebar).

Considerations for Battery Systems

Battery backup and off-grid systems are more complex, so there’s more to check. The system’s overall operation can be more obvious than with a batteryless grid-tied system—if it’s not working, there will be no electricity. But just because you flip the switch and the lights come on during your daytime walk-through doesn’t mean that the batteries will have enough storage to keep the house’s appliances running after the sun goes down, let alone through a three-day snowstorm.

Batteries are crucial components in any off-grid system, and costly to replace, so be aware of any upcoming battery replacement needs before you purchase the home. Batteries should be visually inspected for corrosion, age (check if they have manufacture date tags), and electrolyte level.

Besides being old and poorly maintained, these batteries are an inappropriate type for use with residential RE systems and housed in a non-Code-compliant box.



Evolving Installation Methods

Methods and equipment that were once commonplace may now be unacceptable within the industry, or may not meet *National Electrical Code (NEC)* or *International Building Code (IBC)* requirements. The flashing of all roof penetrations is now required by the current *IBC*. Many older rack systems may not have flashing. While leaks are not common, they occur more often with unflashed systems because the rack feet rely only on sealant to keep the water out—not gravity, as with a flashed foot. If you have a system without flashed feet, it will probably cost a few thousand dollars to upgrade, since the entire array has to be removed along with the old feet.

Another issue is safety and *NEC* compliance. Most grid-tied systems received building permits and were inspected to allow connection to the grid. But if you are buying an older off-grid system, it is possible that it never received a permit or was inspected. Does it meet *Code* requirements for wiring, conduit, disconnects, and enclosures? If not, did the installer use best practices for the time, thus making it safe? For the safest operation, systems should be upgraded to meet the *Code*—so account for this cost when making an offer to the seller. In some jurisdictions it’s not only a good idea, but the law; your system will be required to meet the current *Code* when the property changes hands. Septic systems and smoke detectors are common items affected by laws requiring upgrades when selling property, but electrical equipment may also be included depending on your local jurisdiction.

But none of these checks really give you a full picture. Ideally, perform a load test to see how much energy the batteries hold compared to their original rating. Systems can still be functioning with old batteries, but the batteries may be operating at a significantly reduced capacity. That capacity might be enough to power loads for a few hours without additional PV input, but may not be enough to support loads for an extended duration. Some off-grid houses are sold in the summer, when even marginally operating batteries might serve a few small loads through the night. It's when shorter days and cloudier weather come that you'll realize that you need new batteries. Also, because infrared cameras have been declining in cost, more installers have this tool and may be able to provide an IR inspection of the battery bank. This can quickly show failed battery cells (because they will be a different temperature) and bad connections.

System Inspection Checklist

A professional who evaluates a system at a house will look for the following:

- Is there any broken or damaged equipment?
- Is all the wiring intact and conduit in good condition, with no corroded, sun-damaged, or loose conduit, dangling wiring, or unsecured electrical boxes?
- Is the system working?
- How does the measured power on a sunny day compare to expected output?
- What's the lifetime energy production of the system and what kind of energy production should you expect in the coming years?
- Is the system monitor (if present) working?
- Is there evidence of animal damage or infestation? Is there sufficient protection for the array wiring?
- Are there any missing bolts, clips, or structural parts?
- Is there mold, dirt, or vegetation buildup on or around the array?
- Are there any remaining warranties on any of the system components?

For battery backup and off-grid systems:

- What is the rating of the batteries?
- What was the load-tested capacity of the batteries?
- What is the age of the batteries?
- What is the general condition of batteries?



Orion Thornton

Dangling cables can be easily damaged through abrasion or from chewing critters, and can be one indication of a poorly installed system. This system also has grounding daisy-chained from module to module, which does not meet code requirements.

Off-Grid System Performance

Another big factor to consider if you are buying a house with an off-grid PV system is that it can be in perfect functional order, working well for the previous owner—but may not work well for you or your family. Off-grid system performance is dependent on the system's electrical loads—both the power draw of the appliances and the user's usage patterns. For example, the system may have been sized for only a few loads and miserly power consumption, with the previous owner judiciously using only a few lights at night and timing laundry loads to coincide with the sunniest hours of the day.

If this is your first time living off-grid, it's always best to make sure a working backup generator is part of the system, as you will probably use more energy than you expect. Is there already a generator with the system? If so, what quality is it? If you are expecting to use the generator frequently (such as in areas with very little winter sun), you'll want to see a heavy-duty water-cooled generator, usually propane- or diesel-fueled, designed to run for several hours a day—for years. An air-cooled backup generator may be suitable for sunnier areas, in which it's only used a few times a year. Portable generators are generally only good for the smallest cabin systems. If in doubt, consult with an RE installer about what sort of generator is appropriate for a particular system and climate.



Zeke Yewdall

Leased Systems, Ownership, and Warranties

Sometimes a system is leased rather than owned by the seller—how will that transfer to you? Are you assuming the lease, or is the seller buying out the lease when the home sells, and you will own the system outright? There can be benefits and drawbacks to either: If you own it outright, you won't have a separate (possibly escalating) lease payment, and the cost will be part of your tax-deductible mortgage payment instead. However, it may no longer be warranted, serviced, and insured by the leasing company.

Although they have more than a decade of service behind them, these off-grid inverters are still functioning fine.

And make sure you get a tutorial on operating the system. Smaller off-grid systems can be quirky, and being privy to the system's idiosyncrasies—such as “never start the table saw unless you turn the well pump off first, or it'll overpower the inverter, tripping it offline”—is important. If the system was professionally installed, consider contacting the installer to explain the operation of the system, discover what issues it has had over the years, and what upgrades they recommend. You might learn more about the system than you will from the previous owner, plus it is valuable to develop a relationship with the company that can service it. You might also find out that the previous owner bought the highest-quality components available and oversized the system, or the worst possibility—that they cut corners wherever they could, and did not properly care for the batteries. If you are planning a much different load profile than the system was originally designed for, this also gives you a chance to discuss what upgrades will be required so the system can meet its new requirements.

Warranties

If you are buying a used PV system, inquire about its warranty. If something does go awry, it might be possible to get it fixed—without having to pay full price. There are usually several separate warranties: a manufacturer warranty on the equipment—this can range from two years (some charge controllers and off-grid inverters) to 10 years (grid-tied inverters to 25 years (PV modules); and an installation warranty, which will vary in length and terms. Many grid-tied systems require at least a five-year installation warranty to qualify for rebates.

If the system still has the installation warranty in effect, make sure to give your name and information to the installer to take advantage of remainder of the warranty. During this period, they may service system problems for you without charge. However, once their warranty has expired, they may charge a fee for labor to service a manufacturer warranty. (Note that, in some circumstances, manufacturers may cover the installer's service calls.)

If the original installer is no longer available, you may have to find a new installer to service the system. Unfortunately, it sometimes happens that installers leave the business or stop working in some geographical areas. This may mean that you have no installation warranty at all, or you may need to contact an out-of-state office of the installation company.

Animal Attack

Examine the PV system for evidence of chewed insulation on cables and for debris that may clog the inverter's cooling fins. Insulation-hungry squirrels, for example, can turn a PV array into junk in a matter of weeks, and critter damage is a serious threat to PV array longevity. Rats, raccoons, pigeons, and wasps also can damage PV arrays. Ideally, a rooftop array, mounted parallel to the roof, should be completely screened around the edges with wire mesh. If an array has been disabled due to chewed wires, the inverter will most likely indicate a ground fault. This damage can usually be repaired, but usually at a great expense to remove and replace the array, and to repair the wires. Flush-mounted roof arrays



Inspection of an under-producing array revealed a loose MC connector between two modules.

Orion Thornton

This wire was pinched between a module and the rack, and eventually caused a ground fault. This can be a common problem with sloppy installations.



Zeke Yewdall



Zeke Yewdall

Squirrels have severely damaged this wiring, putting it at high risk for a ground fault. (The taut wire is due to lifting the module for inspection.)

are the most prone to harboring critters, because they create an inviting hiding place for squirrels and birds. Tilt-up or ground-mounted arrays are less inviting, but can still be damaged by animals. Bird or wasp nests blocking airflow on inverter cooling fins are more easily removed.

Access

Zeke Yewdall is the chief PV engineer for Mile Hi Solar in Loveland, Colorado, and has had the opportunity to inspect and upgrade many of the first systems installed during Colorado's rebate program, which began in 2005. He has also upgraded many older off-grid systems. He teaches PV design classes for Solar Energy International.

The owner/manager of Bozeman, Montana-based Onsite Energy, Orion Thornton has focused his recent efforts on contracted inspection work for first-generation grid-tied PV systems installed prior to 2005. He also works as a PV instructor for Solar Energy International.



Grounding Bites! Literally...

The IronRidge **Integrated Grounding System** bonds solar modules directly to IronRidge Rails, eliminating the need for separate module grounding parts and procedures.

It saves time, reduces costs, and improves safety.



GO GREEN AND MEAN IT WITH HuP[®] SOLAR-ONE[®] BATTERIES

Looking for **INDUSTRIAL**
strength and reliability
in a field-proven, green
battery? Look no further!

HuP Solar-One Batteries:

- Are warranted for 80% deep cycling 2100 times
- Are solidly constructed with positive plates .031 thick and industrial terminals/hardware
- Are available in 10 sizes, reducing or eliminating paralleling
- Are constructed with removable cells, allowing for easier installation
- Use 95% post-consumer recycled materials
- Are shipped FREE within the lower 48 states
- Are built to last, with a 10-year factory warranty



HuP[®]
SOLAR-ONE[®]
Batteries

Off-Grid ▪ Grid-Tie ▪ TOU ▪ Load Leveling
Preppers ▪ Industrial AGM Batteries

HuP Solar-One
Serving the RE industry for over 17 years
Northwest Energy Storage
800-718-8816 ▪ 941-474-0110 ▪ www.hupsolarone.com

PLATINUM

WITH PV



**Comment
& Discuss**

this article @
homepower.com/158.42

Kelly Davidson (4)

by Kelly Davidson

The process began with a chance meeting at the 2006 Solar Decathlon in Washington, D.C., an international competition that challenges collegiate teams to build solar-powered homes. Architecture student Adam Rude, who helped design the University of Colorado (CU-Boulder) house, ended up giving the last tour of the day to Robert Freling, executive director of the D.C.-based nonprofit Solar Electric Light Fund. Freling was taken right away with Rude's design philosophy, and by the end of the tour told him, "I have a friend in Colorado who is looking for an architect. I think you two should meet."



The home's south face was designed to capture direct solar gain in the winter, reducing the need for supplemental space heating. A 7.02 kW awning-mounted PV system is anticipated to offset all of the home's electricity use.

The home includes a ground-level office that doubles as a guest bedroom when the sliding doors are closed.



Finish materials used in the home were carefully selected to satisfy LEED point requirements and preserve indoor air quality. Forest Stewardship Council-certified white ash paneling is used for the walls of the first level, as well as on the stair treads and veneered interior doors.



Weeks later, back in Boulder, Rude sat down for his first meeting with Freling's friend, Kitty Brigham, a retired nonprofit administrator who wanted to build a net-zero energy home. "I liked him instantly. I just took the leap and said, 'Why don't you design a house for me?'" Brigham recalls. "I told him that I liked angles and trilevels, and he took it from there."

Rude, who graduated shortly after that initial meeting, didn't have the resources to take on the project on his own, so he turned to his mentor and design advisor from the Solar Decathlon—Mark Sofield, a local architect who ran his own shop. The two partnered on the project, with Rude taking the lead on the schematic design, under Sofield's direction as architect of record. Two additional members of the CU-Boulder Decathlon team—engineer Chad Corbin and lighting designer Todd Gibson—signed on for the project as well.



Kelly Davidson (4)

A deck on the third story affords sweeping views of the Flatiron Mountains. The solar-electric canopy provides electricity for the house, as well as some protection from the rain and sun.

Performance First, Then Form

Every architect's dream, Brigham gave the design team few constraints, with only one real demand: "Performance first, then form." Driving the design was her pursuit of LEED Platinum certification, the highest ranking awarded by the U.S. Green Building Council. "I knew building to platinum standards could be a costly venture, but I wanted to showcase what's possible and hopefully inspire people to walk the talk," Brigham says.

From the start, Brigham envisioned the home as a space she would "share" with the nonprofits and committees that she works with. SELF, for one, plans to use the space to host retreats for its board members. "The central living space had to be very open—a place where I could host meetings," says Brigham, who holds volunteer leadership roles for several nonprofit organizations, including SELF, Boulder County Audubon Society, and Oregon Shores Conservation Coalition. "And I wanted a rooftop living space," she adds.

Rude scoured the foothill communities near Boulder looking for land in the mountains, but for one reason or another, none of them worked. The design team ended up

finding an ideal site farther east in Longmont, literally in Sofield's backyard.

Brigham purchased two lots along the street that makes up the southern boundary of Prospect New Town, a new urbanist housing community that transformed an 80-acre tree farm into a walkable, multiuse neighborhood. With a horse pasture and farm fields to the south, the site—a little less than 0.25 acres—offers views of Boulder's Flatirons rock formations and the foothills in the distance. And, with any luck, Brigham says, new building restrictions imposed by the city should keep the views intact for many years to come.

Not only does Sofield live in Prospect with his family, he also wrote the architectural guidelines for the community and designed several of the homes and buildings there. Prospect—which won a Governor's Smart Growth Award in 1996 for its innovative alternative to suburban sprawl—boasts a mix of businesses, detached homes, row houses, live/work lofts, and apartments, all in a broad range of traditional and modern architectural styles in a rich spectrum of colors. Even with its strikingly angled and geometric form, Brigham's home fits right in.



Ample south-facing glazing admits direct solar gain, which is absorbed by the concrete floor. This heat energy, stored in the floor, is released when interior temperatures drop below the floor's temperature.



Overhangs provide some protection from the summer sun, although heat-blocking shades are also used.

Meticulous Planning for High Performance

Six years of planning, design, and construction led to a 2,302-square-foot trilevel home that uses a fraction of the energy that a conventionally constructed house in Colorado might use. With energy-efficiency measures and a 7 kW solar-electric system rooftop canopy, the all-electric home is on track to produce as much energy as it uses each year and receive LEED Platinum certification (see sidebar.)

Key to the home's energy footprint is a passive solar design that minimizes active heating and cooling needs. The German Passivhaus standard served as a guiding force during the design process.

The home's structural, thermal, and aesthetic spine is an exposed concrete mass wall, with all the floors and ceiling joists attaching to it. The wall bisects the floor plan in such a way that every room in the house, from top to bottom, benefits from the passive conditioning. The thermal mass absorbs heat during the day and releases it throughout the evening. Although the wall appears continuous, it actually addresses three different envelope conditions: interior only; interior/exterior; and exterior only. The two 8-inch-thick concrete faces are separated by 4 inches of insulation only in the interior/exterior portion to prevent thermal transmission. The contiguous face is also thermally broken where the roof attaches to the wall.

Wall thickness was driven by the structural requirements of the second condition (interior/exterior) more than any other consideration. Based on the glazing areas, however, it was calculated that 697 cubic feet of interior mass would be needed to adequately absorb passive solar gain. This amount is attained by the interior mass wall, and by the concrete and tile floors in the office, bedroom, and living room that receive direct solar gain.

The 9-inch-thick wood-framed walls and 12-inch roof cavities, as well as the space beneath the on-grade floor slab, contain polyisocyanurate spray-foam insulation—achieving an average wall R-value of 40 and an average roof R-value of 60. Fiberglass-framed, dual-paned Serious Materials 925 windows were selected to help maximize passive solar gain

A central mass wall forms the spine of the home and also serves as a passive solar collector, radiating heat when interior temperatures drop.





Kelly Davidson ©

A clever open-air drying rack, incorporated into this cabinet, eliminates the energy used to heat-dry dishes in a dishwasher. The countertops are made of Durat, a material that contains post-consumer industrial plastic.

on the south side, with solar heat gain coefficients ranging from 0.35 to 0.45. The south-facing master bedroom window and southwest-facing windows and doors on the first and second floors admit solar gain, which is absorbed by the floor slab and radiated when the house's air temperature is lower than the slab's temperature. Though also partially shaded by an architectural overhang, the southwest windows require sun-blocking shades to minimize solar gain during the summer. The first floor's south wall is slightly angled (at 80°), creating a sculptural angle and a tapering overhang that provides more shade as the sun gets higher in the sky.

Passive & Active Considerations

As project engineer, Corbin developed multiple energy models and analyses to determine the home's passive solar design and optimal mechanical makeup, taking into account the local climate and the area's abundance of sun (66% of all daylight hours are sunny and clear). An initial analysis determined that the home, as originally designed, would require supplemental cooling 11% of the year and supplemental heating 77% of the year. This ratio was a factor in several design decisions, including the glazing ratio.

As a result of the energy models, the glazing area was increased to approximately 28% of the floor area, mainly on the south side of the home—a decision that reduced the building's heating load at the expense of increased summer cooling demand.

"There's always a trade-off when you design a home for passive heating and cooling," Corbin says. "The large glazing area contributes to heating the building, but during the summer, it works against you. The key is finding the right balance."

To minimize heat gain during the summer, reflective shades are installed over the south and west windows. Brigham keeps the shades drawn from noon to sunset, if not longer, between May and September.

Only electric appliances were installed, including an induction cooktop, convection oven, and two on-demand tankless water heaters (see sidebar.) Brigham opted for passive alternatives to dishwashing and clothes drying. After being hand-washed, dishes air-dry in kitchen cabinet racks, where they are also stored. In the laundry room, a large floor-to-ceiling cabinet hides drying racks for clothing. A high-efficiency lighting scheme utilizes a combination of LED and fluorescents to help minimize energy consumption and meet LEED requirements.

An exterior door from the shower opens into a private outdoor vestibule, allowing an indoor/outdoor shower experience.





Kelly Davidson (2)

With slotted steel risers, the home's central staircase acts as a giant vertical return, feeding the return air grille on the ground level.

Domestic hot water loads were modeled at 25 gallons per day per person, within the range of typical residential loads suggested by ASHRAE. This load represented cooking, cleaning, bathing, and waste water usage, but did not include the additional water required for a large soaking tub originally designed into the master bathroom. "It was one of the few things the homeowner really wanted," Sofield says. "But she opted not to build it after she saw the numbers." Each bath would have used 11.75 kWh and at least 100 gallons of water—more resources than Brigham felt comfortable consuming for what she considered to be a luxury item.

Throughout the home, fixtures and fittings satisfy the LEED requirements for water-use efficiency, meeting the set limits for average flow rates—less than 1.5 gallons per minute for the faucets and outdoor spigots, less than 1.75 gpm for the showerhead, and less than 1.1 gallons per flush for each of the two toilets. A small-capacity Energy Star clothes washer handles Brigham's weekly washing needs. Additionally, the home claimed the maximum LEED credits allowable for managing roof runoff. In Colorado, where water laws dating to the 19th century still grant usage rights to roof runoff to downstream users, rain retention is prohibited. Sofield enlisted a civil engineer to size the infiltration ponds appropriately to return water to the aquifer.

Heating & Cooling

The home's heating, ventilation, and air-conditioning system relies on a high-efficiency Carrier electric air handler capable of delivering 1,050 cfm in cooling mode and 945 cfm in heating mode. Modeling showed that the cost of the additional PV needed to operate the air handler was less than

the cost of an air-source heat pump, the primary alternative considered.

The floor between the first and second levels houses the supply-air ductwork that provides conditioned air to all spaces. Return-air circulation occurs naturally through gaps beneath the doors into the bath and laundry rooms, and louvered doors into the first-floor office. With slotted-sheet steel risers, the staircase acts as a giant vertical return, feeding the return air grille on the ground level.

Cooling is accomplished with an earth tube (or ground-loop heat exchanger)—a 12-inch-diameter PVC pipe buried 3.5 feet deep beneath the home that runs along the perimeter of the foundation. Return air from the home circulated in the tubes is cooled by the ground temperature and delivered back to the house via the air-handler. Based on average earth temperature data from the National Renewable Energy Laboratory, the earth tube can provide air cooled to 78°F—even during the hottest months of July and August.

Ideally, the earth tube, Corbin says, would have been trenched deeper into the ground to provide even cooler air, but digging deeper was cost-prohibitive.

Rounding out the HVAC system is a heat-recovery ventilation (HRV) system, which is required to meet LEED Platinum indoor air-quality standards. The system simultaneously exhausts stale, humid indoor air to the outside and introduces fresh, outside air to interior spaces. Heat between the two air streams is exchanged, reducing



A heat-recovery ventilator admits a continuous source of tempered fresh air to interior rooms, helping maintain good indoor air quality.



This rooftop canopy is enhanced by a unique building-integrated PV array that also incorporates clear glass panels. The Sanyo bifacial modules in the array harvest light energy from both sides, leading to increased energy production.

heating energy losses due to ventilation. A solar wall along the southwest corner of the home was considered for heating ventilation air but ultimately ruled out. The findings showed that the solar wall would have reduced the cost of the PV array (by approximately \$1,150), but the construction costs for the wall would have been significantly greater than the PV cost savings.

The PV System

“We didn’t just want to tack solar modules on the house. We wanted to integrate them into the design,” Rude says. The team selected Sanyo’s HIT bifacial modules. The double-sided modules—which can harvest solar energy from both faces— increase energy production within the fixed rooftop space. The design staggers HIT modules and clear glass panels in the grid of a steel canopy. Enough light passes through to grow plants underneath, while providing adequate protection for shade-seekers. Plus, the light reflecting onto the back of the modules adds about 5% to the array’s annual output.

