

SINCE  
1987

TOP RACKING SOLUTIONS FOR PITCHED-ROOF SOLAR ARRAYS

# home power

SOLAR ▶ WIND ▶ HYDRO ▶ DESIGN ▶ BUILD

## THE 2014 WIND ISSUE

TURBINE  
BUYER'S GUIDE

WIND ENERGY  
PHYSICS

CHOOSE  
THE RIGHT  
TOWER

Plus:  
Battery Care  
& Maintenance



June & July 2014, Issue 161  
 \$5.95 US • \$5.95 CAN  
 0 74470 78082 3 0 6 >  
 homepower.com



*making renewable do-able™  
for over 15 years!*

## COMPETITIVE PRICING - SOLAR FOR DIY - TECHNICAL DESIGN

**QUIET OPERATION!**  
Primus Windpower  
Air40 Turbine



**FOR SOLAR & WIND!**  
MidNite Solar Classic  
MPPT Charge Controller

**FREE SHIPPING!**  
Magnum 2000W 12V  
Pure Sine Wave Inverter



**25 YEAR WARRANTY!**  
SolarWorld 275W  
Mono Solar Panel

**GREATER CYCLE LIFE!**  
Trojan T-105-RE  
Premium Flooded Battery



\*Products advertised are made in USA!

**PLUS** 1000's additional Solar & Wind products online at [www.altEstore.com](http://www.altEstore.com)

altE® Store provides you the products, tools, education, expertise and the technical service you need to safely and successfully put together your own system. Let us help you make renewable do-able!

**EXTRA DISCOUNT!**  
Mention code:  
**HP161**  
when you order today!

Call us at **800.320.9458** or **978.562.5858**  
or visit us online at [www.altEstore.com](http://www.altEstore.com)



Offering You Quality Brands Such As...

# 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

# Looking For A Great 30 AMP MPPT Charge Controller?



**MidNite Solar's**

# **THE KID**

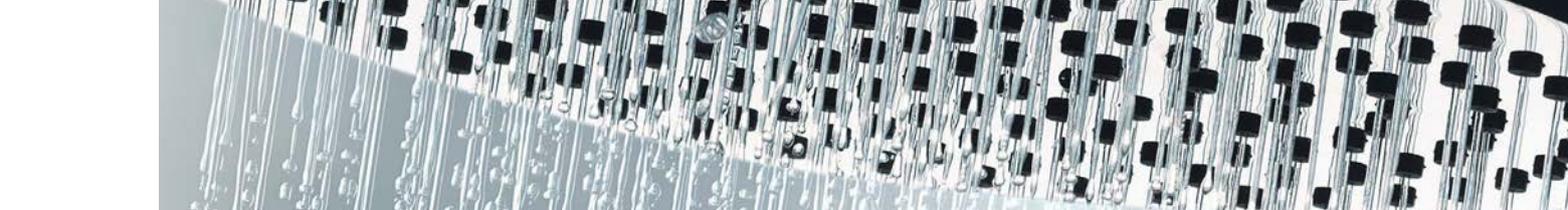
*By Mario*

**Made In The USA**

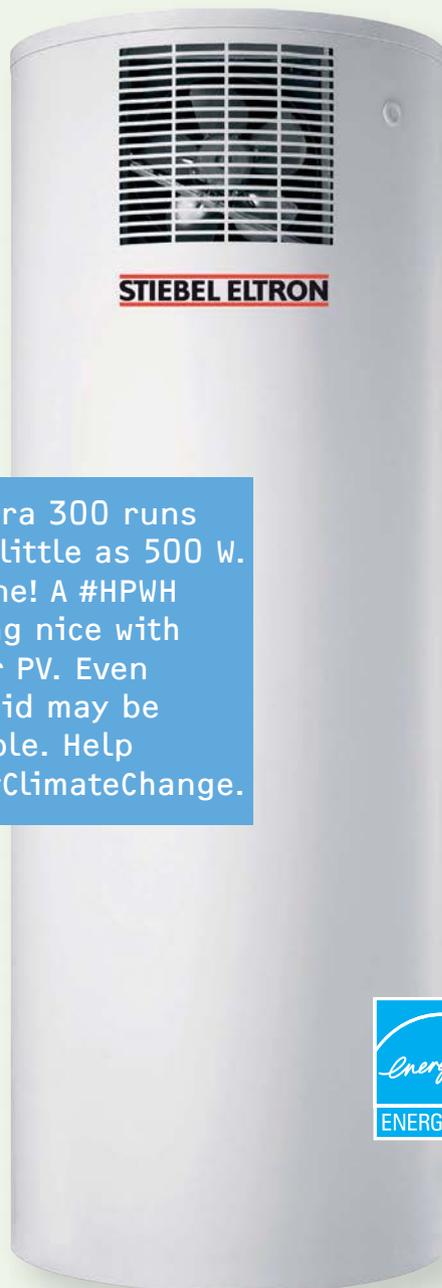


[www.midnitesolar.com](http://www.midnitesolar.com)

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



This is not a “hybrid.”