Rude designed the canopy for the 7.02-kilowatt system, which was sized to meet the home’s projected energy load of about 9,000 kWh annually. Florian, a Cincinnati, Ohio, greenhouse company that also builds solar structures,

Tech Specs

Overview

- System type: Grid-tied solar-electric with battery backup
- System location: Longmont, Colorado
- Solar resource: 4.89 average daily peak sun-hours
- Production: 750 AC kWh per month (estimated)
- Utility electricity offset: 100% (estimated)

Photovoltaics

- Modules: 36, Sanyo HIP-195DA3, 195 W STC (+ backside irradiation contribution), 55.8 Vmp, 3.5 Imp, 68.7 Voc, 3.73 Isc
- Array: 7,020 W STC. Six 6-module series strings (each string: 334.8 Vmp, 3.5 Imp, 412.2 Voc, 3.73 Isc)
- Array combiner box: OutBack FLEXware PV combiner box with 15 A fuses
- Array installation: Florian Greenhouse custom racking patio covers, facing south and east, 6° and 4° tilt

Energy Storage

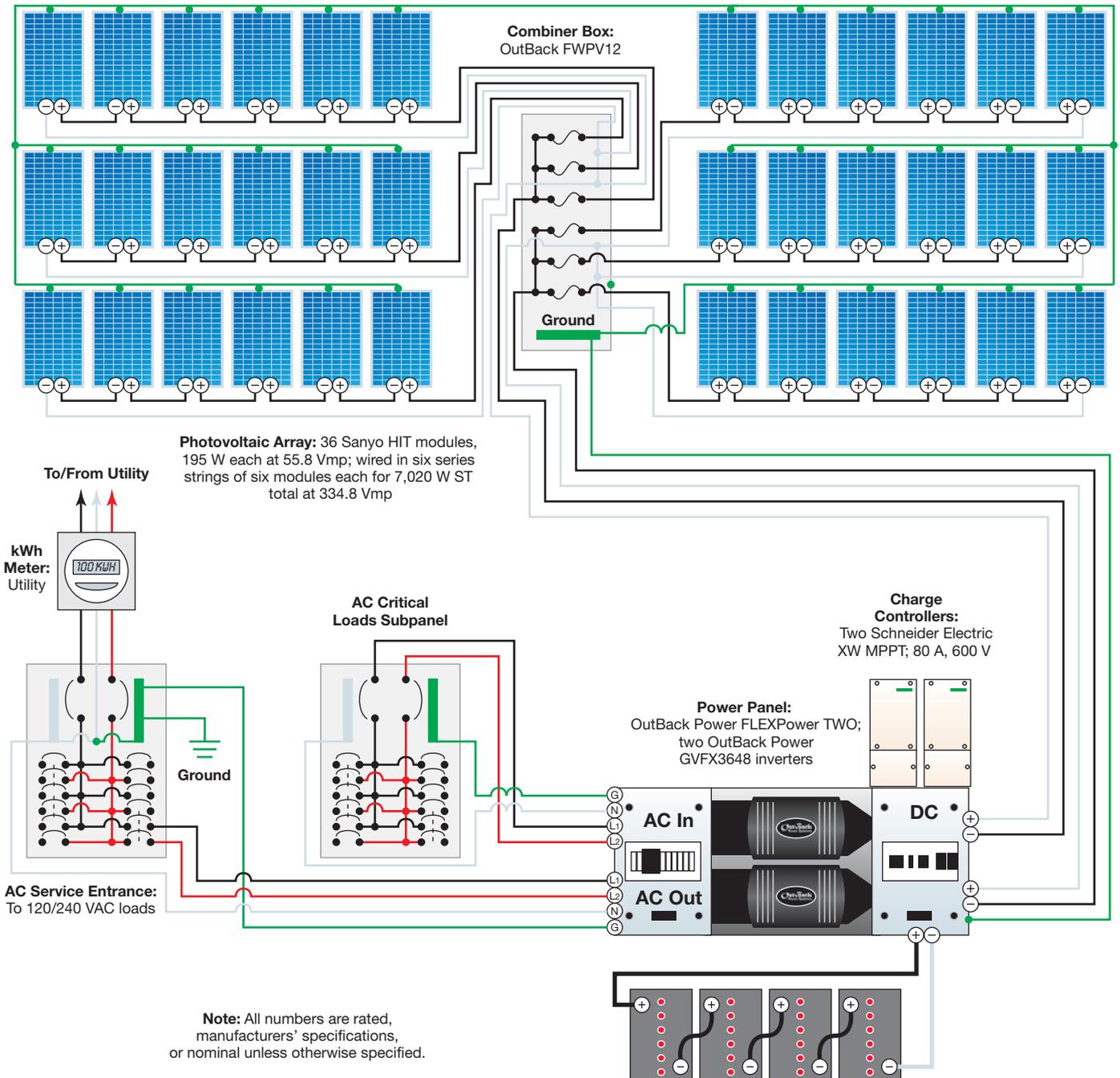
- Batteries: Four Fullriver sealed AGM, DC105-12 VDC nominal, 105 Ah at 20-hour rate
- Battery bank: 48 VDC nominal, 105 Ah total
- Battery/inverter disconnect: 175 A breaker

Balance of System

- Charge controllers: Two Schneider Electric XW MPPT 80 600, 80 A, MPPT, 600 VDC nominal input voltage, 48 V nominal output voltage
- Inverters: OutBack Power FLEXpower Two FP2-29 system consisting of two OutBack GVFX3648 inverters, 48 VDC nominal input, 120/240 VAC output,
- System performance metering: OutBack MATE2

Kelly Davidson

BRIGHAM GRID-TIED PV SYSTEM WITH BATTERY BACKUP



Positioned for Platinum

For architect Mark Sofield, the Brigham residence marks a career first. While he has long focused on green building and energy efficient design, he had never pursued LEED certification through the U.S. Green Building Council.

“We weren’t entirely convinced of its value at first. It is an expensive and extremely time-consuming process, and ultimately Kitty decided it was something she wanted to do. She wanted to put the home on the map and showcase what can be done,” Sofield says.

Though the application is on hold until hardscaping and irrigation systems are complete, Sofield is confident the home will earn all the points necessary for Platinum status once the list is complete.

The LEED for Homes Rating System measures the overall performance of the home by eight categories:

1. Innovation and Design Process
2. Location and Linkages
3. Sustainable Sites
4. Water Efficiency
5. Energy and Atmosphere
6. Materials and Resources
7. Indoor Environmental Air Quality
8. Awareness and Education

Every decision, large and small, plays into the point system. The slab-on-grade construction eliminated the materials necessary for an additional subfloor and finish flooring, meeting the requirements for material-efficient framing.

“[LEED certification] is a complicated process and unbelievably time-consuming,” Sofield says. “I appreciate the idea behind the criteria and it pushed me to learn new methods, but in some cases, I found the rating system to be an impediment to achieving our energy and sustainability goals. We ran into several frustrating junctures where we ended up spending more money and consuming more resources just for the sake of points.”

A second hot water heater in the laundry room, for example, was added to satisfy a LEED requirement. “This was one of the cases when I questioned the LEED process,” Sofield says. “We had to add a second small water heater to serve the washing machine and utility sink in the laundry room because the run from the primary heater was 5 feet too long to earn one LEED credit. It didn’t seem to make practical sense in terms of the heat lost through the run compared to the life-cycle footprint of an additional unit, but that’s what we had to do [to get the points needed].”

Sofield credits the rating system for introducing him to new techniques in exterior water management strategies and hardscaping—key points that fall under the Sustainable Sites category. Surface water management strategies include permanent erosion-control planting, permeable lot surfaces, and vegetative catch-basins and swales that direct all roof runoff to two infiltration ponds in the rear of the property.

To earn the one point for mitigating heat-island effects, light-colored, reflective paving stones were installed around the home’s exterior. But when the stones and concrete did not meet the high-albedo requirements (a solar reflective index of at least 29), the team decided to satisfy the requirement by shading the hardscaped areas with trees and trellises. Completely shaded hardscaped areas earn an additional innovation credit.

fabricated the custom aluminum frame that holds the 36 PV modules and clear glass panels in place. The finished canopy faces south and east and is tilted at 6° and 4°. Ideally, Rude says, the canopy’s southern tilt would have been tilted at 10° or greater, but neighborhood covenants restricted the canopy’s height. “At a 40° tilt [the location’s latitude], the system would have been rather obnoxious, and not well integrated into the design,” Rude says.

The frame for the canopy was assembled on site by a local welder and hoisted into place by a crane. An installation crew from Boulder-based Namaste Solar mounted the modules and ran the wiring down to the ground-floor mechanical room.

This OutBack Power FLEXPowertWO is a fully prewired and factory-tested dual-inverter system. It comes complete with the required DC and AC wiring boxes and breakers, inverter input/output bypass assembly, and MATE monitoring system.



Kelly Davidson



Kelly Davidson

Two Schneider Electric charge controllers protect the battery bank from overcharge and can accept the high DC voltage (412.2 Voc) from each subarray.

load center) and to the other household loads, with any surplus going to the grid. However, what has been recorded by reading the utility bidirectional meter indicates that from February to late September 2013, the PV system has exported to the grid 2,453 kWh in excess of what the home has used (3,550 kWh). Brigham records the incoming and outgoing energy every day, straight from the utility meter. The exercise has become part of her daily routine, like drawing the shades on the southeast windows. While a full year's worth of data hasn't yet been collected, Brigham is optimistic that the PV system will offset her household consumption. So far, over the late spring and summer months, she has only paid the monthly service charge of \$21.50 to the City of Longmont. "I'd be happy with net-zero, but I'm aiming for net-plus," Brigham says.

Access

Home Power Associate Editor Kelly Davidson lives in Longmont, Colorado, where she and her husband are upgrading their 1970s trilevel home with new insulation, doors, and windows, in preparation for a PV system in the coming years. This season's project—two new windows—is being made possible by a low-interest loan through the local Energy Smart program.



A small battery backup system—four 105 Ah batteries—has enough energy to power critical loads (air circulation, refrigerator, microwave, laptop, and some LED lights) for a limited time during a utility outage.

The PV was not commissioned until February 2013. Battery-based grid-tied PV systems can be complicated to meter, since power is flowing to the battery bank (the critical

groSolar® Distribution

Brilliant Energy SolutionsSM

Brands. Price. Delivery.



You have our best brands, personal support, and expertise at every stage of your project. Exceptional service combined with low prices and flexible, on-time delivery from our coast to coast warehouses, lets you maximize the results of every project with groSolar as your solar equipment partner.

Premier brands, plus many more...



800.374.4494

grosolar.com/distribution



Keep Cool. Efficiently.



12/24 Volt energy efficient refrigerators and freezers with AC option

Average power from 5 watts

Extra thick polyurethane insulation for greater efficiency

Awarded NASA Invention of the Year - 2011

915.821.0042 ■ El Paso, Texas

DC Powered Refrigeration
SunDanzer.com



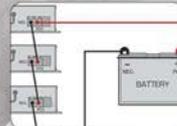
DEPENDABLE, PROVEN CHARGING SOLUTIONS FOR SOLAR BATTERY INVESTMENTS...

Solid in design and engineered with solar needs in mind, IOTA Battery Chargers have a record of delivering reliable power solutions for crucial solar applications.

12-volt, 24-volt, and 48-volt models with amperage ratings up to 90 amps.



Charge controller option for proper charging and confident battery life maintenance...



Series and Parallel charging capability for individual system requirements...



For use with deep-cycle batteries, VRLA, flooded lead acid, and AGM battery types....



Rugged design backed by IOTA's 2-Year Warranty.

Call 1-800-866-4682 or visit www.iotaengineering.com to find your nearest IOTA Distributor and access our technical library of charging application resources!



Harris Hydro

Hydro-Power for Home Use

Adjustable Permanent Magnet Brushless Alternator

- 25-30% more efficient than brush-type alternator
- Marine Grade Construction throughout
- Retrofittable on existing turbine base

Denis Ledbetter
707 986-7771

denisl@wildblue.net
www.harrismicrohydro.com

Manufactured by LoPower Engineering
P.O. Box 1567
Redway, CA 95560

LOCKED AND LOADED

SEISMIC-RATED RACKING SYSTEM FOR L16 BATTERIES



THE RELIABLE L16 WORKHORSE
HAS NEVER LOOKED SO GOOD!

COMPATIBLE WITH

Rolls

BATTERY ENGINEERING

L16 MODELS

| 2 Volt | 6 Volt |
|------------|-----------|
| S-1380 | S-460 |
| S-1590 | S-530 |
| S-1725 | S-600 |
| S-1400EX | S-500EX |
| S2-1275AGM | S6-460AGM |

Stationary Power Systems introduces a first with seismic-rated racking systems.

Available in several space-saving 2-tier options, these sturdy, powder-coated steel racks are the professionals' choice. Floor-mounted with batteries securely locked in place, SPS racking systems are maintenance-friendly, providing proper air-circulation to maximize battery performance. L16 batteries offer more capacity at a lower cost than front-terminal battery alternatives. A full battery, racking & cabling solution is available.

With nearly 60 locations nationwide, Stationary Power Systems offers a full line of batteries, racking and complete cabling solutions for a variety of battery configurations.

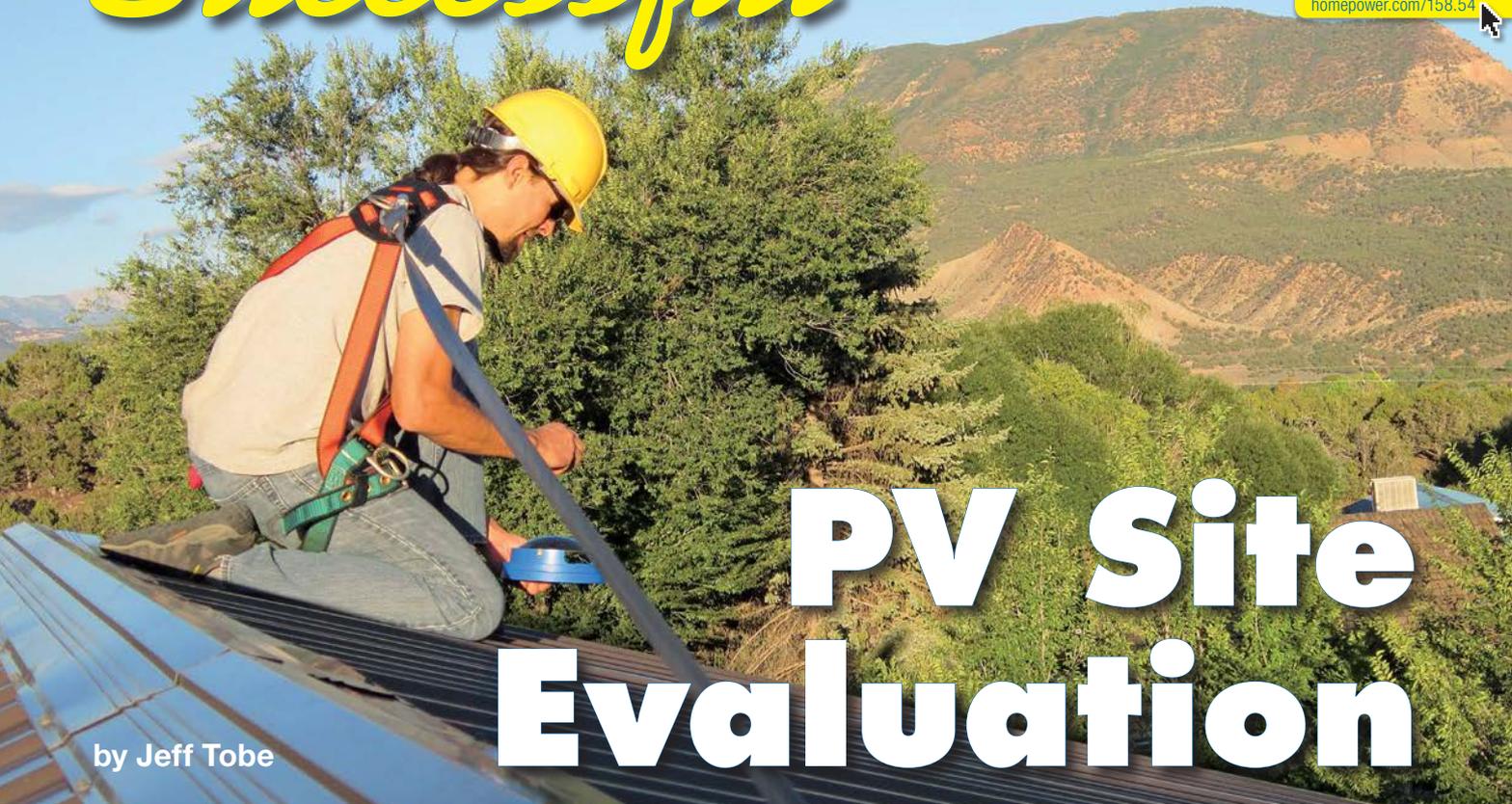
| Model # | Tiers | # of Batteries | Available Voltage |
|---------|-------|----------------|-------------------|
| 1T4B | 1 | 4 | 12V & 24V |
| 2T8B | 2 | 8 | 12V, 24V & 48V |
| 1T8B | 1 | 8 | 12V, 24V & 48V |
| 2T16B | 2 | 16 | 24V & 48V |
| 1T12B | 1 | 12 | 12V & 24V |
| 2T24B | 2 | 24 | 24V & 48V |

WWW.SPSYSTEMS.NET
1.877.924.4949
SALES@SPSYSTEMS.NET



Successful

Comment & Discuss
this article @
homepower.com/158.54



by Jeff Tobe

PV Site Evaluation

Jeff Tobe

Performing a comprehensive solar site analysis is the first step toward ensuring a well-performing solar-electric system. New tools and technologies are available for evaluating a site's solar potential. But while these tools can bring us powerful information at the touch of a button, nothing can take the place of conducting a thorough assessment of the proposed array location.

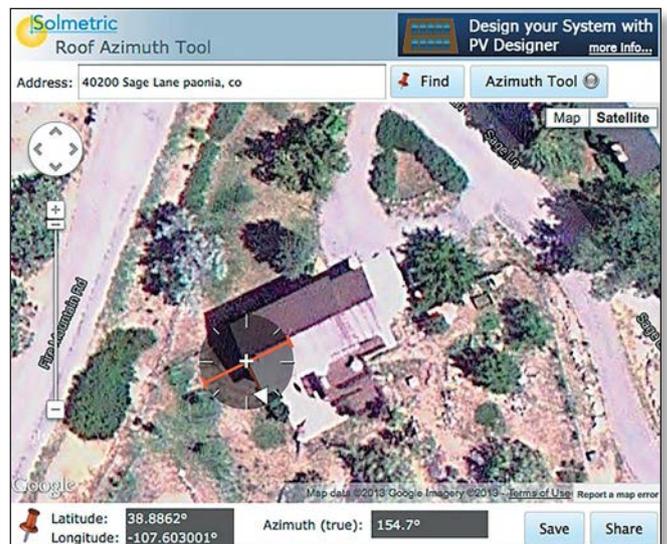
Orientation & Tilt

As a PV array's orientation (azimuth, the direction it faces) or tilt varies from "optimal," potential energy harvest decreases. The optimal combination of array tilt and azimuth will depend on a few variables, including geographical location, seasonal weather patterns and system application. Azimuth and tilt are both required data for system design and energy estimating programs such as the PV Watts calculator (see Access).

A PV array's orientation is often referenced to true south. A compass doesn't always point to true south, so magnetic declination, the angle variation between magnetic north/south and true north/south, must be taken into account, since it varies by location. There are various resources available to determine magnetic declination for most locations around the globe (see Access). With the use of a compass and local magnetic declination, a roof's orientation is simple to determine (see "Methods" in this issue). Since most buildings

are not constructed with solar in mind, roofs that face true south are uncommon. Fortunately, most PV arrays within the continental United States oriented within 30° of true south still offer excellent potential energy harvest, often within just a few percent of the maximum.

Solmetric's Roof Azimuth Tool can determine orientation from aerial photos. Google Earth has a similar tool that can determine approximate roof area.



Before the Survey

Plan for safety. A thorough site evaluation may include working with ladders and scaffolding, on slippery or steep roof surfaces, and in adverse weather conditions and confined spaces. If you are considering solar as a profession, it's a good idea to complete at least an Occupational Safety & Health Administration (OSHA) 30-hour class for "construction" or "general industry." An "OSHA 30" course can be completed online, but receiving some hands-on training with specific safety equipment, such as scaffolding erection and assembling fall-protection systems, is recommended.

Developing a relationship with a local safety firm can also be helpful in getting specialized training, as well as occasional consulting assistance on challenging installations. A comprehensive safety training program should include fall protection, ladders and scaffolding, and the National Fire Protection Association 70E arc flash compliance, for starters. And part of the site evaluation should include photos and other documentation regarding possible anchor points for fall protection, as well as notes regarding any additional safety concerns, such as skylights, overhead utility lines, steep roof surfaces, and other site-specific hazards.

Use a checklist. Make sure all details are covered, using site-evaluation forms and checklists. This includes details like the location of inverter equipment and conduit routing.

Tool up. Even a simple site survey requires basic hand tools for routine tasks, such as inspecting electrical enclosures. A tape measure and roofing chalk will come in handy for marking and capturing the effective shade area around roof obstacles like chimneys and plumbing vents. An appropriate ladder is essential for roof access and capturing "the solar window" for PV arrays elevated above the ground. Be sure to have a reliable light and dust mask or respirator for inspecting the attic and crawlspace. A contractor's clipboard will keep all of your documents organized. And of course, don't forget your solar siting tool, inclinometer, compass, and digital camera.

web extra

For an interactive PV site evaluation spreadsheet, see homepower.com/PVsitespreadsheet.



An inclinometer is an inexpensive tool for quickly determining the a surface's slope. The needle is pointing to the angle in degrees.

Jeff Tobe



An inexpensive smartphone app can measure the roof angles in degrees, percentage, rise-to-run ratio, and even radians.

Ben Root

Due to wind-loading and aesthetic concerns, most rooftop arrays are mounted parallel to the roof plane—so the roof's pitch determines the array tilt. For grid-tied systems here in the United States, "optimal" roof angles—which maximize an array's production—range between 25° and 35°. The roof pitch can be measured with an inexpensive inclinometer or a smartphone, which uses an app that takes advantage of the phone's internal sensors to measure angles.

As roof pitch decreases, the roof's orientation to true south becomes less influential on a grid-tied system's performance. At a steeper tilt, the array will capture less energy during early mornings and late afternoons due to the sun's oblique angle. As the array's tilt approaches 0° (horizontal), the array is able to capture more of the early morning and late

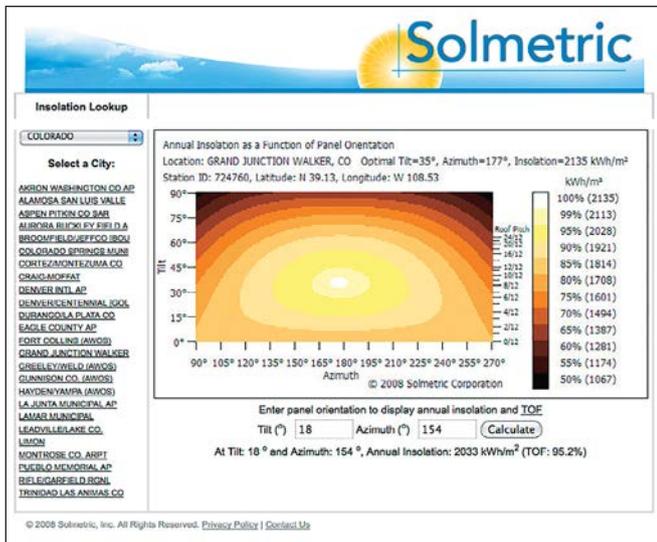
Orientation & Tilt Reference

Location: Grand Junction, Colorado; 39.13°N Latitude

| Orientation | Roof Tilt, in Degrees & Pitch | | | | | |
|-------------|-------------------------------|----------|----------|-----------|-----------|--------------|
| | 0° Flat | 18° 4:12 | 30° 7:12 | 45° 12:12 | 60° 21:12 | 90° Vertical |
| 90° East | 0.84 | 0.84 | 0.82 | 0.77 | 0.70 | 0.53 |
| 112° ESE | 0.84 | 0.89 | 0.90 | 0.87 | 0.81 | 0.61 |
| 135° SE | 0.84 | 0.94 | 0.96 | 0.94 | 0.89 | 0.66 |
| 157° SSE | 0.84 | 0.96 | 0.99 | 0.99 | 0.93 | 0.67 |
| 180° South | 0.84 | 0.96 | 1.00 | 0.99 | 0.93 | 0.65 |
| 203° SSW | 0.84 | 0.95 | 0.98 | 0.96 | 0.90 | 0.64 |
| 225° SW | 0.84 | 0.92 | 0.93 | 0.90 | 0.84 | 0.62 |
| 248° WSW | 0.84 | 0.87 | 0.86 | 0.82 | 0.75 | 0.56 |
| 270° West | 0.84 | 0.81 | 0.77 | 0.71 | 0.64 | 0.48 |

afternoon sun, which can increase overall energy production (see the "Orientation & Tilt Reference" table that shows the effects of decreasing the tilt angle with respect to azimuth). Since the goal for most grid-tied PV systems is to maximize the annual energy yield, winter production can often be "sacrificed" to maximize production in the summer, when the available peak sun-hours increase.

With your preferred solar design tool, such as Solmetric's Annual Insolation Tool, you can create a chart for quickly evaluating potential energy production as it varies with array tilt and orientation (see "Free Tools for Estimating PV Output"



Solmetric offers a free online tool for determining annual insolation based on various combinations of azimuth and tilt. This example roof is within 5% of the ideal tilt and orientation.

in HP147). The results will reveal the ideal array orientation and tilt for an unshaded array in that particular location. This chart can be used to compare different mounting scenarios, such as multiple roof planes, as well as pole- or ground-mount options (for more information, see “Methods” in HP155).