**STIEBEL ELTRON**



Accelera 300 runs on as little as 500 W. Imagine! A #HPWH playing nice with #Solar PV. Even off-grid may be possible. Help stop #ClimateChange.



We decided 30 years ago that the world needed heat pump water heaters, not “hybrids.” The difference is simple in concept, but execution must be difficult, since we’re the only true heat pump water heater available in the U.S.A.

We rely on the heat pump to make water, not on the back-up element. That’s why our engineers used only one element, and it’s at the top of the tank, ensuring hot water during high demand but keeping energy costs minimal; why our extremely large condenser wraps around the bottom outside of the tank; why our tank is 80 gallons; and why we made many other engineering decisions.

We don’t call it a “hybrid.” It’s not. It’s a heat pump water heater.

- › Designed for low operating cost, large storage capacity, high first-hour rating, and reliability
- › Made in Germany
- › Designed to be efficient in a wide operating temperature range with a COP typically between 3–6
- › 50 gallons of 140°F water can be drawn before activation of single 1700 W back-up element
- › 240 VAC, 15 A circuit breaker
- › The largest seller in Europe for 30 years

**STIEBEL ELTRON**

**Simply the Best**

800.582.8423

www.stiebel-eltron-usa.com



34

## Main Features

### 34 **wind** turbines

**Ian Woofenden & Roy Butler**

Find out which wind turbines are best for your site.

### 44 **PV** mounts

**Jeff Tobe**

What you need to know to choose a PV roof-mounting system that is appropriate for your home.

### 52 **battery** maintenance

**Carol Weis & Christopher Freitas**

Regular care of your RE system's batteries will help ensure that they can provide years of high performance.

## 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](http://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](http://twitter.com/homepowermag)



### Share us everywhere!

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

### Events & Training

Search, browse, or post an RE event or training in your area. [homepower.com/events](http://homepower.com/events)

### Contractors Directory

Search more than 1,000 local service providers to help with your project. [homepower.com/contractors](http://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](http://homepower.com/subscribe)

## On the Cover

**Jenny Heinzen and Clay Sterling install a vintage Jacobs Wind Electric Co. wind turbine at the Midwest Renewable Energy Association's headquarters.**

Photo by Amiee Wetmore/MREA

52

Photos: Courtesy Bergey Windpower; whattookusolong.org for USAID (2); Courtesy Quick Mount PV; Vaughan Woodruff (2)

44



## Up Front

- 6 **from the crew**  
*Home Power crew*  
Shedding some light on conservation & efficiency
- 10 **news & notes**  
**Kelly Davidson**  
Solar vets
- 14 **media**  
**Kelly Davidson**  
Enervee appliance guide
- 16 **events**  
Renewable energy fairs
- 18 **gear**  
**IronRidge**  
Integrated grounding & FlashFoot  
**OutBack Power**  
Radian inverters
- 20 **returns**  
**Kelly Davidson**  
Operation Free
- 22 **solutions**  
**Brent Summerville**  
Campus wind power
- 24 **methods**  
**Roy Butler**  
Choosing a turbine tower
- 26 **mailbox**  
*Home Power readers*
- 28 **ask the experts**  
**RE industry pros**  
Renewable energy Q & A

70



60



66

## More Features

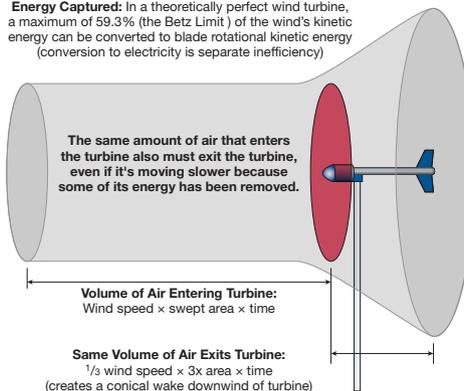
- 60 **infrared** cameras  
**Vaughan Woodruff**  
How to diagnose solar water heating collector problems with an infrared camera.
- 66 **SG** measurement  
**Christopher Freitas**  
Measuring specific gravity can give you valuable insight into your battery's health.
- 70 **wind** physics  
**David Laino**  
The science behind capturing wind energy with a turbine.