To use Solmetric’s online tool, select your state from a drop-down menu and then select the location that best matches your local weather patterns. In our example, Grand Junction, Colorado, has very similar weather to the site’s location. Selecting the location generates an “annual insolation” graph that can be customized with specific orientation and tilt angles. To interpret the chart, find your tilt angle or roof pitch along the vertical axis and then match that up to the azimuth along the horizontal axis. This will lead to an intersecting

point in the graph with a color designation that reveals a percentage value as compared to the ideal conditions, which are listed at the top of the legend area. The annual insolation value can be used to quantify the impacts of various tilt and azimuth angles. The scale along the right provides color-coordinated values expressed as a percentage of the ideal conditions and the associated insolation value in kilowatt-hours per square meter.

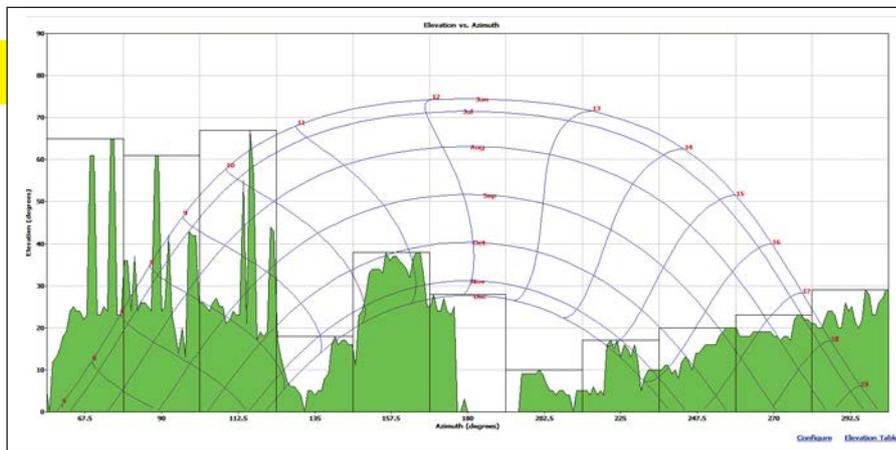
The Solar Window

The most common professional siting tools—the Solar Pathfinder and Solmetric SunEye—can help determine a particular site’s solar access or solar “window”—the average amount of sun that falls on a particular site, usually between 9 a.m. and 3 p.m. Maintaining shade-free access during this time is necessary to maximize system production while sunlight is at its peak. Solar siting tools allow quick comparisons between multiple locations on a property to determine the optimal location for system production, reliability, and overall aesthetics. Note that there are also some smartphone apps available, such as Solmetric’s IPV (for iPhone), Comoving Magnetics’ Solar Shading (for Android), and Onyx Solar Energy’s app (iPhone & Android).

Both of the pro tools, however, have optional software for analyzing the data and creating a detailed report. Standard software features include the ability to overlay multiple points of data, like a “four corners” evaluation to determine the overall solar access for the area. The data can generally be presented several ways, graphical or numerical. The software also allows users to digitally remove obstacles, such as trees or chimney vents, from the captured image and will recalculate the solar window and estimated energy production.

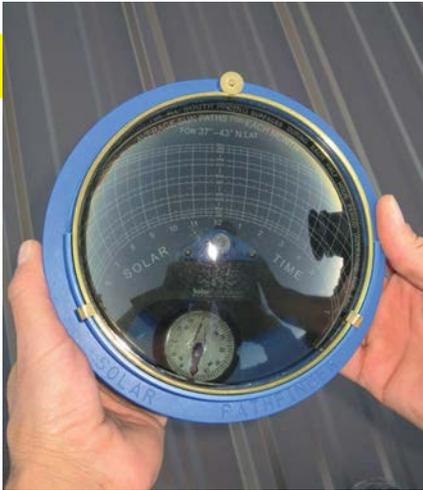
Evaluating a site’s solar access requires capturing data points for the four corners of the proposed PV array. You can either use a tripod or a beanbag to create a level surface for the siting tool. Obstacles and trees adjacent to the building may require additional readings along the perimeter of the proposed array

continued on page 58



The SunEye 210 is Solmetric’s latest solar siting tool, which displays an annual sun-path view, showing annual and seasonal solar access values (left). The accompanying software includes additional displays, such as the obstruction elevation (above).

Jeff Tobe ©



Column data has been split over multiple pages, scroll down to see the other parts.

Summary Report

Solar Obstruction Data (Part 1 of 2)

| Month | Unshaded % of Ideal Site Azimuth=180 Tilt=18.0 | Actual Shaded Solar Radiation Azimuth=154.0 Tilt=18.0 kWh/m ² /day | Actual Shaded AC Energy (kWh) Azimuth=154.0 Tilt=18.0 | Actual Unshaded AC Energy (kWh) Azimuth=154.0 Tilt=18.0 | Ideal Unshaded AC Energy (kWh) Azimuth=180.0 Tilt=18.0 | PV Solar Cost Savings \$/kWh | PV/Watts Unshaded % Actual Site Azimuth=154.0 Tilt=18.0 | Actual Site Efficiency % Azimuth=154.0 Tilt=18.0 |
|-----------|--|--|---|---|--|---------------------------------|---|--|
| January | 93.76 % | 2.91 | 146.71 | 153.00 | 153.00 | \$13.79 | 93.24 % | 74.02 % |
| February | 94.58 % | 3.31 | 146.33 | 153.00 | 182.00 | \$13.75 | 93.94 % | 80.26 % |
| March | 97.56 % | 4.67 | 227.56 | 230.00 | 243.00 | \$21.39 | 97.64 % | 91.70 % |
| April | 98.63 % | 5.31 | 244.02 | 246.00 | 242.00 | \$22.94 | 98.74 % | 99.60 % |
| May | 99.19 % | 6.30 | 288.03 | 289.00 | 256.00 | \$27.07 | 99.18 % | 100.00 % |
| June | 99.43 % | 7.72 | 327.30 | 326.00 | 285.00 | \$30.77 | 99.41 % | 100.00 % |
| July | 99.13 % | 5.91 | 259.04 | 260.00 | 227.00 | \$24.35 | 99.09 % | 100.00 % |
| August | 98.81 % | 6.21 | 273.39 | 275.00 | 259.00 | \$25.70 | 98.86 % | 100.00 % |
| September | 98.55 % | 5.77 | 250.09 | 252.00 | 263.00 | \$23.51 | 98.60 % | 94.25 % |
| October | 96.52 % | 4.75 | 221.54 | 227.00 | 200.00 | \$20.82 | 96.41 % | 83.53 % |
| November | 94.05 % | 4.09 | 190.52 | 199.00 | 255.00 | \$17.91 | 94.59 % | 73.10 % |
| December | 91.71 % | 2.98 | 147.74 | 157.00 | 213.00 | \$13.89 | 91.48 % | 67.47 % |
| Totals | 96.83% | 59.91 | 2,722.29 | 2,769.00 | 2,880.00 | \$256.89 | 96.77 % | 88.66 % |
| | Unweighted Yearly Avg | Effect: 93.39% | Sun Hrs: 4.99 | | | | Unweighted Yearly Avg | Unweighted Yearly Avg |

Notes: Shade free roof area. East side of South east facing roof. Clear of vent stack and chimney.

The Solar Pathfinder uses a highly reflective dome to reveal obstructions, which can be outlined on a paper sun-path chart (above left). It has a built-in level and compass, and the base can be adjusted for the site's magnetic declination. Digital photos taken of the Pathfinder reading can be used with the Assistant PV software to generate detailed summary reports (above right).

Deviating from "Optimal"

Several factors may influence whether it is smart to forego installing the PV array at its "optimal" orientation and tilt for a given location.

Local utility policies may reward grid-tied system orientations that would otherwise not be ideal. For example, time-of-use (TOU) metering may place a premium on energy consumed or produced during the afternoon hours. In this case, a PV array that favors a westerly orientation and produces more energy (and earns credit at the higher rate during peak-load times) may be beneficial.

Local climate characteristics, such as morning fog or regular afternoon thunderstorms, may also influence the ideal array tilt and orientation. Regular morning fog in coastal areas may warrant arrays that favor a more westerly orientation. Many locations in the Rocky Mountains experience afternoon thunderstorms during the summer months and often have winter storms followed by very sunny mornings. The combination of these two weather influences may favor arrays with a slight easterly orientation. In snow country, steeper tilts may be required to help prevent snow buildup and potential ice damming around the modules.

Off-grid PV systems also have special considerations that dictate their ideal orientation and/or tilt. Consider a fixed-mounted off-grid PV array that serves a home with higher energy consumption during the winter months. This home will benefit from an array that's more steeply tilted to more effectively capture the low winter sun angle. A PV water-pumping system that is used for summertime irrigation and/or livestock watering will require a shallower tilt to take advantage of the high-angled summer sun.



To properly evaluate a proposed PV array location, capture readings from all four corners of the intended array area.



A solar siting tool can be used to determine a "shade-free" distance from roof obstacles, such as this plumbing vent. This should be recorded on the site evaluation form.

continued from page 56

location. Protrusions, such as chimneys and vents, on the roof can be quickly evaluated using the siting tool to determine a “shade-free” distance from the obstacle. Using a piece of roof chalk, the shade-affected area can be marked around the protrusion. The resulting shaded area can then be recorded on the roof layout part of the site survey. Mapping roof obstacles beforehand can minimize or eliminate having to make expensive redesign decisions during the system’s installation.

Assess the Roof

While on the roof, analyze the condition of the roof surface and structural integrity of the rack attachment area. A roof’s estimated age and thickness should be documented. Identifying signs of deterioration and damage varies depending on the roofing material. Having an experienced roofing contractor evaluate the roof can be money well-spent.

Noticeable waviness or spongy spots in the roof warrant further evaluation of the structure. Installing PV arrays on older roofs can later result in expensive removal and reinstallation of the array. Failure to recognize potential issues, such as compromised structural elements, can pose significant hazards if attachment points are stressed during large windstorms and other weather-related events. When attic access is available, inspecting and mapping the rafters is recommended.

Local weather considerations can also influence design choices and should be recorded during the evaluation process. In heavy snow areas, knowing the expected snow loads on the roof is necessary to select an appropriate racking product rated for the conditions, as well as determining the rail span distance between attachment points. Snow loads can also dictate module selection, since modules have specific static ratings. Wind-loading also must be considered for equipment placement and selection for many of the same reasons. Most rack and module products have wind load ratings that



Check the roof’s condition—repairs or reroofing should happen before installing a PV system.

Orion Thornton

Inspecting the attic is another way to assess the roof’s structural condition, check for leaks, and map rafters for future array mounting.



Jeff Tobe

Pole & Ground Mounts

Ground- or pole-mounted arrays may offer some advantages compared to roof-mounted systems, such as the ability to choose the best solar window, if the roof is shaded, and use the ideal orientation and tilt to maximize annual energy harvest—and the payout from available incentives. Production-based incentives (such as feed-in tariff programs), which pay a premium rate above retail for solar-produced energy, may influence your decision to go with a pole- or ground-mounted system, since increasing production by 5% to 10% over a 10- or 20-year power contract can add up to a significant payout. Pole-mounted arrays offer the additional advantage of easy seasonal tilt adjustment.

But these mounting options also present their own challenges, including expensive excavation and concrete. Trenches for conductor routing may require figuring out how to deal with existing structures, landscaping, concrete pads, underground sprinkler system locations, and buried utilities. (See “Ground Mounts for PV Arrays” in *HP139*, “Interrow Shading” in *HP151*, and “PV Array Siting & Mounting Considerations” in *HP155*).



Pole and ground mounts can take advantage of optimal placement, orientation, and angle.

Jeff Tobe

range between 90 mph and 120 mph. The perimeters of most residential roofs are exposed to greater wind forces than interior portions of the roof and may not be usable in many locations with high wind loads. This can limit array placement and size, as can required roof setbacks for firefighters (see “PV Array Siting & Mounting Considerations” in *HP155*). The local building department is a good place to glean information on expected snow and wind loads.

The Rest of the System

After completing the solar window analysis, you still need to plan for routing conduit, grounding conductors, and placing the balance-of-system components (inverters, disconnects, and combiner boxes). A thorough inspection of the existing electrical panel includes documenting the enclosure make and model, as well as verifying additional breaker space, and checking the main breaker size and bus bar ratings. The service equipment ratings will be used in system design calculations to determine allowable PV backfeed capacity and

the associated breakers needed for interconnection. Ensuring adequate breaker space avoids expensive surprises later, like needing to upgrade the service panel.

Planning for *Code*-compliant conduit routing requires considering equipment placement, the mechanical integrity of equipment mounting and conductor runs, aesthetics, local regulations, and climate. Part IV: Wiring Methods, Article 690.31 of the 2011 *National Electrical Code (NEC)* dictates the type, placement, routing, and marking of conduit. Because of the higher temperatures commonly encountered on roofs, the details of conduit routing can affect system design due to required derating of conductor ampacity.

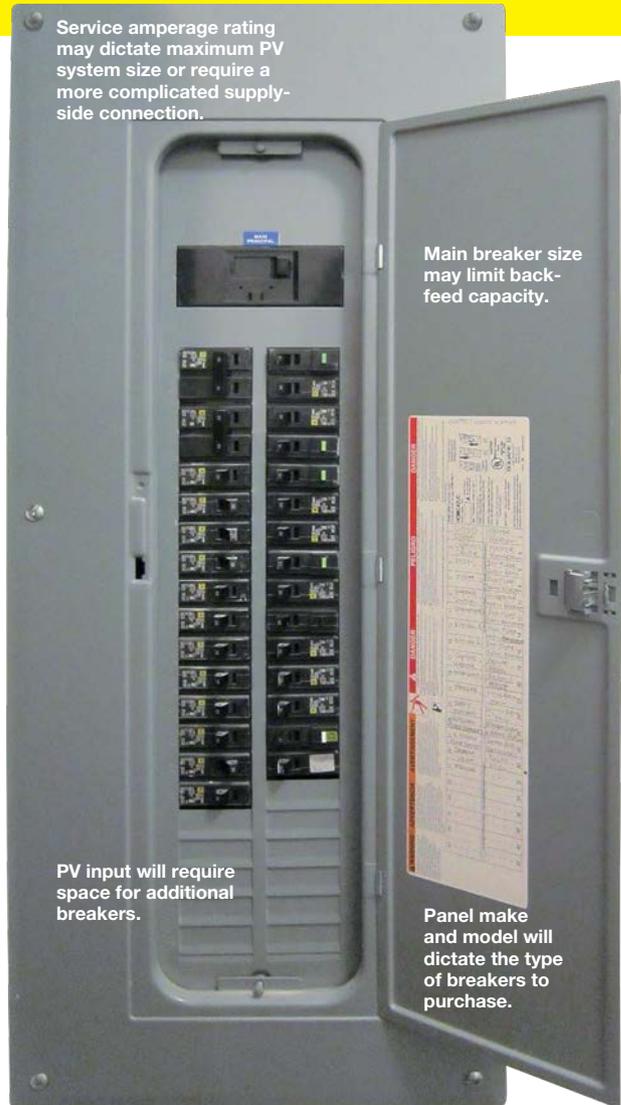
Identifying grounding components of the existing AC electrical system is another important step of the site survey. The location of the existing grounding electrode conductor (GEC) and grounding electrode (often a ground rod) will inform decisions for routing the PV system grounding conductor(s) to interconnect the two systems. In some cases, the inverter will have a GEC that must be connected to the building's existing grounding electrode or GEC. Depending on the system, the PV array may also have a GEC that must be connected to the grounding system. Planning these routes will help ensure *Code*-compliant installation.



Plan for wire and conduit runs in advance. The path between array and balance-of-system components needs to meet the *Code* as well as logistical requirements. This junction box makes a transition between PVC conduit coming from the pole-mounted array to EMT conduit running through the building interior to the inverter.



Check for obstacles—a propane tank in the yard indicates underground pipe runs that should be avoided when trenching for wire runs.



Service amperage rating may dictate maximum PV system size or require a more complicated supply-side connection.

Main breaker size may limit back-feed capacity.

PV input will require space for additional breakers.

Panel make and model will dictate the type of breakers to purchase.

Generally, a new grid-tied system will connect to the existing electrical infrastructure at the AC service entrance. Besides checking equipment condition, look for service amperage rating, main breaker rating, busbar ratings, and adequate breaker space. Incompatibility with any of these things may dictate upgrading the panel.

Inverter and disconnect placement involves satisfying *Code* regulations that apply to the working space around the equipment, weather considerations, and aesthetics. Disconnect locations must be accessible and installed within height limitations. In cold climates, some inverter models need to be installed indoors to keep them within their operating temperature range. Inverters placed outdoors should avoid south or west orientations as the intense sun may cause the inverter to derate its power output to protect internal components from excessive heat damage. Direct solar exposure can also burn out the LCD screen, which includes state of operation information, energy production values, and potential error messages.



Jeff Tobe

Balance-of-system components take up space, and have Code and practical access requirements. Map their placement in advance.

Additional Considerations

Analyzing the building's loads—and researching measures for improving the overall efficiency—is another important part of the site evaluation. Shrinking a building's loads can often result in a smaller PV system, resulting in PV system savings that are greater than the efficiency investments. Lighting and refrigeration are two of the easier places to start with efficiency upgrades—incandescent bulbs and old refrigerators are prime candidates for replacement. Insulation and other weatherization measures can also make a significant impact on electricity usage in homes with electricity-based space heating.

Access

Jeff Tobe is a PV curriculum developer and instructor at Solar Energy International (SEI). He has been instrumental in the development

RISE Certification

Solar installers may be interested in a new certification related to the methods and best practices for integrating solar arrays with various roofing materials. Formed by a coalition of roofing and solar industry professionals, Roof Integrated Solar Energy (RISE) was created to ensure that appropriate measures are taken by solar roofing professionals to preserve the roof system's performance and service life.

The RISE certification structure will be familiar to solar pros who have completed North American Board of Certified Energy Practitioners (NABCEP) certification. To become a certified solar roofing professional (CSRFP), candidates need to satisfy basic prerequisites (see riseprofessional.org).

of SEI's state-of-the-art PV lab training facility in Paonia, Colorado, and spearheads renewable projects for indigenous communities in the United States. He is an ISPQ-certified PV Instructor, has a NABCEP certification in Technical Sales, and is a NABCEP-certified PV Installation Professional.

- Magnetic declination finder • bit.ly/CalcDeclination
- PV-ready home checklist • bit.ly/PVHomeChecklist
- PV system production estimator (PVWatts) • bit.ly/PVWattsV1
- Solmetric roof azimuth tool • bit.ly/SolmTools
- Solar Site Evaluation Training & Certification:
 - Solmetric • bit.ly/SolmTraining
 - MREA • midwestrenew.org





Electric Drive Vehicle INFRASTRUCTURE TRAINING

**Learn about
the unique aspects of EV
infrastructure — *all in one place!***

**Training
with Impact**

**Installers • Code Officials • Utilities • Fleet Managers
Consumers • State, County, and Local Government Officials**

**Modularized course developed to educate all
audiences involved in the success of EVs.**

Also available — complete selection of EV training for automotive technicians;
first responders; automotive program instructors; and more!

Call (304)293-7882 or visit www.AEDve.info

Acknowledgment: This material is based upon work supported by the Department of Energy Office of Energy Efficiency and Renewable Energy under Award Number DE-EE0002108.

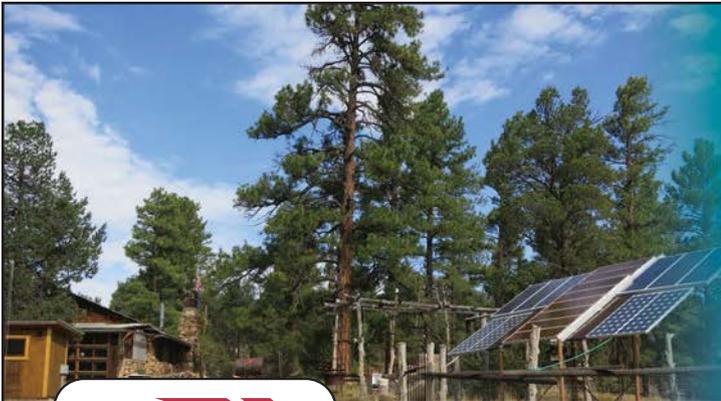





Ridgeview Business Park • 1100 Frederick Lane • Morgantown, WV 26508
Phone: (304) 293-7882 • Fax: (304) 293-6944

www.naftc.wvu.edu

A Program of
 West Virginia University



LIVING OFF GRID DOES NOT MEAN YOU'RE ALONE.



YOUR SOURCE FOR:

Solar and renewable system design and support. Call us for free help designing your system.

All components in an easy, online store, including:

- Solar panels
- Wind generators
- Inverters
- Batteries
- Pumps
- Accessories and more

We ship nationally. No sales tax on PV systems/equipment.

800-383-0195 ▪ www.solar-electric.com

ELECTRICITY FROM THE SUN SINCE 1979

SPLASH

monitoring

Maximize the potential of renewable energy systems using web-based monitoring

- ✓ Lobby screens: Get maximum PR value with dynamic animations driven by realtime data
- ✓ 70+ animations to choose, or have one custom made
- ✓ SMS & Email Alerts for failures or performance tips
- ✓ Graph historical data
- ✓ Live data updated every 10 seconds
- ✓ Brand with any logo
- ✓ Highly Educational
- ✓ Cost-effective and installs in minutes!

Choose SPLASH to monitor your commercial, educational, or home system today.

www.splashmonitoring.com

GENERATE POWER FROM NATURALLY FALLING WATER

visit powerspout.com for a dealer near you!

For **low** flows, heads **3m - 130m**
12ft - 430ft

◀ THE ORIGINAL POWERSPOUT PLT

For **high** flows, heads **1m - 5m**
3ft - 16ft

◀ SELF-CLEANING POWERSPOUT LH

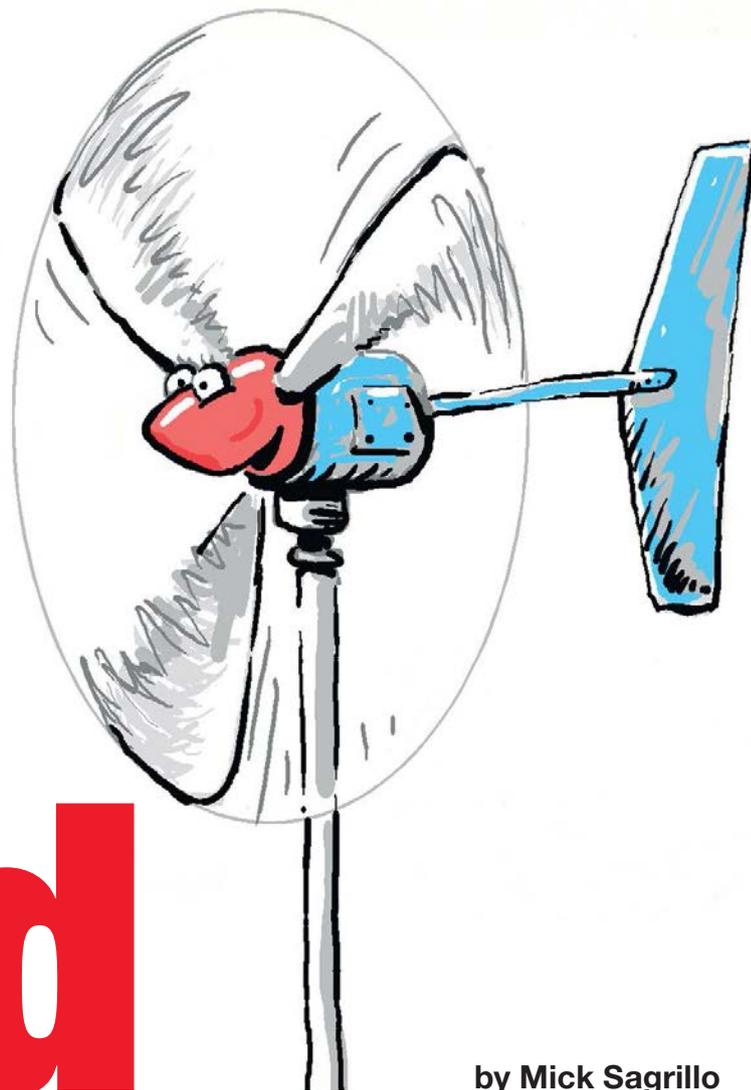
For **medium** flows, heads **2m - 30m**
6ft - 98ft

◀ THE ALL NEW POWERSPOUT TRG

up to 1.6kW EACH!

PowerSpout
WATER GOES IN POWER COMES OUT

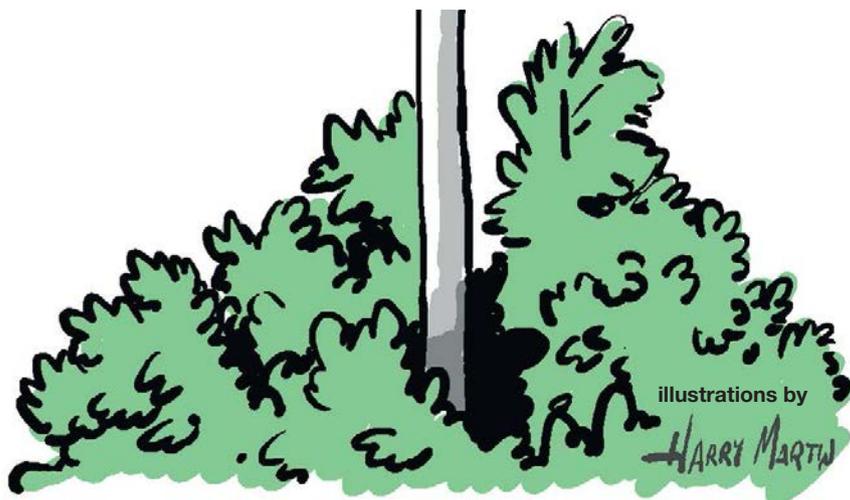
The number and variety of wind turbine designs available has never been greater. With so many choices, it seems like we should be seeing all manner of wind turbines busily spinning and generating electricity. Yet too many sit idle—generating little, if any, electricity.



by Mick Sagrillo

Wind Matters

That's because a wind-electric system must encompass much more than just the turbine. Besides a turbine (aka wind generator), you'll need an adequate wind resource, a properly sized tower, a suitable site, and the wherewithal to maintain and watch over the system.



illustrations by

HARRY MARTIN

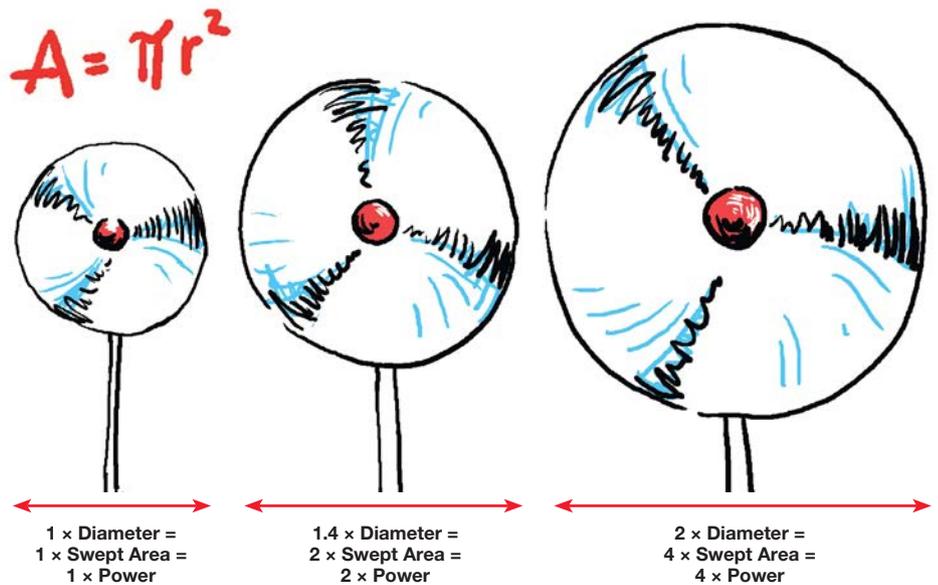
Swept Area Matters

A wind turbine's blades are fixed to a hub. Together, they make up the rotor. The rotor turns in the wind, converting the kinetic energy in moving air (wind) into rotational momentum to spin an electrical generator. The rotor is the collector for a wind turbine, harvesting wind energy, which is then converted into electricity by the generator.

Hundreds of different rotor designs have been invented, tried, and discarded over the past eight decades. Regardless, there are still all sorts of claims about unprecedented efficiencies of various new turbine designs. So how can you sort out fact from fiction?

Let's use a simple analogy to explain the concept of the rotor as a collector, using a solar hot water collector. A 4- by 8-foot collector is capable of collecting a certain amount of sunlight and converting that sunshine into a certain amount of hot water. If we double the size of the collector, it makes sense that the system would now be able to collect twice the sunlight and generate twice as much hot water.

The bigger the renewable energy collector, the more energy it is exposed to that can be collected—and the more



Increasing swept area increases the captured wind energy proportionally.

output the system will generate. The area of the wind that the rotor intercepts is called the *swept area*. Just as with solar collectors, increasing the swept area of the rotor increases the amount of wind the turbine can intercept and convert (to electricity). There is no circumventing this concept; it's just simple mathematics. Doubling the diameter of the rotor results in a *four-fold* increase in the swept area—and potentially four times the electricity for any given wind speed.

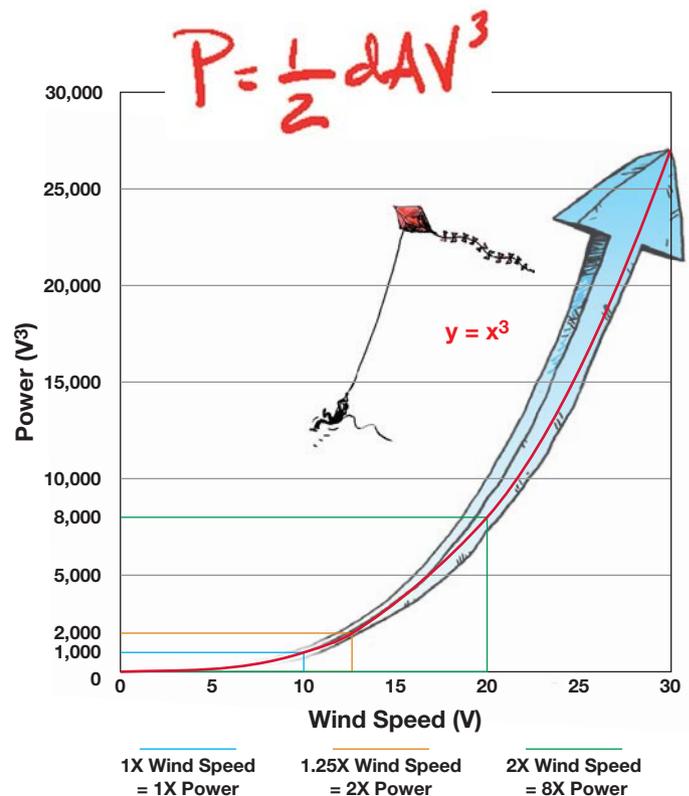
Fuel Matters

Wind is the fuel for the wind turbine. The more fuel the wind turbine has available to it, the more electricity it will generate. Wind fuel has two components, both equally important. One is the quantity of wind available. The other is the quality of the wind passing through the rotor. Let's look at these separately.

Wind Quantity Matters.

The equation that defines how much power is available to any wind turbine rotor is $P = 1/2 d A V^3$, where P is the power in the wind, d is the density of the air (affected by both elevation above sea level and air temperature), A is the swept area of the rotor, and V is the wind velocity (speed). For a given wind turbine and site, swept area and density are constants. As such, the power available in the wind is approximately the cube of the wind speed.

So, the power that is in the wind (P) is proportional to the cube of the wind speed, or V^3 . The interesting thing about this relationship is the effect of increasing wind speed. For example, a 2.5 mph difference in wind speed—say, from 10 to 12.5 mph, is an increase of only 25% in wind speed. However, since $P \sim V^3$ (not just V), the numerical increase in the power equation attributable to wind speed is nearly 100%: $10 \times 10 \times 10 = 1,000$, while $12.5 \times 12.5 \times 12.5 = 1,953$. So even small increases in wind speed result in very large increases in power available in the wind that can be converted to electricity.



The power in the wind is a function of the cube of its velocity.

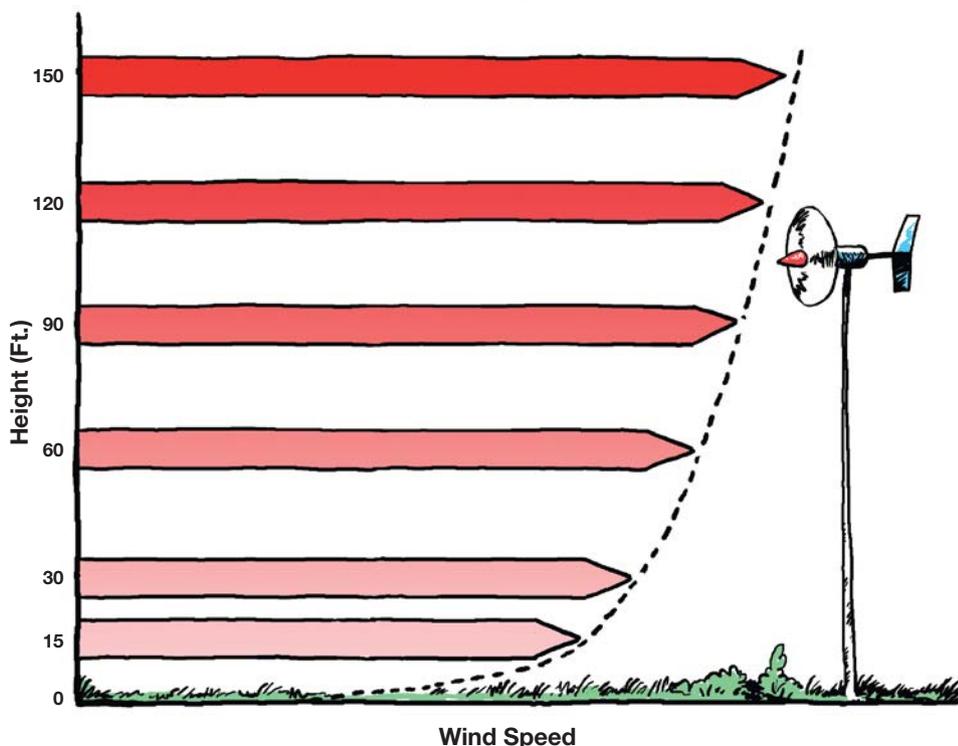
Wind Quality Matters

You don't necessarily need strong winds to get useful energy production from your wind-electric system. You might only need marginally stronger winds. So, how can you access those stronger winds? Time for another analogy.

Imagine floating down a river in a canoe, but rather than sitting back and enjoying yourself, you pay very close attention to what's happening on the water. The first thing you notice when you put your canoe in is that there is slow flow near the bank. As you paddle out into the river, however, flow picks up somewhat. By the time you get to the center of the river, the farthest you can be from either bank, you notice that the flow is fastest.

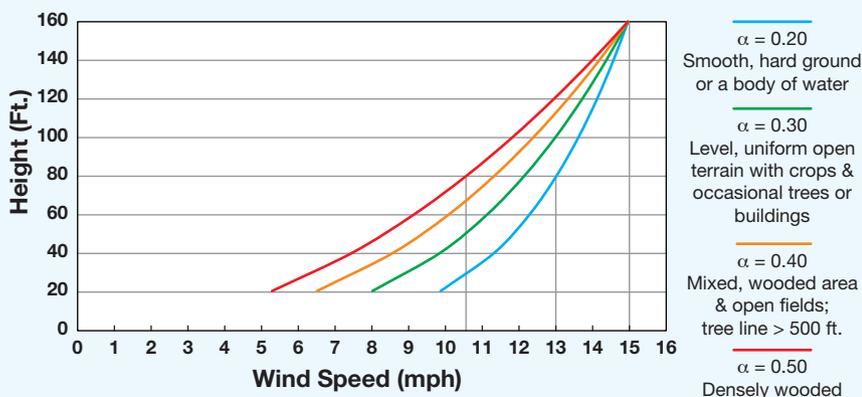
Near the bank of the river, the flowing water is slowed by its interaction with the riverbank's friction. Like water, air is a fluid. And just like

Wind Profile



Note how wind speed increases with the height above the ground.

Effects of Wind Shear on Wind Speed



The effect of four example wind shears (surface textures) based on a common 15 mph wind speed at 160 feet and ground clutter averaging about 20 feet tall. Below this height, the speeds measured are erratic due to the interaction between the turbulent winds and the ground clutter. As a result, the unreliable data for this wind is not plotted on the graph. The lower end of any given wind profile will vary with average height of the ground clutter. Taller ground clutter will result in the wind shear curves starting at a higher point on the graph.

Note, for example, how at 80 feet, the alpha of 0.20 has about 25% greater wind speed than the alpha of 0.50—that's almost double the power. Also notice that for an alpha of 0.50, the wind speed at 160 feet is about 45% more than the alpha of 0.50 at 80 feet—more than three times the power. (The alphas used here were developed for Wisconsin's Focus on Energy program and are not the "textbook" alphas sometimes used.)

water, its flow is inhibited by its contact with what's on the ground: vegetation, land forms, and buildings. The farther from these sources of friction, the faster the wind.

The illustration above shows a *wind profile*, the length of the arrows representing wind speed—longer arrows mean higher speeds. As you move away from the surface of the earth and its ground cover, wind speed increases. To access stronger winds, you need to reduce friction by getting your wind turbine rotor higher up in the wind profile.

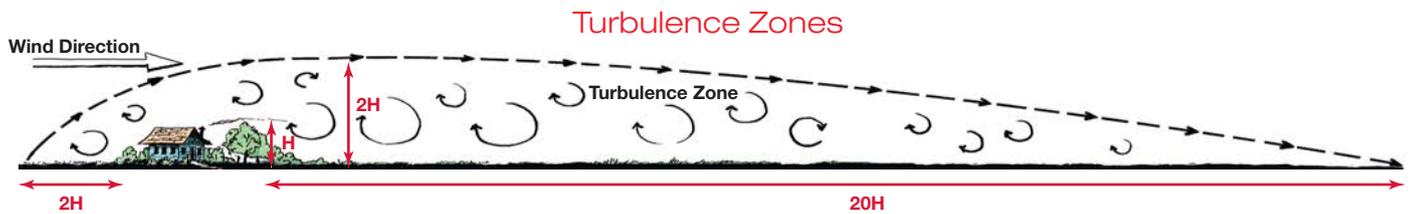
Different locations will have different wind profiles depending on the amount of friction presented to the air mass (see graph at left). The friction that ground cover poses is known as ground drag. Different ground covers are akin to different grades of sandpaper. Smooth ground cover—such as a hay field—doesn't present much drag to a moving air mass, whereas densely scattered trees and buildings present a lot of drag. The rougher the ground cover, the greater the drag and the more the air mass is slowed.

Turbulence is Trouble

Wind turbine blades are airfoils, similar to airplane wings. Both operate on the same principle of lift—the force that allows planes to fly, and wind turbine blades to rotate to extract energy out of the wind. Airfoils need laminar airflow—constant and smooth flowing winds—over them to maximize the lift they can generate—which will maximize the kinetic energy they are able to extract from the wind.

Turbulence, which is caused when the wind tumbles over obstacles (trees and buildings, for example), is chaotic airflow. The greater the ground drag due to taller or more obstacles, the more turbulence that is created. Wind breaks, farmyard wind barriers, and snow fencing are often used to create turbulence to disrupt strong winds.

Turbulence changes laminar airflow into a chaotic, tumbling, churning mess. This wreaks havoc on lift devices that depend on laminar winds. Remember the last time you flew in an aircraft that hit a pocket of turbulence? The plane was tossed about and lost altitude because of decreased lift on the airfoils (wings). The same thing happens with a wind turbine: It is buffeted by turbulence as is evidenced by the way it changes direction, trying to follow the chaotic wind, and spins erratically without generating much electricity, since there is little usable energy in turbulent winds. Unfortunately, the “bubble” of turbulence around a house or on a farm can be of considerable distance, height, and width.



An obstruction can create turbulence zones that are, above it, twice its height (2H); upwind, twice its height (2H) horizontally; and downwind, 20 times its height (20H) horizontally.

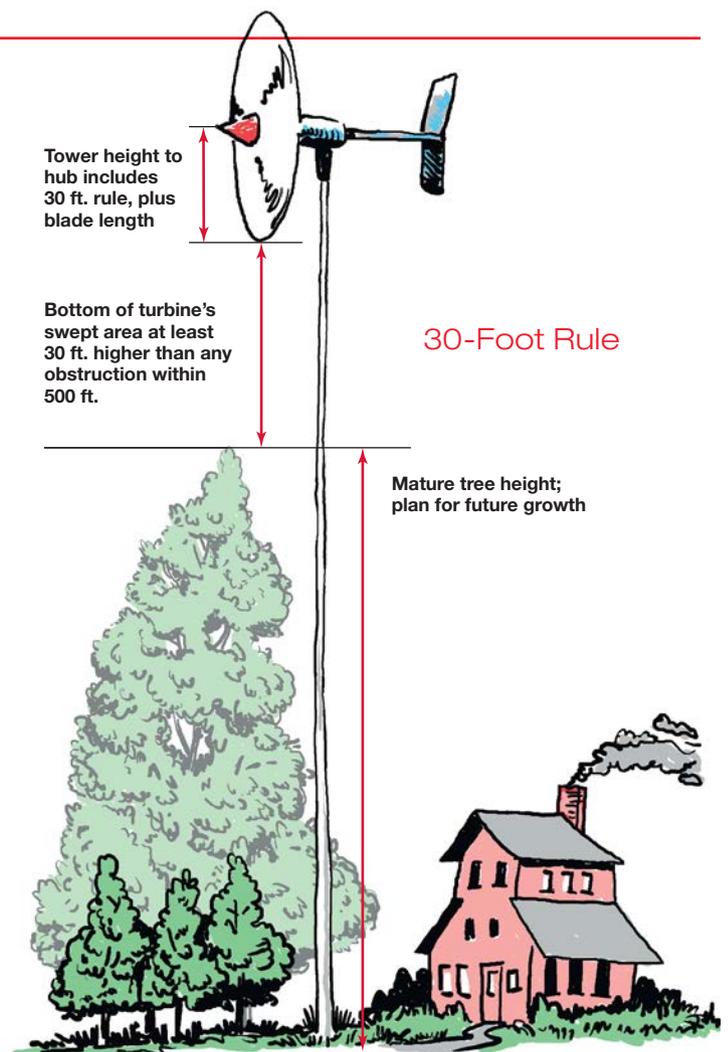
Height Matters

The problem facing a prospective wind turbine site should now be obvious: You need to minimize turbulence *and* take advantage of the power of incremental wind speed by getting the turbine higher into the wind. The solution is pretty obvious: Mount your turbine on a tall tower. If ground-dwellers afraid of heights don't like to hear that message, they shouldn't consider a wind turbine for their electricity.

How tall does the tower need to be? The first rule used in the small wind industry for determining minimum tower height is that the entire rotor of the wind turbine must be at least 30 feet higher than any obstacles within 500 feet of the tower. This rule is based on several facts:

- Wind speed increases with height above the ground.
- Turbulent winds have little extractable energy.
- Increased vertical separation between ground clutter (trees and buildings) and the wind turbine rotor means that the rotor is moved out of chaotic turbulent winds and into clean laminar wind flow with more extractable energy.

Wind turbines are presumably installed for two to three decades of service, during which time the trees in the area will probably grow taller. As such, we also need to consider the mature tree height, not the current tree height, when determining tower height.





This wind turbine was installed in 1982 using the 30-foot rule for fixed obstacles—tree growth was not accounted for. In the last three decades, the trees have grown tall enough to render the wind turbine useless.

Location Matters

Most locations have winds that blow out of somewhat-specific directions over the bulk of the year. These are known as prevailing winds and are plotted graphically in a wind rose.

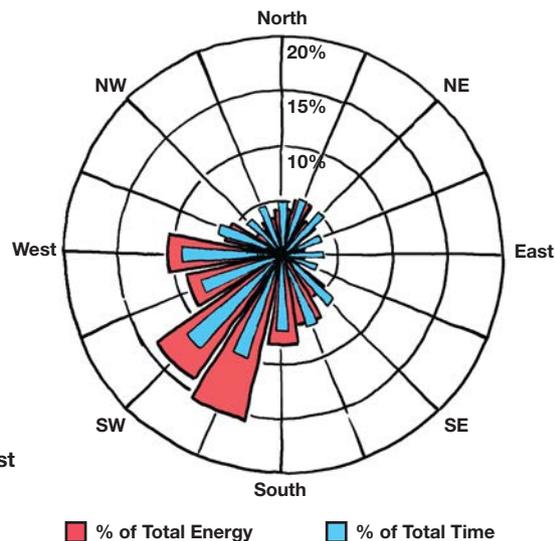
Using the wind rose for your site will help determine the best location for your tower. Over the course of the year, the wind blows from all directions, so any location on your property is going to be a compromise. However, you can minimize turbulence while optimizing your site's wind profile by placing your tower as far upwind in the direction of the area's prevailing winds as possible.

My Wisconsin homestead is typical—a house and a few buildings, all with electricity, fencerows for privacy and to block winter storm winds, and a few tall trees. At first glance, one might opt to site the wind turbine close to the house for a shorter wire run, which is exactly what we did with our first turbine. If you look at the wind rose for our site (at right), however, you'll notice that this places our tower

The site for the first turbine (1) turned out to be highly compromised—downwind from almost all obstacles on the property relative to the prevailing wind direction. Subsequent turbines were placed at sites 2 and 3.



Wind Rose



The wind rose for this site shows that the strongest winds come predominately from a southwest and south-southwest direction.

downwind of almost all obstacles on our property relative to the prevailing wind direction. While the turbine generates adequately, it would actually generate more if it had been sited somewhere else. The locations of our two other wind turbines are much less subject to turbulence most of the year.

The compromise I had to make, especially with the third site, is a longer wire run. However, wire cost constitutes a small percentage of the cost of an entire wind system installation. More important was getting upwind of the major sources of turbulence at our site—a strategy that will help optimize energy generation and reduces wear and tear on the equipment.

You should be able to access a wind rose for your location from your state energy office or wind map, or local agricultural office. The U.S. Department of Agriculture's Natural Resources Conservation Service has downloadable wind roses from various climate stations (see Access). Other good sources of prevailing wind directions include the National Oceanic and Atmospheric Association or Weather Underground, both of which keep local climatological data.

“Breakthrough” Technologies & Other Whirligigs

Hardly a week goes by without at least one press release about a new and improved wind turbine design hitting my email inbox. These company press releases touting a breakthrough technology are picked up and propagated by media outlets, which unfortunately bestows credibility on the company. Even more unfortunately, well-intentioned people who want to generate some of their own electricity take the bait.

So, what’s wrong with all of this? And why does the small wind industry take umbrage with these seemingly new designs? Nearly all of the new “breakthrough” technologies share an amazing number of similarities.

Promise: An unusual design, other than the typical two- or three-bladed horizontal axis wind turbine (HAWT). Some are vertical axis or squirrel cages, shrouded or funnels, or some other unusual rotor configuration.

Reality: The designs are simply a regurgitation of something unusual-looking. Although they are eye-catching, they never worked, which is why the designs were abandoned decades ago.

Promise: Rooftop units with small rotors or ground-mounted, designed to generate (“spin”) at lower wind speeds to avoid the added expense of the tower.