## In Back

- 76 **code corner**  
**Ryan Mayfield**  
PV overcurrent protection
- 80 **home & heart**  
**Kathleen Jarschke-Schultze**  
Out to pasture
- 83 **advertisers index**
- 84 **back page basics**  
**Mick Sagrillo**  
Wind resource

**Energy Captured:** In a theoretically perfect wind turbine, a maximum of 59.3% (the Betz Limit) of the wind's kinetic energy can be converted to blade rotational kinetic energy (conversion to electricity is separate inefficiency)



# The Lights Are On

## When Nobody's Home

© istockphoto.com/ phototropic

In my house and at my workplace, renewable energy (RE), energy efficiency, and conservation are naturally part of my everyday conversations. As a *Home Power* reader, they are likely part of your life, too. So it's easy for us to fall into the trap of thinking that they are also parts of everyone else's life.

Unfortunately, they're often not. Unless we live next door to a power plant, a fracking operation, or a mountaintop removal site, many of us still remain divorced from the sources of energy that power our lives. We rely on the electricity that flows to our sockets, but it remains largely invisible. Some count on the natural gas or propane that is piped to their ranges, but never think to trace it back to its origin. Tons of atmospheric carbon dioxide? Too nebulous. And what about conservation and negawatts—the amount of power that need not be produced as a result of efficiency and conservation?

As part of his work for a local solar installation company, my husband Shawn routinely performs residential solar site surveys. His daily work gives him an inside look at people's energy consumption habits, and it's shocking for me to hear his stories. Monthly energy bills in the \$300 to \$400 range are common, and folks just "don't know *what* to do" to reduce their bills. They want to "go solar," and then are shocked when they are presented with the size (and high price!) of a PV system required to offset excessive electricity use—while banks of lights blaze, two big-screen TVs chatter, and a stereo blares in the background.

Renewable energy is exciting to people—and somehow it's easier to understand how to produce electricity than to reduce our consumption of it. So what can we do to make sure the other "big two"—efficiency and conservation—work their way into our collective consciousness?

You can be a beacon of change to influence your friends, family, and coworkers. Here are just a few ideas:

- **Shine some light on the impacts of energy use.** Enter a ZIP code, and the U.S. EPA's Power Profiler ([bit.ly/EPAProfiler](http://bit.ly/EPAProfiler)) shows where the region's grid electricity comes from, how it's generated, and how much pollution it produces.
- **Share information on practical ways to improve household energy-efficiency and conservation strategies.** Share *Home Power* and direct folks to the wealth of free information on our website. Visit the Energy Star and Enervee websites (see "Media" in this issue) to find more energy-efficient appliances.
- **Join the solar revolution.** Have a solar home? Volunteer to host tours through your local Green Drinks group or Tour of Solar Homes. Have kids? Let them participate in making their own solar ovens or set up a home energy monitoring system.
- **Shed some light on the Joneses.** A healthy dose of competition can provide a powerful motivation for change. Promote a neighborhood greening to see "how low you can go."

—Claire Anderson, for the *Home Power* crew

### Think About It...

*"You may never know what results come of your action, but if you do nothing there will be no result."*

—Mahatma Gandhi



## UNO 7.6kW / 8.6kW. The inverter that thinks it's two inverters.



With more flexibility than any other string inverter on the market, UNO-7.6 and 8.6 is the only high power residential inverter with dual MPPT channels to support installations at multiple orientations – increasing the energy harvest from today's diverse residential roofs. The UNO is built to last with low maintenance natural convection cooling, NEMA 4X enclosure rating, capability for remote firmware upgrade and optional WiFi monitoring to easily track the system performance. Designed with future utility requirements in mind, the UNO includes the California Rule 21 features: reactive power control, active power curtailment and customizable voltage and frequency trip settings. The UNO-7.6 and 8.6 lets you offer your customers a lot more system for a lot less cost.

For more information please visit: [www.abb.com/solarinverters](http://www.abb.com/solarinverters)

# 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](http://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**

*Associate Editor* **Kelly Davidson**

*Graphic Artist* **Dave Emrich**

*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](http://homepower.com)



[facebook.com/homepower](https://facebook.com/homepower)



[twitter.com/homepowermag](https://twitter.com/homepowermag)

## Subscriptions

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

800-707-6585 or 541-512-0201

[subscription@homepower.com](mailto:subscription@homepower.com)

[homepower.com/subscribe](http://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](http://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](mailto:submissions@homepower.com)

[homepower.com/writing](http://homepower.com/writing)

## Website

[homepower.com](http://homepower.com)

Send your comments regarding the site to:

[web@homepower.com](mailto:web@homepower.com)

## Ask the Experts

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

[asktheexperts@homepower.com](mailto:asktheexperts@homepower.com)

## Letters to the Editor

Email your comments and suggestions to us at:

[mailbox@homepower.com](mailto:mailbox@homepower.com)

or write to the address above.