Reality: As above, it’s all about collector size and where the fuel is. A whirligig with a small rotor will likely only ever generate enough electricity to overcome the resistance losses in the wire run. Also, note that spinning does not equate to generating electricity. For kicks, calculate the units that go into the power equation in a much-touted 2 mph startup wind speed. Then compare this number with the units in a 10 or 15 mph wind. Do this using $P \sim V^3$.

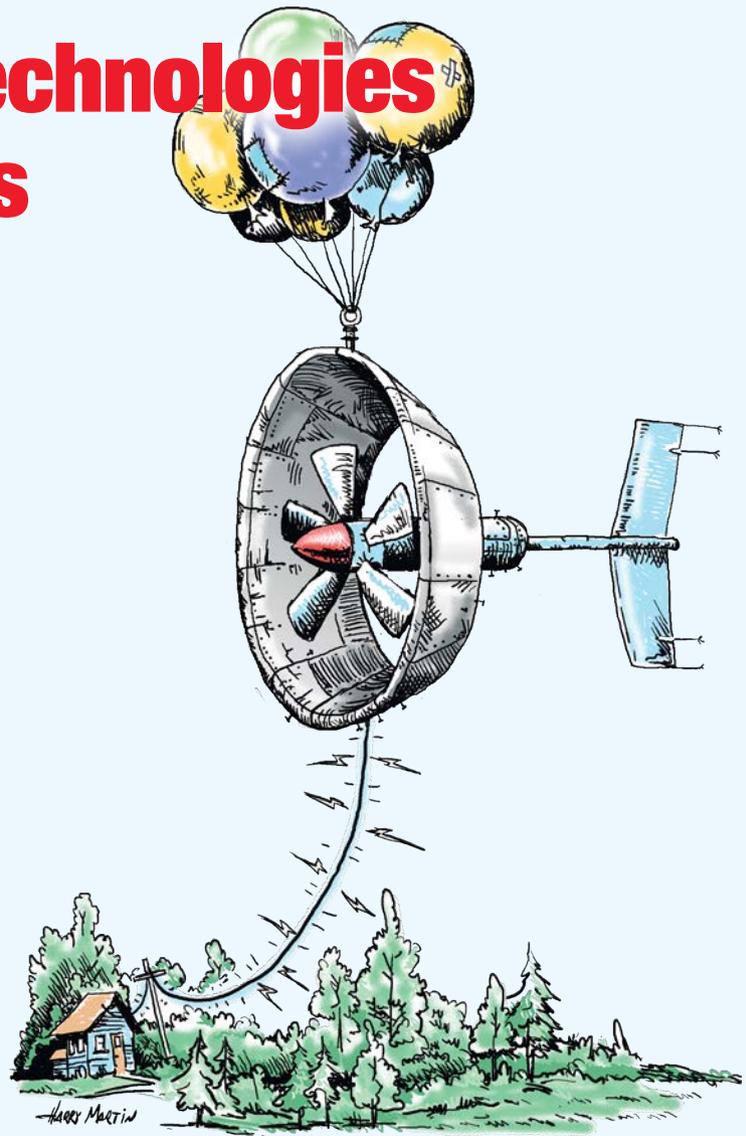
Promise: The designer claims “thinking outside the box” with an innovative idea, bringing new insights to a stagnant technology.

Reality: Wouldn’t it be good if the innovator knew what’s actually *inside* the box before beginning to think outside of it? In other words, shouldn’t a designer understand why successful wind turbine designs—small ones, as well as the tens of thousands of utility- and larger-scale wind farm turbines—all look like they do? They should also understand why hundreds of unusual rotor designs were abandoned decades ago and are not being implemented by established manufacturers.

Promise: Conceptual designs claiming unprecedented efficiencies.

Reality: Show real performance data from multiple real-world installations. Wind tunnel or lab test results and website calculations are the equivalent of wild guesses as to what a generator will do in the real world. Short-term and controlled tests of a prototype from one installation at an ideal site don’t reflect real-world performance. For confidence, you need performance data from a production model (not a prototype) from an independent third-party or owner.

Promise: They solve non-existent problems. These range from being bird-friendly to vibration-free, and everything between.



**Beware of turbine designs that are “outside of the box.”
The box has been built from decades of practical physics.**

Reality: Let’s take just one example: bird-friendly. The intimation is that two- and three-blade HAWTs kill birds. Unfortunately, large utility-scale wind turbines do kill some birds. Taken in perspective, however, bird mortality with the largest of turbines is far lower than the impact from conventional energy sources (none of which, it seems, are held to the same environmental standards that are imposed on renewables). The few surveys or studies on bird mortality done on small wind installations might suggest a possibility of a handful of bird deaths over the entire life of the installation at sensitive locations—far less than one summer’s bird mortality from many picture windows or domestic cats. Bird mortality is hardly the concern with small wind turbines that these claims make them out to be.

Promise: All-too-frequent headline: “Revolutionary new design...”

Reality: Product sophistication and fine-tuning come from evolution—building on prior art—not revolution. Small wind turbines have been around for nearly 85 years. We’ve had time to sort out what works and what doesn’t based on the science of physics and fluid dynamics, and with engineering and mathematics. Over the history of wind turbines, the designs that have proven themselves to work are two- or three-bladed HAWTs.

Lessons That Matter

So, what can we take from all of this? The lessons are pretty straightforward:

- Swept area determines how much of the wind's power your turbine can extract. There is no way around the mathematics of your collector size.
- Wind turbines exposed to laminar winds generate more useful amounts of electricity. Wind turbines sited in turbulent locations (on buildings, or at or below tree level) cannot—and will not—generate much, if any, electricity. There is no way around the physics of fluid dynamics.
- The 30-foot tower height rule helps determine whether the wind turbine will be exposed to quality winds over the life of the system.
- Siting your wind turbine upwind in the direction of the prevailing wind will minimize turbulence.

The economic payback in a wind turbine is directly proportional to the electricity it generates over its life. If a wind turbine is sited in turbulent winds, it simply will not generate much electricity, making it a questionable investment. In addition, the turbulence will cause increased wear and tear on the turbine, shortening its useful life. But a wind system includes more than just the turbine—it includes a tower that's properly sized for the site, foundation, wire run, balance-of-system components, all labor and materials for installation, and various other costs.

People take care of investments when they make sense. Wind system owners invest maintenance and repair dollars in things that work, like a properly sized and sited wind turbine. Owners quickly abandon ideas that don't work. The history of small wind tells us that rooftop wind turbines and wind turbines installed on towers too short for the site are quickly abandoned and become derelict once they need repair. Simply put, they were bad investments. A \$20,000 wind-electric system that only lasts for two years is a poor investment compared to an \$80,000 system that lasts 20 years.

Which Wind Turbine?

If you are shopping for a wind turbine, where do you go for help? Three organizations host websites with recommendations based on equipment that is certified to an American National Standards Institute standard, actual performance test results, and industry feedback.

The Small Wind Certification Council (SWCC) is a certifying body that confirms that published turbine test results conform to the American Wind Energy Association's 9.1-2009 Small Wind Turbine Performance and Safety Standard. Turbines that are certified to have met the AWEA 9.1 criteria are listed at smallwindcertification.org. Make sure you peruse the list of SWCC-certified turbines, not the applicant turbine status.

The Interstate Turbine Advisory Council (ITAC) is a consortium of state public-benefits programs that fund the installation of renewable energy systems. They publish the Unified List of Wind Turbines (at bit.ly/ITACTurbines) that participating state programs may be willing to fund.

Intertek is another organization that certifies wind turbine test results to the AWEA 9.1-2009 standard. However, this website (bit.ly/IntertekDirectory) is a bit more confusing since Intertek certifies components as well as entire wind turbines.

If the wind generator you are considering is not on one of these three lists, move on. Or at least understand that you are making a risky purchase of an untested, unproven design, and be ready to accept the outcome of your speculative investment.

Access

Mick Sagrillo (msagrillo@wizunwired.net) consults, teaches, and writes about wind power. He and his wife have powered their house with wind for 32 years, and Mick has flown dozens of models during that time.

Downloadable wind roses • bit.ly/NRCSWindRose



FINALLY!

A METER FOR YOUR SYSTEM

NEW! A self-powered meter for hydro, wind or solar, with enclosure and built-in shunt. This unit measures volts (10-90V), amps (30A Max), watts (W), and amp hours (Ah).

only \$95!





WATER BUDDY
 - Portable 8 lbs (3.5 kg)
 - Up to 300 watts
 - 12/24 or 48/120 V



LH1000
 - Standard or Easy Tune Generator
 - 3-15 ft (1-4.5m) head
 - Non-corrosive precision made parts



STREAM ENGINE
 - Standard or Easy Tune Generator
 - Turgo or High Head Runner
 - 10 ft (3m) and up head

Energy Systems & Design
 Microhydropower since 1980

www.microhydropower.com
 YouTube channel: ESDhydro
 sales@microhydropower.com
 506-433-3151

BUY DIRECT FROM THE MANUFACTURER

Off-Grid & Grid-Tied
Solar / Hydro / Wind
Solar Water Pumping
Educational Toys
Homestead Supplies
Books
Wholesale Available



Since selling the first retail solar panel back in 1978, Real Goods has empowered millions with education, systems, components and installations. From our 12 acre Solar Living Center in Hopland, CA we test and experiment while educating over 200,000 visitors a year. We're proud to give the best technical support and training in the industry.



WWW.REALGOODS.COM

Toll Free Tech Support 7 Days a Week!
(800)919-2400



CELEBRATING 35 YEARS OF SUSTAINABLE EMPOWERMENT

BATTERY PROBLEMS?

The BLS™ The **Battery Life Saver™**
electronic device
The Most Effective Desulfator Available
Since 2002

Rejuvenates
old batteries

Extends
battery life

Maintains
batteries in optimum
condition

The BLS uses patented square wave technology that dissolves lead sulfate crystals and prevents further build-up. It will not interfere with electronics (electromagnetic compatible).

- *Only one device needed per bank
- *Easy DIY Instructions
- *5 Year Limited Warranty
- *120 Day Money Back Guarantee
- *Environmentally Friendly
- *U.S. Patent # 7374839

USA ingenuity for
the benefit
of the planet

www.BatteryLifeSaver.com

For a Free Info Packet : 1-(866)-301-8835

GET MORE TURBINE *POWER!*

Tired of watching your
Wind Turbine spin, but the green
charging LED doesn't light?
Get more low wind kilowatt
hours from your Whisper*
100/200/500 investment.
More information online
at www.qlog.com

**WIND
MISER**
The next best thing to more wind



QLog Corp.
33 Standen Drive,
Hamilton, Ohio 45015
info@qlog.com

(513)874-1211

*Whisper is a trademark of Southwest Windpower, Inc.

LOW THERMAL MASS SUNSPACES

by Gary Reysa

The Little-Known Gem of Solar Heating

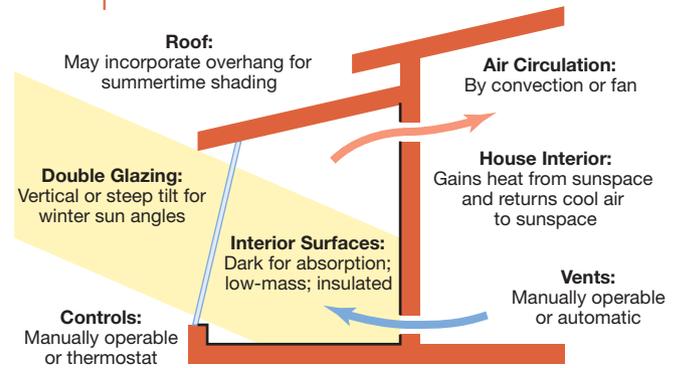
**Comment
& Discuss**

this article @
homepower.com/158.70

Sunspaces have long been appreciated as a way to provide some extra living space with sunny appeal. They can also be used as supplementary heaters, collecting free solar energy that can be channeled to warm interior rooms on sunny winter days.

Courtesy William Sikora

Sunspace Characteristics



This article describes a low thermal mass sunspace (LTMS), which can be thought of as just a big “walk-in” hot air collector. This design is optimized to provide significant heating for the house.

Characteristics

The features that characterize a LTMS are:

- A large, south-facing glazed area that is steeply tilted or vertical for excellent winter sun collection. Double-glazing should be used in cold climates to decrease heat loss.
- Nonglazed surfaces (walls, roof, and floor) that are insulated and sealed to reduce heat loss.
- Sunlit surfaces that are dark in color for good heat absorption, and are low in mass so the solar radiation rapidly heats these surfaces, and the surfaces transfer that heat to the air. (This is in contrast to high-mass sunspaces, in which the solar energy goes primarily into heating the sunspace mass.)
- A high-capacity fan and duct system that transfer heated air in the peak of the sunspace into the house, and a return air system that returns cool house air near the floor of the sunspace.
- A high-capacity vent system allows excess heat to be vented outside when space heating is not needed.
- These sunspaces are normally attached to or integrated with the home’s south face.

A sunspace designed to these parameters will be quite efficient as a space heater for the attached house. It will also be comfortable during the day for other activities, since the excess heat that would make the sunspace uncomfortably warm is being distributed to the main house. A sunspace can start providing heated air to the house as soon as the morning sun shines on it, since the low thermal mass allows it to heat quickly and little heat is stored in the space itself.

The big advantage for the LTMS is that it provides space heating equivalent to what active solar thermal collectors provide while allowing the space to be used for many activities, including lounging, four-season clothes drying, wood drying, or a well-lit shop. A downside of the LTMS is that once the sun sets, the space will cool to outside temperatures quickly—it is not a good space to hang out on cold evenings. In cold climates, it is also *not* suitable for growing plants through the winter.

In contrast to a high-mass sunspace, the LTMS does not provide any storage for the heat it produces. This is usually not a problem since the house’s heating demands plus the ability of the house’s thermal mass to store heat are enough to absorb the heat that the sunspace can produce. Solar gain glazing (including sunspaces) can be up to about 10% of the floor area of the house without requiring storage.

If the house has low heat loss and/or the sunspace has a large amount of glazing compared to the house size, then sunspace heat can be stored. For example, one strategy in the past, which has fallen somewhat out of favor, was to duct the heat to rock-bin heat storage; an air-to-water heat exchanger also can extract and store some of the heat in a water tank. It is best not to store heat in thermal mass inside the sunspace since most of that stored heat will be lost through the sunspace glazing after sunset.

The author’s “low-mass” sunspace is actually a high-mass greenhouse that was tested for thermal performance—before the mass and plants were moved in.



Gary Reiser



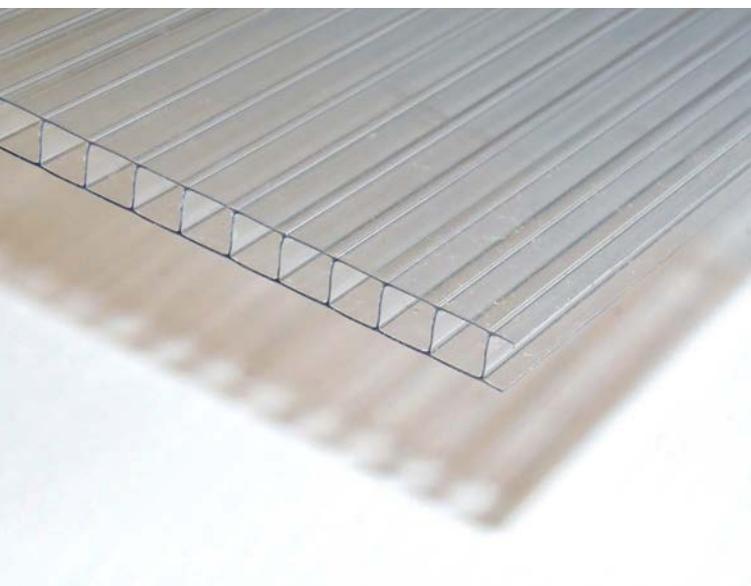
The greenhouse used for sunspace testing. The long ducting here was used to measure airflow. Make sure to size the fan to deliver 3 cfm per square foot of glazing with the duct system that you have chosen.

Moving the Heated Air

A thermosyphon system with large vents distributed across the width of the back (house) wall of the sunspace—high for the hot air vents and low for the return vents—might be able to provide the required airflow, but a fan-forced system will be the right choice for most situations.

The LTMS should be equipped with a fan or blower to move the heat to the house as quickly as it is produced. The testing suggests that an actual fan flow rate of about 3 cubic feet per minute per square foot of sunspace glazing is sufficient to remove the heat under sunny conditions. A variable-speed fan or multiple fans that can be turned on one at a time would allow the flow rate to be adjusted for less-sunny or early- or late-day conditions. Select the right fan capacity, but also be sure to consider fan type and placement to avoid annoying noise.

My test sunspace, a stand-alone structure that eventually was converted into a high-mass greenhouse, uses a Ranco ETC controller—a simple heating controller that switches a fan on when the temperature exceeds a setpoint temperature. (A snap-disk switch would have served the same function.) This controller activates two Dayton 10-inch-diameter fans (27 W each), one mounted at the peak of the west wall and the other at the peak of the east wall. While the fans have free air delivery of 600 cfm each, with duct losses, they actually produce 325 cfm each. This setup was close to the specification of 3 cfm per square foot of glazing and worked well. This could easily be made into a two-stage system by hooking up each fan to its own controller and setting one controller to a lower temperature so that the first one comes on at 80°F, and the second one comes on at 90°F.



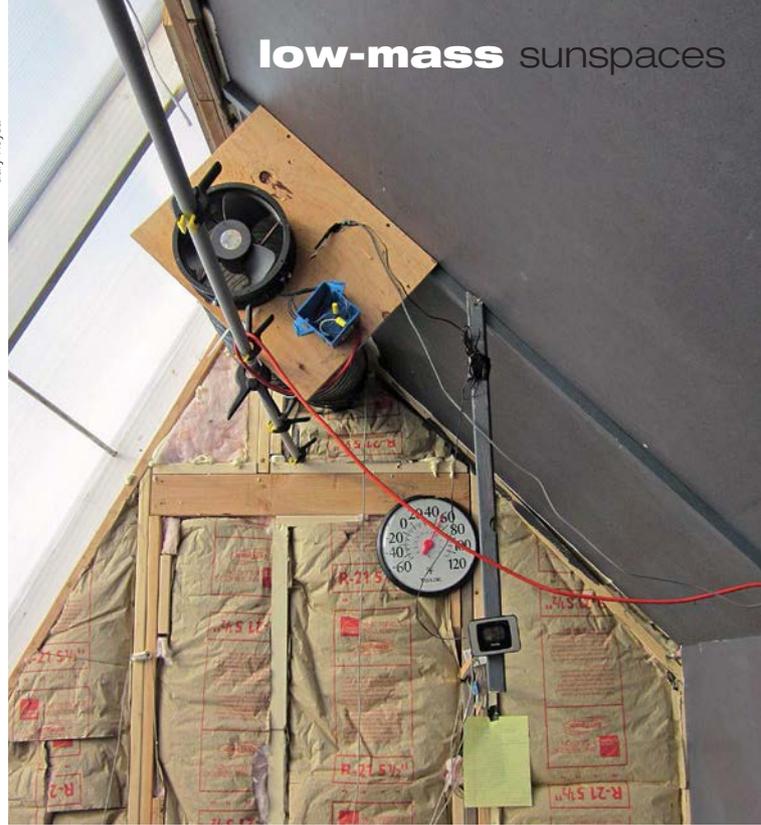
Left: The glazing used in the test LTMS is 10 mm double-wall polycarbonate with an R-value of 1.8. At about \$2 per square foot, it is less expensive and easier to work with than two panes of glass, although its lifespan is shorter.

Right: The Ranco ETC thermostat turns the fans on and off based on the sunspace's temperature. This is a temporary installation for testing; permanent installation would be made more cleanly.



Gary Reyes (3)

Gary Reysa



The west end of the sunspace shows the 10-inch Dayton fan and R-21 fiberglass insulation (to be covered with Rboard). The Rboard on the north wall is painted black for improved solar energy absorbance.

The Sikora sunspace control scheme (see “Inspiring Sunspaces” sidebar) uses a line-voltage cooling thermostat in the sunspace and a line-voltage heating thermostat inside the house to control a blower that distributes heated, filtered air from the sunspace into the loft of the home. Inside the home, ceiling fans help distribute the heat. When both thermostats are closed, the 260 cfm blower starts. Cool air enters the sunspace from the house through a one-way damper, which prevents backflow when the blower is off.

The duct into the house must include a passive, spring-return damper that opens only when the fan is on to prevent cold air from flowing into the house at night. That said, some of the spring vents do not seal very well—the ones I have are just fair. Fabric dampers might work better. The poly-film dampers I used on my shop thermosyphon collector could work well inside a sheltered sunspace, with inlet and outlet dampers facing opposite directions. Motorized damper actuators (such as those made by Honeywell) also are available that could provide a positive seal.

Keeping the ducts inside the sunspace, rather than outside, is also helpful for mitigating heat loss. This shelters them from the wind, and eliminates the need for insulating them. The sunspace also reduces heat loss from the house to the outdoors since it provides extra insulating and sheltering where it is attached.

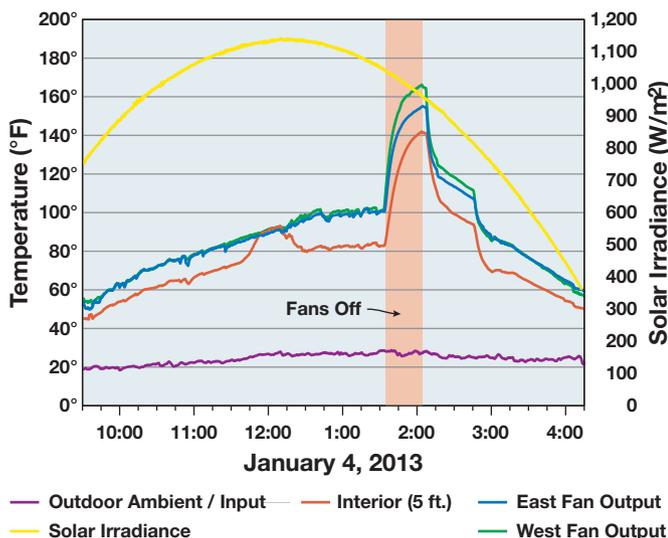
How Much Heat?

The test 200-square-foot sunspace in southwestern Montana has 200 square feet of south-facing twin-wall polycarbonate glazing tilted at 60° for good winter solar collection. The walls and roof are insulated to R-27 and the floor to R-8. The low-mass walls are Atlas Rboard rigid insulation painted with black latex paint—they heat quickly and pass that heat into the air. The Rboard has a fiber face sheet that takes paint well and is durable, but is not approved for direct exposure to a living space for flammability reasons. The floor consists of EPS rigid foam panels laid over compacted sand, with

plywood laid over the trafficked areas. For the test, black weed barrier cloth, which makes a solar-absorbent surface, was placed over the floor. The structure was sealed using spray foam and caulking to reduce infiltration.

You don’t have to be this particular in specifying surfaces that are dark in color and low in mass. For the walls, any dark-colored surface will work, and wall coverings like wood paneling or 1/4-inch plasterboard will not significantly sacrifice performance. For the floor, a surface like cork or carpet or even garden bark will work as long as it is insulated underneath.