## Marketing

Promotional opportunities and offers:

[marketing@homepower.com](mailto:marketing@homepower.com)

## Advertising

For inquiries and information related to advertising in *Home Power* or on [homepower.com](http://homepower.com):

**Western States:**

[connie.said@homepower.com](mailto:connie.said@homepower.com)

541-326-5773

**Eastern States:**

[kim.bowker@homepower.com](mailto:kim.bowker@homepower.com)

541-858-1791

[homepower.com/advertising](http://homepower.com/advertising)

©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.



**Repair costs  
getting too  
expensive?**

## **Maybe it's time to replace your inverter.**

If repair costs on your existing Sine Wave inverter are getting too expensive, it might be time to replace it with a new MSH-RE Inverter/Charger from Magnum Energy. The MSH-RE (MSH4024RE) combines the tried and tested engineering of Magnum's MS line with hybrid technology that make it an optimal choice for your renewable and backup power needs.

### **MSH-RE Series Hybrid Technology:**

Most inverters only use one source of energy to power loads, either from incoming AC power – utility or AC generator – or from the batteries. The MSH-RE Series combines the energy from both sources to power loads. This allows the inverter to recharge the batteries when there is surplus power or deliver more power to the loads if they require more than the AC input can supply by itself.

### **MSH-RE Inverter/Charger Features:**

- 120 VAC 60 Hz output
- Two 60 amp AC inputs:  
Grid input at 60A  
Generator input at 60A
- Load Support parallels the inverter output with incoming AC sources allowing it to run larger loads from smaller generators
- Works with any Magnum accessory, including the AGS, remotes, and the Magnum router.



See the **MSH-RE Series** in person at The Energy Fair, June 20-22 **Booth A11**, Custer, Wisconsin

To learn more about Magnum products visit [www.magnumenergy.com](http://www.magnumenergy.com)

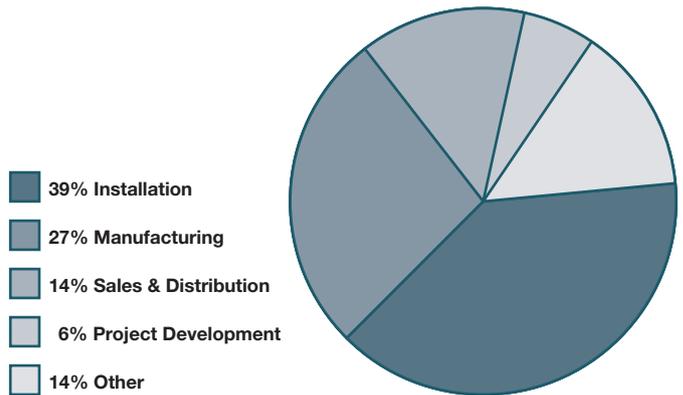
**MAGNUM**  
E N E R G Y

# Solar Vets

After serving in Afghanistan, U.S. Navy Reserve lieutenant Nat Kreamer returned home in 2006 determined to help build the nation's renewable energy (RE) economy. "Veterans like me know firsthand that more clean, affordable, and domestic energy makes America and the world safer. We've been on the front lines of a natural resources war, and we know what sacrifices our current energy landscape involves. So we're highly motivated to make this industry succeed," says Kreamer.

It was during his service abroad that Kreamer conceived an idea to reduce the upfront costs needed for residential PV systems. Leveraging his civilian background in energy consulting and finance, he developed the power purchase agreement (PPA) business model and co-founded SunRun, which offers leases for residential solar-electric systems in 11 states. But Kreamer's mission didn't end there—today, he serves as the chief executive officer of Clean Power Finance, an online business providing software and financial services to solar professionals and investors.

## Veterans in Solar Jobs



Source: The Solar Foundation's National Solar Jobs Census 2013



Courtesy U.S. Department of Defense

**Experience with using renewable energy systems while serving in the military can translate into viable skills in the civilian job sector.**

Kreamer is one of many veterans helping shape America's RE future. According to a joint report released by Operation Free (see "Returns" in this issue) and The Solar Foundation, the U.S. solar industry employs 13,192 veterans—that's 9.2% of all solar workers in the nation. The first-of-its-kind report—*Veterans in Solar: Securing America's Energy Future*—highlights the contributions of veterans to the solar industry, using data derived from The Solar Foundation's annual *National Solar Jobs Census 2013*.