System Temperatures & Irradiance



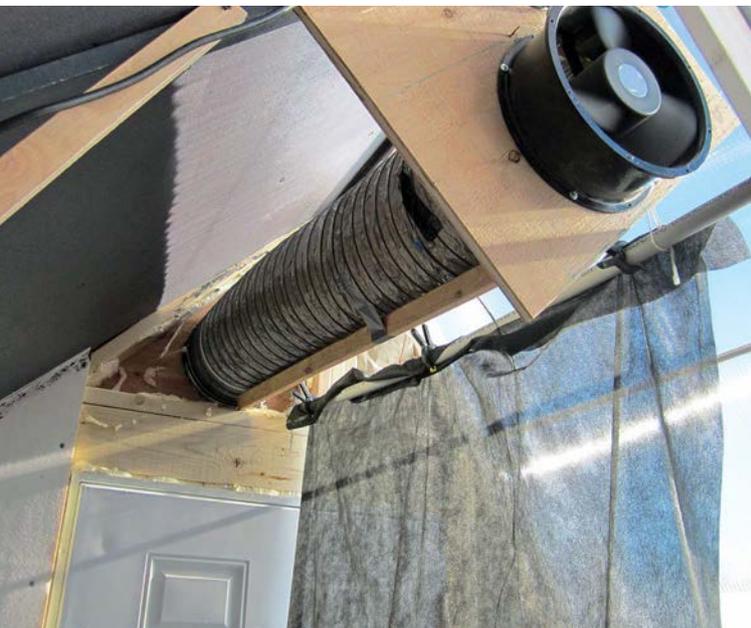
Sunspace Heat Output

| Time | Inlet Temp. (°F) | Outlet Temp. (°F) | Temp. Rise (°F) | Heat Output* (Btu/Hr.) |
|----------------------|------------------|-------------------|-----------------|------------------------|
| 10 a.m. | 19.8 | 61.0 | 41.2 | 23,668 |
| 11 a.m. | 22.3 | 76.4 | 54.1 | 31,079 |
| 12 p.m. | 26.6 | 90.0 | 63.4 | 36,422 |
| 1 p.m. | 27.4 | 99.5 | 72.1 | 41,420 |
| 2 p.m. | 28.3 | 99.5 | 71.2 | 40,903 |
| 3 p.m. | 24.8 | 87.0 | 62.2 | 35,732 |
| 4 p.m. | 25.1 | 64.0 | 38.9 | 22,347 |
| Total Btu/Day | | | | 231,571 |

Heat Output (Btu/hr.) = Air Velocity x Duct Area x Air Density x Temperature Rise x 60 min./hr. x Specific Heat of Air (0.24 Btu/lbs.°F)

Measured: Air velocity = 600 fpm; Duct area = 1.09 ft.²; Air density = 0.061 lbs./ft.³

Notes: Air density is low due to the sunspace’s location at an elevation of 5,000 ft.; peak irradiation was measured at 1,140 W/m² due to reflected radiation from the snow field in front of the glazing



Gary Reyes

Left: The east-end ducting and blower fan—a Dayton 10-inch, which provides 665 cfm of free air delivery. The shade cloth was an experiment at preventing overheating in the space.

The solar radiation was measured using an Apogee pyranometer mounted in the plane of the glazing. The heat output to the house was calculated from the temperature rise from inlets at the lower southeast and southwest corners to the fan outlet ducts and the flow rate out of the two 10-inch ducts. To measure airflow, a flow velocity survey was taken in the long, straight section using a calibrated Kestrel-turbine-style anemometer. The inlet air is ambient air that averaged 27°F.

The “System Temperatures” graph shows the inlet, outlet, and ambient temperatures and solar radiation for a sunny-day test on January 4, 2013. Under steady collector conditions a little after 1 p.m., the heat output of the collector is 42,200 Btu per hour, and the solar input is 69,900 Btu per hour—which calculates to an efficiency of 60.3%. This is comparable to high-quality commercial solar collectors operating under the same conditions.

If the heat output is calculated for each hour, the total heat output for the day adds up to 232,000 Btu. These heat-output numbers are higher than typical because the test was done with outside ambient inlet air (at 27°F) instead of room-temperature air (65°F, for this calculation). The cooler the inlet air, the more efficient the collector. The heat output adjusted for room-temperature inlet air instead of 27°F inlet air would be about 19% lower, or about 188,000 Btu per day. This is equivalent to 2.9 gallons of propane burned in a 70% efficient furnace. So, even this modest-sized sunspace produced a lot of useful heat—even on a day of the year that has close to the fewest number of sun-hours. Near midday, the sunspace is producing 10,000 watts of heating power—and the only energy being used to “produce” this is the two 27-watt fans.

At about 2 p.m., the fans that push hot air out of the sunspace were turned off. Without fans or vents to remove heat, the

temperature in the peak of the sunspace quickly climbed to more than 150°F. This is an indication of how fast an LTMS responds when ventilation is stopped and how effective the insulation and double-glazing are in reducing sunspace heat loss.

I wondered how sunspace output would be affected by not following the design rules, so I tested it before the insulation was added, and with a bare dirt floor. The difference was dramatic. Under similar sun and ambient temperature conditions, the heat output of the unfinished sunspace was about 33% of the finished sunspace. Following the design guidelines significantly improves the heat output.

Preventing & Dealing with Overheating

For the summer season, some method will be required for positively venting the sunspace on sunny days. Having at least two inlet vents (located low) and two outlet vents (located high) is recommended. To ensure comfortable temperatures during the midday, exhaust fans will probably be needed in the outlet vents. One good choice would be thermostatically controlled greenhouse ventilation fans. Another option would be solar-powered fans, perhaps the type of solar fans sold for attic ventilation. The solar fans would provide more airflow as the solar intensity increases, and would probably not require a separate control.

I have converted the test LTMS sunspace into a solar greenhouse, and for the summer ventilation I’m using a solar-powered attic vent fan in the east peak and one of the 10-inch fans in the west peak. The solar-powered fan varies its speed with sun intensity, and is quiet—even in full sun. Alone, however, it does not provide enough ventilation. The Dayton fan is set to come on when the peak temperature in the sunspaces is 90°F. Two solar-powered fans would probably serve the space’s ventilation needs.

Summer vent inlets could be located low on the east and west walls, or below the south glazing, or opening windows

continued on page 78

The Ramifications of a Little More Mass

If 1/4-inch plasterboard is installed over an insulated wall, then how long does it take the sunspace to get the plasterboard up to the sunspace’s operating temperature? How much does the extra mass detract from the performance?

Quarter-inch plasterboard weighs 1.2 pounds per square foot and has a specific heat of 0.26 Btu/lbs.°F. It takes 20 Btu per square foot to warm the plasterboard from its overnight temperature of 40°F to its solar-operating temperature of 100°F [(1.2 lbs./ft.²)(0.26 Btu/lbs.°F)(100°F – 40°F)]. If the sun is shining on the plasterboard at more than 200 Btu per square foot per hour, theoretically it will only take about six minutes to get the plasterboard to 100°F. (In real-world situations, it takes a little longer because there is more total wall/back roof area than there is glazed area.) You would probably not lose more than half an hour of collection time in the morning if thin plasterboard was used in the sunspace.

INSPIRING SUNSPACES

A wide range of designs are possible. Here are some examples from across the country.

Mike Pelletier's Gunnison, Colorado, sunspace was added to the south face of the house and married to the home's original architectural style. The 221-square-foot sunspace (6.5 feet wide by 34 feet long) has 270 square feet of south-facing vertical glazing. The cost of materials to build the sunspace was about \$4,500.

Pelletier and his family use the sunspace for lots of activities: house-heating, clothes drying, food drying, a climbing wall, the kids' play loft, and sunny lounging. Future plans include adding a hot air collector behind the sunroom glazing and above the awning/reflector to help boost the air temperature from the sunspace to the home's interior.

To get the warmed air to the house, Pelletier started with a thermosyphon system, but found the circulation rate disappointing—so a fan designed for a long duct system was added. It took some experimentation to get the distribution and noise levels right, but it works well now.



Courtesy Mike Pelletier (3)

"We use the propane boiler only when it's cloudy and when I'm away," Pelletier says. "Otherwise, we use a wood stove along with the sunspace. When we first moved here, we burned six cords of wood during the first winter. After doing lots of insulating and

adding the sunspace last year, we burned a bit less than two cords—and it was a cold winter. The sunspace's temperature doesn't seem much affected by the outside winter temperature, but the amount of clouds does affect its temperature—that's no surprise."



Left: The sunspace serves multiple functions beyond space heating, including clothes drying and a kids' play space.



Right: The add-on sunspace integrates well with the home's design.

MINNESOTA



260 cfm blower starts. (The small amount of thermal mass in the sunspace allows for use of a smaller-than-normal blower.) In the spring and fall, the air temperature delivered to the house can exceed 100°F. During the cold Minnesota winters when the sun is out, the air temperature from the sunspace averages about 80°F. “The fan kicks in every day when the sun is out, no matter what the temperature is outside,” says Sikora.

Cool air enters the sunspace from the house through a one-way damper. Summer overheating is reduced by opening the upper and lower access doors in the sunspace.

Sikora says that their entire heating bill for 2011–2012, which includes water heating, was \$350—very low considering their climate’s 7,981 heating degree days.

Architect William Sikora designed both stories of this 80-square-foot LTMS in Minneapolis, Minnesota, to be accessible. The upper floor can be used for sunbathing, clothes drying, wood drying, or for storing items not affected by heat. The first floor is used for storing firewood and garden equipment. Twin-wall, 8 mm polycarbonate was used for exterior glazing.

The sunspace has some thermal mass storage as evidenced by the gradual temperature drop after sunset (see “Sikora Sunspace Temperatures” table). Interior stagnation temperatures in the sunspace reach 120°F with the blower off, but interior drywall and the concrete floor provide enough thermal mass to prevent overheating in the house. The blower will run as long as the home requires heat.

Heated, filtered air from the space is conveyed into the loft of the main home via a blower fan and pushed down with ceiling fans. Simple thermostats, one in the sunspace and one inside the home, control the blower. One thermostat is located near the highest point in the sunspace, and is set to close when the sunspace approaches a usable temperature for space heating: for example, 90°F. The living space thermostat is set to close when the temperature drops below room temperature, at about 70°F. The two thermostats are wired in series with the blower, so the blower only comes on when the temperature in the sunspace is between 80°F and 90°F and the temperature in the living space is below 70°F. When both thermostats are closed, the



An inline fan equipped with a backdraft damper and air filter conveys heated, filtered air to the home’s loft via a wall-mounted grille.

Courtesy William Sikora (3)

Sikora Sunspace Temperatures: Dec. 1, 2012

| Time | House Temp. (°F)* | Sunspace Temp. (°F) | Ambient Temp. (°F) |
|---------|-------------------|---------------------|--------------------|
| 8 a.m. | 68.4 | 15.0 | 10.0 |
| 9 a.m. | 68.4 | 42.0 | 10.0 |
| 10 a.m. | 68.0 | 54.0 | 12.0 |
| 11 a.m. | 68.2 | 79.0 | 15.0 |
| 12 p.m. | 68.9 | 88.3 | 19.0 |
| 1 p.m. | 69.4 | 89.6 | 21.0 |
| 2 p.m. | 69.4 | 87.8 | 22.0 |
| 3 p.m. | 68.9 | 75.0 | 21.0 |
| 4 p.m. | 67.8 | 70.5 | 21.0 |
| 5 p.m. | 67.1 | 59.4 | 19.0 |
| 6 p.m. | 66.7 | 50.7 | 18.0 |

Blower Off Blower On

*The home’s heating system was not in use during the time these readings were taken.



On the lower level, one duct serves as the supply for the air-to-air heat exchanger.

The sunspace helps to preheat the air going into ductwork that serves as the supply for the air-to-air heat exchanger. The other duct is the dryer vent, which gives up some of its heat into the sunspace.

PENNSYLVANIA

Nick Pine is a solar designer and innovator who has been a strong proponent of LTMS systems. His three-story sunspace provides most of the heat for his otherwise difficult-to-heat 1820s home in Philadelphia, Pennsylvania.

This 384-square-foot sunspace is 12 feet deep by 32 feet long and 28 feet tall, and has an 8-by-32-foot deck that sits 16 feet above the ground. The south glazing is made from two thin sheets of clear polycarbonate with the space between filled with a low heat conductivity gas—all fabricated on site. This provides clear glazing that is efficient for solar gain and reduces heat loss—at a fraction of what double-glazed glass would cost.

Another innovative feature is the use of a mesh of two layers of 50% shade cloth just inside of the glazing. Cooler return air from the house is introduced to the space between the mesh and the glazing and spreads over the face of the mesh while flowing into it. This cools the mesh and reduces heat lost through the glazing.



Courtesy Nick Pine (3)



Left: Two layers of 50% shade cloth act as solar absorbers, with heated air channeled through them via convection.



Right: The sunspace roof is two layers of corrugated polycarbonate, with the corrugations running in opposite directions. The upper level is used for lounging, and connects to the house via a set of doors.

continued from page 74

in the south glazing. My vent doors are in all three locations, with the south ones being below the glazing. Some LTMS designs have entry doors from the outside that also serve as vents.

Other design features for summer temperature control:

- At mid-latitudes, vertical glazing receives only about half as much solar radiation in midsummer as in midwinter, so it's an automatic way to reduce summer overheating.
- An overhang above the south glazing that is sized to shade all or part of the glazing in midsummer but admit full sun during the heating season will help summer overheating (see the overhang design tool in Access).
- Shade cloth can be used over all or part of the glazing during the summer. Choose a shade cloth density that admits the amount of sun you want.

Heating on a Budget

LTMS additions can be built on very low budgets. One of the most inexpensive sunspace strategies is to erect a half hoop house (often used for greenhouses) against the south wall of the house. Glazing can be two layers of greenhouse poly with a small blower (30 cfm for a modest-sized sunspace) to inflate the space between the poly layers. This could be accomplished with a small DC blower wired to a single PV module. The floor should be covered with an insulating material—perhaps mulch or garden bark. Vents will need to be cut into the side of the house, or windows or doors can be used, as long as there's an inlet duct going down and an outlet

duct to the peak of the sunspace. This simple sunspace can have a payback of less than one heating season.

More permanent sunspaces will cost more, but will have better wintertime performance depending on air-sealing, insulation, and glazing. General payback can be difficult to figure, as sunspaces need to be customized to their application. For example, Mike Pelletier's 221-square-foot sunspace in Colorado (see "Inspiring Sunspaces" sidebar) cost \$4,500. According to PVWatts version 2, about 4.7 kWh per square meter per day fall on a vertical collector in Gunnison, Colorado, on an average winter day. Pelletier's sunspace, then, could theoretically produce 118 kWh per day [(270 ft.² ÷ 10.76 ft.²/m²)(4.7 kWh/m²)]. Even if only 40% of that energy is harvested, that would be equivalent to about 47 kWh per day. If the heating season is 4.5 months, that translates to more than 6,300 kWh per year—a savings of \$630 at \$0.10 per kWh, for a 7.1-year payback (\$4,500 ÷ \$630), plus all the other benefits of having the sunspace. Your savings will vary depending on the sunspace's efficiency, local fuel costs, heating requirements, and solar insolation.

Access

Gary Reysa (gary@BuildItSolar.com) is a retired airplane engineer living in southwestern Montana who spends way too much time on solar projects.

Build It Solar LTMS section • bit.ly/BldItSolarLTMS

Inflation blower kit for greenhouses • bit.ly/InflatFanKit

Overhang sizing tool • susdesign.com/tools.php



AUTOMAGIC BATTERY WATERING



WE MAKE WATER FROM YOUR GAS

Hydrogen and oxygen battery gas catalytically recombined into pure water and returned to each battery cell. Keeps battery topped off for extended periods of time and reduces maintenance costs. Explosive hydrogen gas is virtually eliminated from the battery area. Corrosive spray and fumes are contained and washed back into each battery cell. Electrolyte kept strong longer, extending the useful power and life of the battery. HYDROCAP Vents simply replace the battery's caps. Battery maintenance is greatly reduced. Write or call for more information.



Things that Work!

Hydrocap
CATALYST BATTERY CAPS

www.hydrocapcorp.com

305-696-2504
975 NW 95 St.
Miami, FL 33150

Statement of Ownership, Management, and Circulation. 1. Publication Title: HOME POWER 2. Publication #008-699. 3. Filing Date: 9/25/13. 4. Issue Frequency: Bimonthly. 5. No. of issues published annually: 6. 6. Annual Subscription Price: \$14.95. 7. Mailing address of known office of publication: 312 N Main St, Phoenix OR 97535. 8. Mailing Address of Headquarters or General Business Office of Publisher: 312 N Main St, Phoenix OR 97535. 9. Names and addresses of Publisher, Editor, and Managing Editor: Publisher, Richard A. Perez & Karen L. Perez, PO Box 520, Ashland OR 97520; Editor, Joe Schwartz, PO Box 520, Ashland OR 97520; Managing Editor, Claire Anderson, PO Box 520, Ashland OR 97520. 10. Owner: Home Power Inc, Ashland OR 97520; Richard & Karen Perez, Ashland OR 97520; Joe Schwartz, Phoenix OR 97535; Dale & Marilyn Hodges, Medford OR 97501, Scott & Stephanie Sayles, McMinnville OR 97128. 11. Known bondholders, mortgagees, and other security holders owning or holding 1% or more of total amount of bonds, mortgages, or other securities: None. 12. Tax Status: Has not changed during preceding 12 months. 13. Publication Title: HOME POWER. 14. Issue date for circulation data: 9/1/13.

| 15. Extent and Nature of Circulation: | No. of copies of | |
|---|---------------------------------------|---|
| | each issue during preceding 12 months | single issue published nearest to filing date |
| a. Total No. of Copies | 41,770 | 39,682 |
| b. Paid Circulation | | |
| 1) Mailed Outside-County Paid Subscriptions | 20,641 | 20,092 |
| 2) Mailed In-County Paid Subscriptions | 0 | 0 |
| 3) Paid Distribution Outside the Mail Including Sales Through Dealers and Carriers, Street Vendors, Counter Sales, and Other Non-USPS Paid Distribution | 14,212 | 13,531 |
| 4) Paid Distribution by Other Classes of Mail Through the USPS | 0 | 0 |
| c. Total Paid Distribution | 34,853 | 33,623 |
| d. Free or Nominal Rate Distribution | | |
| 1) Outside-County | 180 | 180 |
| 2) In-County | 0 | 0 |
| 3) Other Classes Mailed Through the USPS | 0 | 0 |
| 4) Distribution Outside the Mail | 1,678 | 1,785 |
| e. Total Free or Nominal Rate Distribution | 1,858 | 1,965 |
| f. Total Distribution | 36,711 | 35,588 |
| g. Copies Not Distributed | 5,059 | 4,094 |
| h. Total | 41,770 | 39,682 |
| i. Percent Paid | 94.94% | 94.48% |

16. This statement of ownership will be printed in the December/January 2014 issue of this publication.

17. I certify that the statements made by me above are true and complete. Scott M. Russell, Operations Director, 9/25/13.



SunEARTH inc.
Quality Solar Energy Products

**THINK THERMAL-
THINK SUNEARTH**



The Empire Series Liquid Flat Plate Collector

www.sunearthinc.com

SunEarth, Inc.

8425 Almeria Avenue, Fontana, CA 92335
(909) 434-3100, FAX (909) 434-3101
Distributor inquiries welcome.

Solar Financing Companies Require SunEye® Measurements

Because...

- Shade significantly reduces energy and revenue production (even with microinverters or power optimizers).
- The SunEye is the most accurate way to measure shade.
- The SunEye saves time, wins more sales, and reduces change-orders.



Solmetric® SunEye-210
Shade Measurement Tool
Fast. Accurate. Professional.

www.solmetric.com

ROGUE
POWER TECHNOLOGIES

The most advanced charge controllers
for small and midsize solar applications



MPT-3048

12/24/36/48-volt, 30-amp
Remote displays and computer interfaces available



MPT-2024

12/24-volt, 20-amp

- Very low standby power consumption
- Heavy-duty convection cooled design with no fans
- No relays in the power path
- Conformal coated
- Fast & fully automatic MPPT
- Extensive fault protection, including reverse polarity
- Displays come standard
- Internal data logging
- RS-485 communication port
- User-upgradable firmware
- 5-year warranty



www.roguepowertech.com | Made in the USA since 2009
Rogue Power Technologies | Ashland, OR 97520 | 541-621-5663

DC differential temperature controllers



3 models improve performance of
PV pumped solar thermal systems

www.ArtTecSolar.com

PAUL WHEATON'S
Wood Burning Stoves
2.0
4 DVD SET

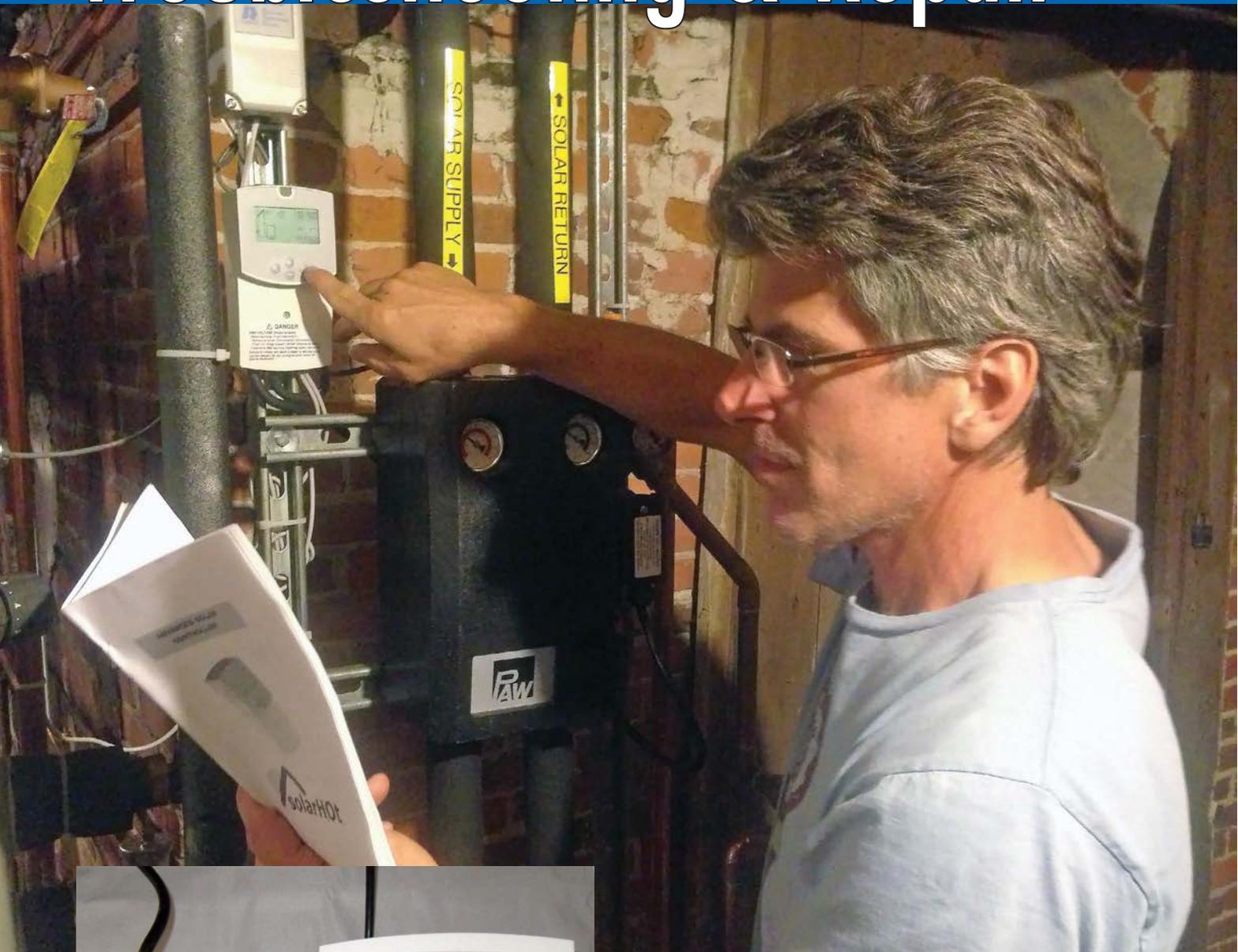
HEAT YOUR HOME
WITH ONE TENTH
THE WOOD OF A
CONVENTIONAL
WOOD STOVE!

LEARN ABOUT
ROCKET MASS HEATERS
ROCKET STOVES
POCKET ROCKETS
ROCKET HOT WATER

DVDS
• FIRE SCIENCE
• SNEAKY HEAT
• BOOM SQUISH
• HOT ROCKET

stoves2.com

Solar Water Heating System Troubleshooting & Repair



Vaughan Woodruff

Part 2: Controls, Sensors & Tanks

by Chuck Marken

Above: A solar technician adjusts the settings on a solar controller. At left: A basic 10K controller (left) has been in service for more than 30 years. LED lights show when it is powered up and when the pump(s) should be operating. A modern 1K controller (right) has digital readouts and a graphic interface.

Chuck Marken



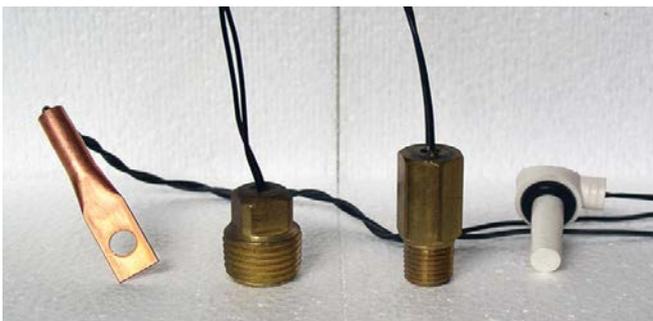
Second only to valve problems, differential controllers and their sensors have the largest failure rates of all solar water heating (SWH) components. Voltage spikes from nearby lightning strikes are blamed for many of the failures, but this is difficult to verify. Differential controls monitor two sensors: one placed at the collector outlet and one placed at the storage tank. At often-adjustable set points, the controllers turn on pumps, blowers, or motorized valves. Of the three control components, my experience is that the differential controls fail most often, with sensors next.

Controls & Sensors

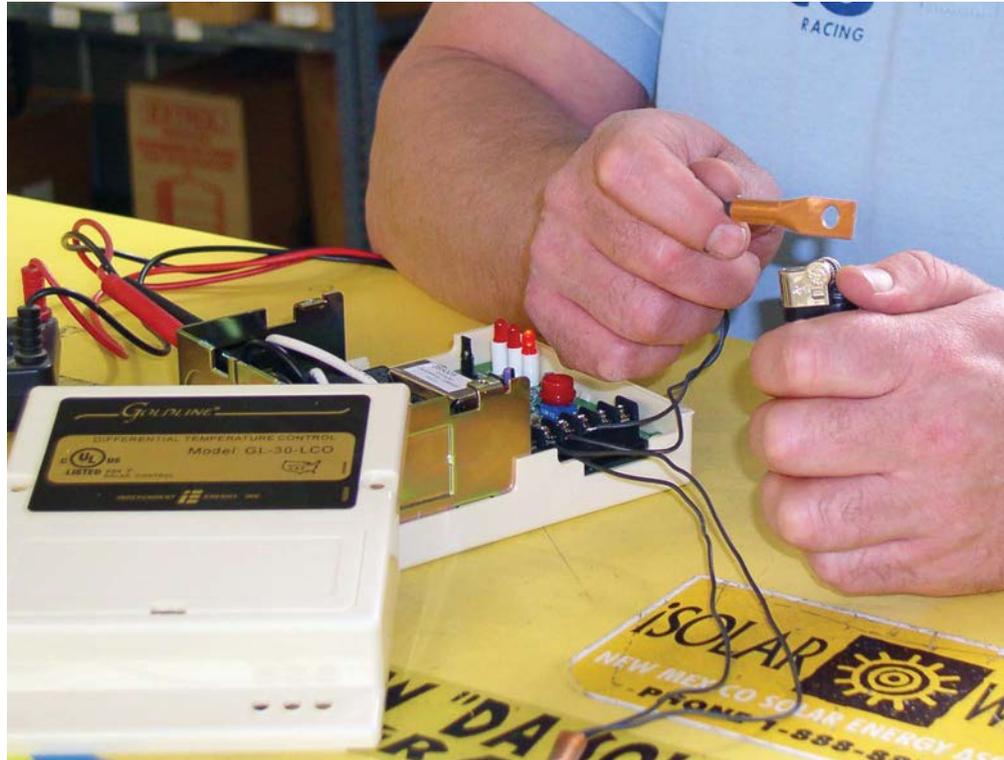
U.S.-made differential controls use “10K” sensors, an industry alias for a thermistor, which vary their resistance as temperature changes. Thermistors used in the solar industry have an inverse function: the resistance decreases as the temperature rises. Ten-K sensors have an electrical resistance of 10 K•ohms (10,000 ohms) at 77°F.

Newer to the U.S. market are European controls that use sensors known as resistance thermal devices (aka resistance temperature detector; RTD). Most use a model PT1000 sensor. RTD sensors used in solar controls are proportional devices where the resistance increases with temperature. They have a resistance of 1,000 ohms at 32°F. European controls have captured some of the market share in the United States in the last few years because they incorporate features that are popular with many consumers: digital displays; multiple inputs and outputs; and other functions, such as a vacation mode to help prevent overheating. Ten-K sensors will not function correctly in European controls and vice versa.

A variety of 10K sensors (left to right): A basic strap-on sensor with a hole for mounting on a lug; two sizes of immersion sensors; and a plastic swimming-pool control sensor. Note the O-ring on the pool sensor—it is designed to be placed in a hole drilled in the PVC piping and serve as an immersion sensor when clamped to the pipe.



Chuck Marken



Chuck Marken

Testing a 10K sensor to see if it will operate the controller.

Some controls have built-in diagnostics to detect sensor malfunctions and report them on the display. A display of sensor temperatures is also valuable for evaluating operation and flow problems. Controls that don't have digital diagnostics require a multimeter to discover which control component has a problem.

Troubleshooting. A control failure is evidenced most often by equipment (pumps, etc.) not turning on when expected. For example, a pump is expected to be energized when the collectors are exposed to bright sunshine and the tank contains cold water. A more unusual circumstance that indicates a control failure is equipment running when it is expected to be off. An example is a collector loop pump running at night.

At room temperature (72°F), a 10K sensor should give a reading of a little more than 10,000 ohms on a multimeter's resistance setting; a PT1000 will read about 1,100 ohms. A heat source is needed for testing sensors. Wrapping your hand around the sensor will work and give a slow rise in temperature. Solar technicians sometimes use a propane lighter or torch for quicker temperature changes. An ice cube can also be applied to the sensor to test that the sensor isn't stuck at a temperature. Increasing temperature will cause the resistance to drop with a 10K sensor and rise with a PT1000. A sensor that gives a reading of either zero or infinite resistance on the meter needs to be replaced.

A temperature difference of about 16°F between the collector and storage sensors usually triggers the SWH pump, blower, and/or valve to activate the system (the “on” differential). Many controls have field-adjustable differentials (although, in some cases, only the “on” setting is adjustable). Some controls have no differential adjustment.

Typical Resistance (Ohms)

| Sensor Type | -22°F | 32°F | 68°F | 140°F | 212°F | 248°F |
|-------------|---------|--------|--------|-------|-------|-------|
| 10K | 177,000 | 85,000 | 12,401 | 2,489 | 680 | 390 |
| PT1000 | 882 | 1,000 | 1,078 | 1,232 | 1,385 | 1,461 |

A control can be tested with two good sensors connected to the sensor terminals. If both sensors start at room temperature, the ON differential can be reached using body temperature to heat the collector sensor. An ice cube on the storage sensor will accomplish the same thing. If the control doesn't turn on when the differential is reached, the control is probably defective. Most controls have an ON-AUTO-OFF switch and it must be in the AUTO position for the control to function on sensor differentials.

Most solar service technicians just replace defective differential controls—they don't repair them, since a strong electronics background and difficult-to-source parts are required. If you have an older SWH system that uses a discontinued controller, you can send it away for repair by Conifer Solar Consulting (conifer-solar-consulting.com).

Troubleshooting Storage Tanks

Steel water storage tanks usually have some type of lining to inhibit corrosion. A relatively new storage tank uses polybutylene, a high-temperature plastic, for a liner, but these tanks have fairly limited history and there's little data available on any failure problems associated with them. Stainless tanks are typically more expensive than steel-lined tanks and have longer warranties and expected lifespans.



Courtesy Rheem

This Rheem Marathon tank has a seamless, blow-molded, polybutylene liner and has a limited lifetime tank warranty and a six-year parts warranty.

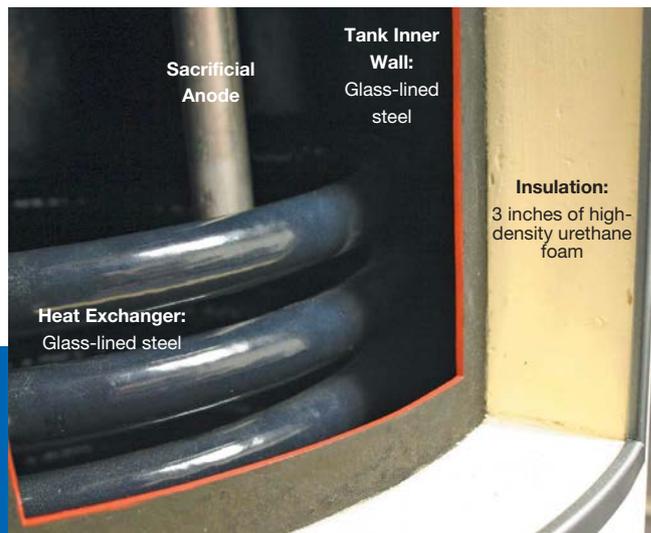


Chuck Maiken

The top sensor is a 10K•ohm sensor; the bottom two are 1 K•ohm sensors. The multimeter is set at K•ohms and reads 1.095 K•ohms when connected to the middle 1 K sensor—close to the reading for 68°F (see table at upper left).

The most common solar storage tank is a modified electric water heater. Most are constructed of steel and lined with glass, which helps minimize corrosion and keep domestic hot water clear. Even though the tank is lined with glass, hairline fractures in the lining can lead to the tank's eventual corrosion as the water reacts with the steel. The longevity of glass-lined tanks varies from 10 to 20 years depending on local water conditions. I have a storage tank in my basement installed in 1984 that is still holding water. This isn't the norm, though; in most places, steel-lined tanks have a 10-year lifespan.

A cutaway view of a Stiebel Eltron glass-lined tank with a submerged, glass-lined heat exchanger.



Courtesy Stiebel Eltron

Sacrificial Anode
Tank Inner Wall: Glass-lined steel
Insulation: 3 inches of high-density urethane foam
Heat Exchanger: Glass-lined steel

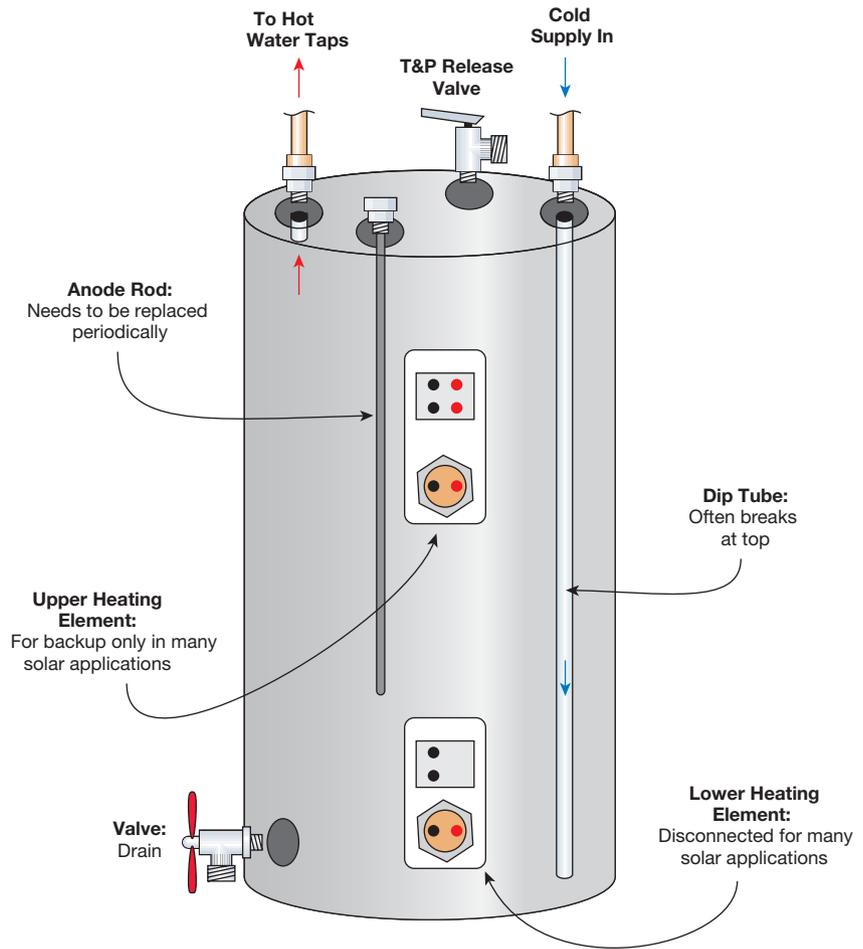
A Typical Electric Water Heater

Slowing corrosion. Water with high levels of total dissolved solids, high acidity or alkalinity, high oxygen and dissolved carbon dioxide, high levels of salts or sulfates, or corrosion-related bacteria and electrochemical corrosion will more aggressively corrode a tank's anode rod, which serves as a sacrificial metal, corroding faster than the steel in the tank. Anode rods made of magnesium or aluminum help protect water heaters and lined steel tanks against corrosion. It usually takes five to 10 years for an anode rod to sacrifice itself completely, but after it is gone, the steel tank will corrode next. Installing a new anode rod (\$30) periodically can extend a steel tank's life almost indefinitely.

Replacement anodes are available that hang under the tank's hot water connection and also flexible ones are available that can be inserted into the tank in clearance-limited spaces. Make sure you buy the correct rod type for your local water conditions. Magnesium anode rods are used in most of the United States, but aluminum rods may be installed where magnesium is a problem. A symptom of using a magnesium anode in areas where the water reacts negatively with this metal can be a sulfurous rotten egg smell and taste in the hot water.

Premium-priced tanks made with type 316 stainless steel have few problems with corrosion. They don't need anode rods for corrosion protection and are compatible with copper and steel piping and components. Tanks made with the more common 304 stainless steel can encounter problems.

Near the end of their lives, all steel tanks start leaking at welds in the ports or seams. The leaks are small to start and are first noticeable as a wet spot on the floor that never dries. These leaks worsen over time, and the only solution is replacement.



Broken dip tube. The fine print on many water heater and storage tank warranties has a disclaimer for using more than 180°F water in the tank, since most tanks have some plastic components inside that may be affected by higher water temperatures. Newer water heaters have plastic "flappers" in the inlet and outlet pipe nipples that inhibit heat loss through thermosyphoning. Another common plastic part is the dip tube that carries incoming cold water to the tank bottom from the cold pipe connection on the tank top, where the thermostat and heating element or gas burner are located. This dip tube, when aged and subjected to high water temperatures, can become brittle and break off.

When a dip tube breaks, cold water can migrate directly to the hot water output since the two connections are only a few inches apart. The symptom alerting you to a broken tube is water delivered at the tap that is hot for only a few seconds and then turns increasingly tepid, or even cold. Dip tubes are most likely to break in backup water heaters that have been subjected to years of very hot water entering the dip tube from the preheat storage tank. Removing the cold water nipple on the tank's top and pulling up the dip tube (or what's left of it) with your little finger will allow inspection. A broken tube must be replaced (about \$10).



The sacrificial anode rod (left) has served its function and is corroded. The new anode rod (right) will replace it. This type of anode is located under the water heater's hot water outlet—evidenced by the pipe fitting on top.

Expansion Tanks

Fluids—whether water or propylene glycol used in SWH systems—expand when heated, which can cause enough pressure to trigger relief valves, causing fluid loss. Expansion tanks (used in antifreeze systems) prevent this by giving the water an air space into which it can expand—but they can fail, too.

In an expansion tank, a rubber bladder separates the fluid from the air. The bladder assists in resisting corrosion of the expansion tank if the fluid contains oxygenated water, such as in a hydronic heating system. Antifreeze-based SWH systems are closed loops that contain little or no oxygenated fluid once the air has been expelled by an air relief valve, making them much less likely to corrode. But they still require an expansion tank.

Manufacturers recommend that the expansion tank air be charged to the same pressure as the liquid system. Many experienced installers charge the air side slightly less (2 to 3 psi) than the liquid, thinking that always having a little liquid in the tank will decrease the wear on the bladder touching the inside of the pipe fitting. As the liquid in the system gets hot, it fills more of the expansion tank, pushing the bladder up. A tank that's too small or severely undercharged relative to the liquid pressure upon it will show much higher readings on the pressure gauge when the liquid gets hot.

A typical SWH expansion tank is properly installed with its bladder end up.



Repair Tip

If a storage tank has an electric element and needs to be drained for component replacement or maintenance, remember to turn off the electrical breaker supplying the power to the elements. If the element inside the tank is exposed to air and energized, it will burn out and need replacement.

Drainback Tank Care

Although drainback tanks aren't typically lined, they also aren't subjected to the corrosion-causing daily exchange of oxygenated water that water heaters and storage tanks endure. An important service check with drainback tanks is ensuring the water level is sufficient to cover the exchanger coils. As with many specifications for SWH systems, a difference of opinion exists on what to use for the heat-transfer fluid (HTF) in a drainback system. My company always used tap water, but some installers use distilled water.

A drainback tank requires no maintenance.



Chuck Marken (2)

Bladder expansion tanks have a pipe fitting at one end and a Schrader valve at the other for charging with air. An expansion tank is best installed with the bladder up and the inlet down, so if the bladder leaks the air will not be introduced into the SWH system, which can stop fluid circulation and cause a pressure-relief valve to actuate, resulting in a loss of collector-loop fluid. This can require recharging the system.

In expansion tanks that are installed pipe-fitting up or sideways, failed bladders are detected by bleeding the Schrader valve with a thumbnail or small screwdriver; any liquid coming out indicates a failed bladder. A failure in an expansion tank may not be noticeable if the tank is installed with the pipe fitting on the bottom of the tank, since air is still present in the space above the water. A tank installed in this orientation is a good reason to slightly undercharge the air side of the tank.

New expansion tanks have the factory charge pressure listed on the box, typically 12 to 40 psi. Don't trust this listing when installing or replacing a tank—check the pressure with a tire gauge. A severely undercharged or undersized tank is essentially the same thing—not enough room for the system pressure changes. Installers usually charge the antifreeze

liquid pressure at 15 to 25 psi. An expansion tank with 12 psi of air is good for a SWH system charged to 15 psi if you desire a slight undercharge. Expansion tanks charged with 40 psi are typically set up for use on potable water systems with backflow preventers. The preventers are a double check-valve vented to the atmosphere that protect municipal water systems from contamination from branch lines to homes and buildings. If you're changing out an expansion tank, have a five-gallon bucket handy, since the old tank might be full of fluid.

Coming Soon

Watch for part three of this SWH troubleshooting series in an upcoming issue.

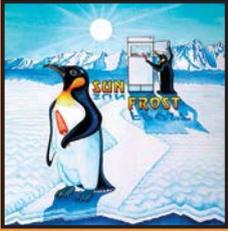
Access

Chuck Marken is a *Home Power* contributing editor and a licensed electrician, plumber/gas-fitter, and HVAC contractor who has been installing, repairing, and servicing SWH and pool systems since 1979. He has taught SWH classes and workshops throughout the United States for Sandia National Laboratories, Solar Energy International, and many other schools and nonprofit organizations.



Sun Frost

Energy Efficient Refrigerators & Freezers



- ▶ Available in DC or AC
- ▶ Select From Over 10 Models
- ▶ Available in 100's of colors, woods & stainless steel finishes

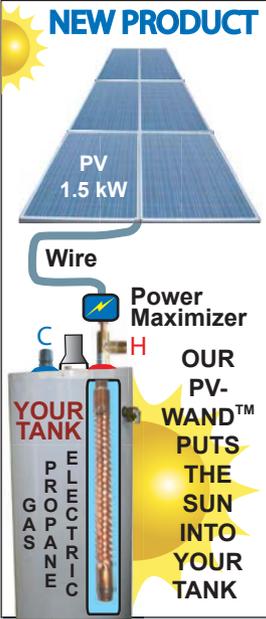
- ▶ Introducing the Sun Frost CS Composting system.
- ▶ Effectively composts Human manure & food scraps
- ▶ Low cost



P.O. Box 1101, Arcata, CA 95518
 tel: (707)822-9095 fax: (707)822-6213
 info@sunfrost.com www.sunfrost.com

Liquid-Electrons™ Hot Water Solar PV-Wand™ Hybrid Water Heater

NEW PRODUCT



OUR PV-WAND™ PUTS THE SUN INTO YOUR TANK

For DIY or Contractor Installation

- PV Off Grid Water Heater
- Low Voltage Wire Connects PV to Solar PV-Wand™ Heater
- Screws Into Your Existing Natural Gas, Propane or Electric Tank
- Power Maximizer Circuit
- Made Simple for Both PV (C-10) & Thermal (C-46) Installers
- Reliable / Maintenance-Free
- No Fluid, No Pump, No Freezing, No Overheating, No Air Locks, No Corrosion, No High Voltage
- Warranty 25 Years
- Installed Cost Below \$4,500 Before Incentives

Made in USA

Qualifies for 30% Federal Tax Credit

Butler Sun Solutions, Inc. Patent Applied For
 Solar Water Heating Appliances 858-259-8895
 www.butlersunsolutions.com

A Peek at the 2014 *NEC*—Part 1

by Brian Mehalic

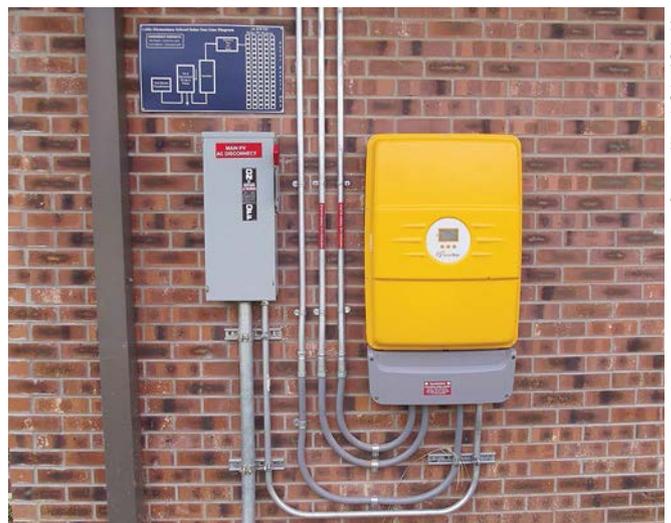
The 53rd edition of the *National Electrical Code (NEC)* is available from the National Fire Protection Association (nfpa.org). It has numerous additions and edits, and some sections have been deleted and some have been reorganized. Technological changes in the industry resulted in particular attention being given to Articles 690 and 705. Plus, there were several *Code*-wide changes. While adoption dates will vary by state and local authorities having jurisdiction (AHJs), these changes will drive new equipment availability, as well as design and installation best practices. This article provides a broad overview of just some of the changes—other changes will be subjects of future “Code Corners.”

Code-Wide Changes

The definition for “Photovoltaic (PV) System” has been moved out of Article 690 and now resides in Article 100, “Definitions.” Perhaps the move indicates that PV is now fully mainstream, and while the definition hasn’t changed, it still has big implications when it comes to disconnects or conductors sharing a raceway or junction box.

A more significant *Code*-wide change is 110.21(B), “Field-Applied Hazard Markings.” PV systems have lots of labeling requirements (see “Code Corner” in *HP154*), and now the *NEC* mandates that *Code*-required labels effectively convey the hazard, be permanently affixed, and be suitable for the environment in which they are installed. Two Informational Notes reference ANSI Z535.4-2011 standards for guidance on effective words, colors, and symbols to use based on the level of hazard, as well as location requirements and durability standards. While Informational Notes are recommendations, not enforceable requirements, following the ANSI standards as a best practice will ensure that hazards are clearly identified, ideally with labeling that will last for the system’s life.

Another *Code*-wide change is the reclassification of high voltage, as defined in Article 490, to “equipment operating at more than 1,000 volts.” This is reflected throughout numerous other Articles, such as 690, Part IX, “Systems over 1,000 Volts.” Section 690.7(C) still limits PV systems



Courtesy Hannah Solar / SolarMax

Three-phase string inverters ranging from 8 kW to 30 kW with a maximum input voltage of 1,000 VDC are becoming common in commercial applications.

for one-and two family dwellings to 600 VDC, and although 1,000 VDC systems were never prohibited on commercial buildings, those applications are now specifically excluded from the category of high-voltage systems, which will make *Code*-compliant installation more straightforward. Expect to see more 1,000 VDC systems in commercial applications as equipment manufacturers introduce more modules, inverters, and balance-of-system (BOS) components rated for this voltage. Note that workspace clearances have not changed and are still different for systems greater than 600 V [Table 110.34(A)] and systems less than or equal to 600 V [Table 110.26(A)(1)].

Article 690: Solar Photovoltaic (PV) Systems

In many cases, throughout Article 690, “photovoltaic” has been abbreviated to “PV,” which helps to shorten the text. New definitions include:

DC-to-DC Converter: A device on a DC PV circuit that can manipulate voltage and current, such as products from SolarEdge, Tigo, and others.

Direct-Current (DC) Combiner: The *Code* says that basically any devices where two or more DC inputs are paralleled to form one DC output fall into this category (including combiner boxes, and sub- or recombiners).

Multimode Inverter: An inverter that can operate in both utility-interactive and stand-alone modes, such as in grid-tied with battery backup systems or SMA America's Secure Power Supply inverters.

Section 690.4 was broadly titled "Installation," and now is more appropriately named "General Requirements." Specific sections that dealt with installation, such as "Identification and Grouping" and "Module Connection Arrangement" have been moved to "Part IV: Wiring Methods." Others, such as "Circuit Routing," have been moved and modified—changed to 690.31(G)(1), "Embedded in Building Surfaces," which no longer addresses routing inside of a building.

Protection: Ground-Fault, Arc-Fault, Overcurrent & Rapid Shutdown

New requirements for **ground-fault protection (GFP)** mandate detecting faults on intentionally grounded conductors, which some types of GFP devices cannot detect (the so-called "blind spot" in traditional GFP)—expect changes in manufacturer's inverter-integrated GFPs. New text also allows the GFP to open (disconnect) the grounded conductor for the purposes of measurement—a common startup procedure for some types of inverters and retrofit GFP systems. The grounded conductor is automatically ungrounded and then insulation resistance between positive and ground, and negative and ground, is verified each day before the inverter begins operation.

Section 690.9(A) clarifies that when properly sized circuit conductors are connected to current-limited sources, such as a PV module, PV source circuit, or a utility-interactive inverter, the potential for overcurrent comes from other sources of "significantly higher current." The intention is that **overcurrent protection** devices (OCPDs) should be placed at the source of the potential fault current. Thus, series fusing is located where multiple PV source circuits are connected in parallel in a combiner box, and the output of a utility-interactive inverter is back-fed through a circuit breaker or fused disconnect where it connects to the utility grid. Note that 690.9(D) now requires "listed PV overcurrent devices in PV source and output circuits" and that 690.9(E) clarifies that overcurrent protection is required on both the positive and negative DC conductors in ungrounded PV systems.

The requirements in section 690.11 for DC circuit **arc-fault protection** have been expanded by removal of the phrase "on or penetrating a building." This, in effect, extends the arc-fault

protection requirement to *all* systems with any DC circuits that have a maximum system voltage greater than or equal to 80 VDC.

A major shift in rooftop system design comes with the new Section 690.12, which requires the ability for **rapid shutdown** of PV systems on or in buildings. Due to firefighter concerns about energized PV system conductors inside buildings or running across rooftops, this section now requires equipment that will limit voltage between any conductors (including ground) to no more than 30 V and 240 volt-amperes within 10 seconds of initiating shutdown. This section applies to conductors that extend more than 5 feet inside a building, or extend more than 10 feet past the perimeter of the PV array. Systems with microinverters, AC modules, or DC-to-DC converters already comply, as the AC interconnection breaker provides this functionality, disabling the module-level electronics (MLEs) and isolating energized conductors to those between the module and the MLEs.

While 30 V is less than the open-circuit voltage of many modules, isolating energized PV conductors to within 10 feet of the array—even if series connections are made prior to that point—provides a compliant method for string-inverter-based systems. This strategy will require additional rooftop switching (240 volt-amperes is the equivalent of 24 V at 10 A, which could be used for a contactor control circuit for rapid shutdown of rooftop combiner boxes). Section 690.56(C) specifies the labeling requirement for rapid shutdown systems; note that the equipment used must be listed and identified [690.12(5)], though the *Code* does not state that the equipment must be explicitly listed for the purpose of rapid shutdown of PV systems.

Disconnects

Section 690.15(C) now requires load-break-rated disconnects on the DC output of combiner boxes mounted on roofs. These disconnects can either be integrated into the combiner box or be an external switch not more than 6 feet away from the combiner box. The disconnecting means can be remote-controlled (such as a contactor, which could also help meet rapid shutdown requirements), but must also be manually operable at the combiner box location. Along with rapid shutdown requirements, this will make it less likely for installers to run multiple PV source circuits from a roof-mounted array to a string inverter at ground level. A combiner box, which will provide means to quickly isolate the array, along with disconnecting means, will become the standard for roof-mounted systems, most likely with a contactor that can be operated either from the ground or locally on the roof.

Access

Brian Mehalic (brian@solarenergy.org) is a NABCEP-certified PV professional and ISPQ-certified PV instructor. He has experience designing, installing, servicing, and inspecting all types and sizes of PV systems. He is a curriculum developer and instructor for Solar Energy International.



Pig + Women + Knives



by Kathleen Jarschke-Schultze

One morning last May, my sister Mary called, very excited. “We have to take this class,” she insisted. “It’ll be fun.” She was talking about a class at the Fatted Calf butchery in Napa, California, offered by women and for women, on carving up a pig carcass. And that is how I found myself with my sisters Mary and Tamra in Bay Area charcuterie and meat expert Heather Bailie’s class, “Pig + Woman + Knife.”

Primal Cuts

We prepped our wardrobe for the class weeks in advance. Mary sewed some white cotton canvas aprons, and I designed an image to decorate the front: a picture of a hog, divided into the primal cuts; the word “woman” underneath that, in a nice font; and beneath that, a butcher knife illustration. I researched and found the United States Department of Agriculture stamp for hog carcasses, so I added that in a lavender color, along with our names. We were ready.

I saw this class as a steppingstone to my goal of raising and butchering pastured pork, since it would teach us basic butchering techniques. With this knowledge, my sisters could help me butcher my hogs when that time came.

We gathered and drove to Napa, our hometown. Arriving at the Fatted Calf, we were led into the back where, on several stainless steel worktables, lay three halves of pasture-raised pigs.

I was kind of disappointed that the heads were not included. One of my father’s childhood memories is helping my grandfather make headcheese on their homestead in Manitoba, Canada. When my husband Bob-O and I raise

our pastured pigs, we will be doing *all* of the butchering ourselves. The more I know, the better.

It was a small class, there were only six of us. One woman was already a chef at a Bay Area restaurant, another was a homesteader, and one was, like us, looking forward to future pigs. We gathered around an intact carcass at the first table.

Bailie, our teacher/butcher, faced us over the hog. She gave us a quick rundown on knife safety and then launched into carcass deconstruction instructions. As she carved, she discussed the seven primal cuts: the butt or Boston butt, picnic ham, loin, ribs, belly (bacon!), hocks, and trotters. We were all enthralled at the grace and efficiency of the cuts. Right then, I wanted to be a butcher.

After the different cuts were separated and identified, and all of our questions answered, Bailie placed all the cuts back into their original position. Once again, we could see the whole side of the hog, but now we knew the cuts and could see where they came from.

Subprimal

We divided into two groups of three and took a hog side. We each took turns making the various primal cuts. It did not take long for us to break down the two hog sides.

We also worked on several subprimal cuts. Not all of us did the same thing. We each were given a task, and when we finished that we could try something else. From Peter, Bailie’s teaching assistant, Mary learned how to trim the fat from the skin. I wanted to try trimming the fat, so I got a turn at that, too.

It's not as easy as it looks. Peter showed Mary how to cut a small slit—about two finger-widths—in the top edge of the hide. By hooking in your fingers there, you can get a good grip on the fat-covered piece. When my turn came, I held the hide up and tried to wield my very sharp knife smoothly along the line of fat to be rendered into lard. Obviously, this is a skill that benefits from repetition and technique.

I wryly thought to myself, "Geez, I'm butchering this job!" Then I thought, "If I was really butchering this job, I would be doing it right!" I have a deep and newfound respect for butchers.

Mary and I were cutting some very big loin chops while Tamra was removing a kneecap at another table. Tamra looked up at Peter and said, "This kneecap is kind of creepy." Peter agreed, "Yes, it is."

After each of us had cut a chop, we placed them on a large tray and seasoned the meat with an array of seasonings—rosemary, lemon zest, and fennel pollen.

Charcuterie

A counter—with a pitcher of ice water, glasses, and a tray of Fatted Calf charcuterie to tempt us—bridged the shop front and the classroom. With a basket of sliced rustic bread from Model Bakery next door and a small bowl of cabbage pickle, our nosh was complete. Salami, mortadella, and prosciutto were the meats I could identify. As we finished one type of preserved meat, another variety would magically appear on the tray. Next to the counter was a hand-washing station, so it was easy to clean up, take a swig of water, and sample the thinly sliced meaty goodness.

Once we were done with the sharp knives, they brought out the wine. We sipped and learned how to use the cuts we had mastered. We made spicy pork crépinettes—little herbed sausage patties wrapped in the lacy caul fat that surrounds pig organs. The caul fat was really pretty. We joked about using it as a pattern for crocheting a caul shawl.

We learned how to tie a roast by practicing on a porchetta—a pork loin and belly roulade seasoned with garlic, lemon, fennel, and rosemary. Again, this is a skill that is harder to master than it looks. We figured that they retied the roasts as soon as we left.

After washing up, we were ushered to some picnic tables outside the shop where our lunch had been set up. The food was scrumptious. We talked and exchanged e-mail addresses so we could share our photos from the day.

Upon re-entering the Fatted Calf, we each found a bag with our name on it waiting for us at the counter. Our large, seasoned chop was in there, along with a couple of the crépinettes and some seasoned, skewered pork we also made.

A Taste of Salt

The next step for me will be the salumi (salted meats) class at the Fatted Calf. I yearn to be able to produce the kind of preserved meats I was eating off that tray. Meat curing is a skill—and an art.

I am fascinated with the concept of preserving food without relying on electricity. It's no wonder—living beyond the grasp of the power lines makes Bob-O and me very conscious of every bit of energy we use. Plus, people have been preserving food without using electricity for centuries. We have worked out some hygienic kinks along the way, making some techniques safer. But for the most part, this is a well-traveled road. And I'm looking forward to the meal stops along the way.

Access

Kathleen Jarschke-Schultze (kathleen.jarschke-schultze@homepower.com) is finishing up the grand dried bean experiment at her off-grid home in northernmost California.



Keep Cool. Efficiently.

12/24 Volt energy efficient refrigerators and freezers with AC option

Average power from 5 watts

Extra thick polyurethane insulation for greater efficiency

Awarded NASA Invention of the Year - 2011

915.821.0042 ■ El Paso, Texas

DC Powered Refrigeration
SunDanzer.com



The Power Tower - The Ultimate Energy Harvesting Platform
 Easy, safe, winch operable, folding, hybrid tower, for, or with, wind turbines and arrays up to 5kW each. USA made. Learn more, call (303) 443 - 0115, or visit solarips.com/towers.



RightHand Engineering, LLC
 Experts in **Renewable Energy Monitoring:**

- Non-recurring fees
- Residential
- Community Kiosks
- Multi-site Telecom
- On & Off Grid
- Display, Log, Alarm
- WinVerter Software
- Custom Solutions
- Consulting
- On-Site Displays
- Internet Accessible

www.RightHandEng.com
(425) 844-1291

HYDROSCREEN CO. LLC

Precision Wedge Wire Coanda Screens

- Self Cleaning
- Easy Installation
- High Capacity
- No moving parts
- Pipe, ramp and box mountings

Hydro, Agricultural, & Domestic Diversions from 10 gpm to 500 cfs

Visit us at **www.hydroscreen.com** or call **(303) 333-6071** e-mail **RKWEIR@AOL.COM**

We don't just sell screens, we engineer solutions!

ROGUE POWER TECHNOLOGIES

The most advanced charge controllers for small and midsize solar applications

- Very low standby power consumption
- Heavy-duty convection cooled design with no fans
- No relays in the power path
- Conformal coated
- Fast & fully automatic MPPT
- Extensive fault protection, including reverse polarity
- Displays come standard
- Internal data logging
- RS-485 communication port
- User-upgradable firmware
- 5-year warranty

MPT-3048 12/24/36/48-volt, 30-amp
 MPT-2024 12/24-volt, 20-amp

Remote displays and computer interfaces available

www.roguepowertech.com | Made in the USA since 2009
 Rogue Power Technologies | Ashland, OR 97520 | 541-621-5663

Applied Thermodynamics
 WE PROVIDE DESIGN AND CONSULTING SERVICES

Specialites

- High Efficiency Heat Exchangers
- Close Approach Heat Exchangers
- Heat Engines
- Waste Heat Recovery
- Renewable Energy Systems
- Thermodynamic Process Design
- Refrigeration Systems
- Chillers
- Heat Recycling

GARY P. HOFFMAN
 Engineering Consulting
www.appliedthermodynamics.com
 P.O.Box 5
 Rushville, New York
 14544-0005
 1-585-615-4170 Office

Email: **garyhoffman@appliedthermodynamics.com**

RAE STORAGE BATTERY
 ESTABLISHED 1945

Authorized **Rolls** Battery Dealer
www.raestoragebattery.com

Renewable energy does not mean continuous energy. Therefore, you must have dependable, reliable batteries...

Rolls, the World's Best.

- Unsurpassed cycling
- Industry's largest liquid reserve
- 10 & 15 year average life span
- 7 & 10 year warranties*

*4000 Series - 7 yr warranty / 5000 Series - 10 yr warranty

Phone 860.828.6007 Fax 860.828.4540 POB 8005 Berlin, CT 06037

Hassle-free Hydro Power

BRUSHLESS since 1982
 HARDENED STAINLESS RUNNER
 BATTERIES OR GRID-TIE
 NO ADJUSTMENTS
 Head Range: 30'-500'
 Power Range: DC Direct: 400-1500W
 AC/DC Units: 1.2KW-4KW
 Transmission Volts: DC Units: 12-120V
 AC Units: 240 or 440VAC
 DC/DC Converters & MPPTs now available

HYDRO INDUCTION POWER

www.hipowerhydro.com 707-923-3507 **hipower@asis.com**

User Friendly Hydro Power

Alternative Power & Machine
 Now Featuring Permanent Magnet Alternators

4040 Highland Ave. Unit #H • Grants Pass, OR 97526 • 541-476-8916
altpower@grantspass.com
www.apmhydro.com

| | | |
|----------------------------------|------------------------------------|----------------------------------|
| AlIEarth Renewables BC | Independent Power Systems ...90 | SMA America11 |
| altE Store.....3 | IOTA Engineering.....52 | Solar Data Systems.....12 |
| Alternative Power & Machine...90 | IronRidge.....40 | Solar Pathfinder.....91 |
| Apex Solar.....32 | Magnum Energy 8/9 | SolarWorld17 |
| Applied Thermodynamics.....90 | MidNite Solar2 | Solectria Renewables21 |
| Array Technologies33 | MK Battery19 | Solmetric79 |
| ART TEC79 | NABCEP25 | Splash Monitoring61 |
| Backwoods Solar14 | NAFTC60 | Statement of Ownership.....78 |
| Battery Life Saver69 | Northern Arizona Wind & Sun...61 | Stationary Power Systems53 |
| Bogart Engineering22 | ONTILITY23 | Sun Frost.....85 |
| Butler Sun Solutions.....85 | Power Spout61 | SunDanzer.....52,89 |
| Chint Power1 | Qlog69 | SunEarth.....79 |
| Energy Systems & Design.....68 | Quick Mount PV.....7 | SunXtenderIFC |
| groSolar.....51 | RAE Storage Battery90 | Trojan Battery31 |
| Harris Hydro.....52 | Real Goods Solar.....69 | U.S. Battery13 |
| HuP Solar-One.....41 | RightHand Engineering.....90 | US Solar Distributing.....15 |
| Hydro Induction Power90 | Rogue Power Tech.....79,90 | Wood Burning Stoves 2.079 |
| Hydrocap.....78 | Rolls Battery Engineering..... IBC | Zomeworks91 |
| Hydroscreen.....90 | Schneider Electric29 | |



Telecommunications
Cathodic Protection
Transportation
Military
Oil and Gas
Security
Railroad
Residential
Commercial
Industrial
Disaster Relief

Whatever your market, ZOMEWORKS can design an Integrated System featuring reliable Cool Cell® Enclosures to meet your needs.
800-279-6342
zomeworks.com



New Software!

- Allows user to copy design and compare results immediately
- Printable report showing the comparison between designs
- Panels can be placed directly on the roof property section
- User can compare up to 4 designs at the same time
- Provides color-coded solar insolation map on roof
- Design Roof Properties and Input Dimensions

SolarPathfinder PV Studio™

Download a Free 30 day trial today! Just visit..
WWW.SOLARPATHFINDER.COM/SPV



Prescriptions for Efficient Windows

If you're shopping for windows, look to the National Fenestration Rating Council's (NFRC) label, which appears on all Energy Star window products. Much like the miles-per-gallon sticker on a new car, the label gives information on how well a window will perform.

The NFRC tests the full window—glass, frame, spacers, and any other component that is a permanent part of the product—providing an accurate reflection of how the product will perform. But the NFRC label can help only if you understand the ratings.

U-factor denotes the rate of heat transfer through the window unit. U-factor values generally range from 0.25 to 1.25, and the lower the number, the better the window resists heat transfer. For northern climates (see map and table), Energy Star recommends a U-factor of 0.30 or below for most window orientations and a maximum of 0.60 for windows in southern climates. Passive House Institute US (PHIUS) has more stringent recommendations to help reach overall energy savings of 60% to 70% and space-heating savings of 90%, compared to a conventionally energy-code-compliant, 2-by-4 stud-framed home. For example, PHIUS recommendations for northern climates (ASHRAE zones 4 through 8) range from a U-factor of 0.11 or less (zone 8) to 0.15 or less (zone 4).

Solar heat gain coefficient (SHGC)—A window's SHGC signifies how much heat from the sun is blocked. SHGC values typically range from 0.25 to 0.80; the lower the SHGC, the more the product blocks solar heat gain. South-facing windows in passive solar homes should have the *highest* SHGC possible, while still having an acceptable U-factor (see

Energy Star Qualification Criteria for Residential Windows

| Climate Zone | U-Factor* | SHGC** | |
|---------------|-----------|--------|-------------------------------|
| Northern | ≤ 0.30 | Any | Prescriptive |
| | = 0.31 | ≤ 0.35 | Equivalent Energy Performance |
| | = 0.32 | ≤ 0.40 | |
| North central | ≤ 0.32 | ≤ 0.40 | |
| South central | ≤ 0.35 | ≤ 0.30 | |
| Southern | ≤ 0.60 | ≤ 0.27 | |

*Btu/hr.-ft.².-°F; **Fraction of incident solar radiation

"Energy Star Qualification Criteria for Residential Windows" table"). In most climates, west-facing windows need to have the lowest SHGCs to prevent heat from the summer sun from entering the home. PHIUS calls for SHGCs of 0.50 or greater for south-facing glass in climate zones 3 through 8.

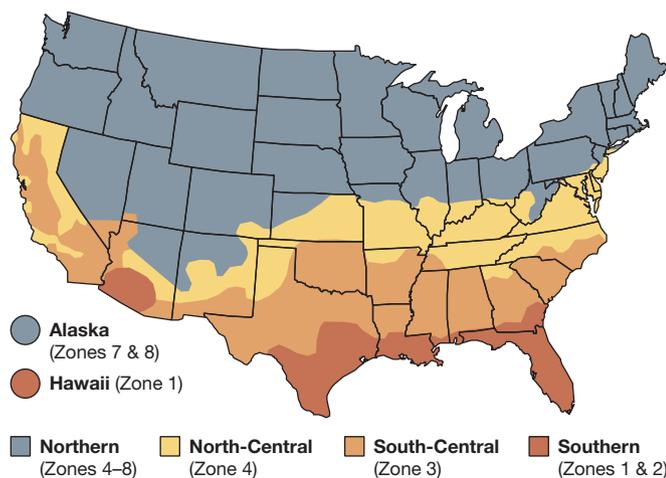
Visible transmittance (VT) is the measure of how much light comes through a door or window. A number between 0 and 1, the higher the VT, the more light is transmitted. Multiple coatings on glass and suspended films between panes will enhance the unit's efficiency, but can affect a window's VT. Windows with a high VT appear relatively clear and provide sufficient daylight and unaltered views; however, they can create glare. For daylighting, choose a VT between 0.5 and 0.7 for good glare control, especially with larger windows.

Air leakage (AL) indicates the rate at which air passes through joints in the window unit. AL rates typically fall between 0.1 and 0.3 cubic feet of air per 1 square foot of window per minute. The lower the AL value, the more airtight a product is. Most industry standards and building codes specify an AL of 0.3 cfm per square foot or less. Providing the AL rating is optional for manufacturers.

Condensation resistance (CR) is how well the window resists water buildup. CR is scored on a scale from 0 to 100. The higher the CR factor, the better a product is able to resist condensation. CR is another NFRC-optional rating.

—Compiled by Kelly Davidson

Energy Star Climate Zone* Map



*ASHRAE/PHIUS climate zones listed in parentheses

web extra

Use the Window Selection Tool at efficientwindows.org to help find energy-efficient windows for your home.



**OUR
BATTERIES
PASS THE
TOUGHEST
INDEPENDENT
TEST:**

After 18 plus years in the Renewable Energy industry, I've seen many brands of batteries just not cut it in the off-grid world. With multiple banks of Rolls batteries running for 10 years or more with very little wear for their age, despite occasional customer neglect, many are still going strong today. When it comes to reliability I can't imagine using any other brand.

Christopher Schaefer, SOLAR & WIND FX INC.

**OUR
CUSTOMERS.**



Rolls
BATTERY ENGINEERING

see more of
what actual customers
think at rollsbattery.com

THE BEST OFF-GRID BATTERY FOR OVER 25 YEARS

“RELIABLE, EASY TO INSTALL AND MY CUSTOMERS LOVE THEM”

Rich Nicol - owner of Solartech, an AllSun Tracker installation partner

Rich represents a growing team of solar entrepreneurs who have discovered the AllSun Tracker complete system advantage for installations large and small. “We now spend less time on system design and more time on sales and installation, which has truly transformed the way we do business.”



As the nation’s leading solar tracker company, we are committed to using our experience to help you grow your business and grow your profits. Our one-day lead time, one-pallet shipment, one-day installation, free ground shipping and free online monitoring will help you complete more jobs, finish jobs faster, and eliminate hassle.

AllSun
TRACKERS™



ALLSUN TRACKERS
premier
PARTNER

Join our growing team of dealer partners who offer our dual-axis tracker systems to their residential and commercial customers. To find out more, track us down at www.allsuntrackers.com.

To learn more, call (802) 872.9600 or email info@allearthrenewables.com