"We are finally able to see, with hard numbers, what we have suspected for years: Veterans are huge assets to the clean energy economy. They bring technical skills and a relentless focus on accomplishing the 'mission,'" says Jaclyn Houser, advocacy director of OF.

Compared with veteran employment in the overall economy (according to the Bureau of Labor Statistics, veterans constitute 7.6% of all workers), the solar industry is a strong employer of former service members. The installation sector (39%) is the largest employer of veterans, followed by manufacturing (27%), distribution (14%), and project

*continued on page 12*



“ We have been installing solar for over 10 years and have worked with most of the distributors out there. We now work exclusively with AEE Solar because of their outstanding customer service, quick response time and selection of top tier solar products at the best prices.

In this ever changing solar market, we feel AEE Solar will be a reliable partner for many years to come.”

JOSHUA MILLER  
Sales and Project Manager  
WESTERN SOLAR

For over 30 years AEE Solar has delivered the products, training and support our customers need to succeed. Through market and technology changes, AEE Solar has been there for our customers, every step of the way. Let us help you succeed.



continued from page 10

development (6%). The remaining 14% work at “other” related organizations—including government agencies, nonprofits, academic institutions, and companies focused on research and development, legal work, finance, and accounting.

Todd Venetz, a disabled veteran who separated from the Marine Corp. in 2010 after a decade of service and deployments to Iraq, drew on a veteran’s scholarship to pursue his bachelor’s degree at Penn State University, where he studied energy and sustainability policy. Today, he is a field coordinator in New York for the Interstate Renewable Energy Council. “I feel it is my duty to do what I can to leave the world a cleaner, better place for our children, and that means doing what I can to reduce our dependency on fossils fuels,” Venetz says.

As a specialist in the Army National Guard, Sean Murphy spent only one year in Kuwait, but the experience was enough to inspire him to pursue training in solar energy. Unable to find meaningful work and consequently unable to pay for schooling, Murphy—a union electrician by trade—made a special deal with Solar Energy International in Colorado, where he did odd jobs in exchange for 8 weeks of PV

## web extra

To download the *Veterans in Solar* report, go to: [bit.ly/SolarVetsReport](http://bit.ly/SolarVetsReport).

To chart your path in solar industry, visit the U.S. Department of Energy’s Solar Career Map at [bit.ly/DOEsolarCareer](http://bit.ly/DOEsolarCareer).



installation training. The training helped him secure work as a solar installer for an engineering firm in Rhode Island, where he recently completed a 3.7-megawatt solar field in the City of East Providence.

The Solar Foundation and OF are working to develop resources and tools that connect employers and former service members. One such tool is an online database or web portal that will translate military experience for civilian employers, and help employers find veterans who match their needs.

—Kelly Davidson



## NEW

### Residential PV Monitoring & Metering Built into a Single Device Guarantee Significant Reduction of Installation Time and Cost

That is why we integrated the market leading Solar-Log® PV monitoring technology into General Electric’s popular residential meter I-210+.



Visit our Booth 8233

**inter solar** | San Francisco  
July 8 - 10, 2014  
Booth 8233



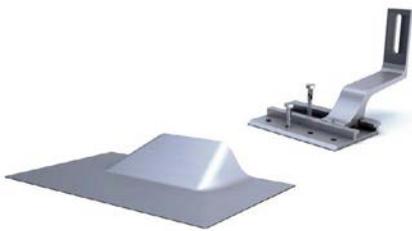
Solar Data Systems, Inc. • USA • [north-america@solar-log.com](mailto:north-america@solar-log.com)

# Say Yes to Tile



## Sell More Solar with Quick Mount PV

Master the art of installing solar on tile with two highly versatile mounting options.



### Quick Hook®

Installs fast – no tile hole cutting. Attractive appearance with no visible flashing. Models for both curved and flat tile.



### QBase™ Universal Tile

Strongest tile roof mount available. Flashed at both the deck and tile levels. Works on both curved and flat tile.

**Free Sample**  
Visit our website  
[quickmountpv.com](http://quickmountpv.com)

**Quick Mount PV®**  
RESPECT THE ROOF

(925) 478-8269



# Enervee Scoring High Marks for Energy Efficiency

We've all been there—standing in the aisle of an appliance or electronics store, trying to make sense of the yellow EnergyGuide tag and the blue Energy Star sticker, wondering whether this model or that model will be the better value and most efficient appliance over the long haul. The online platform Enervee (enervee.com) is making it easier than ever to factor energy efficiency and operating costs into the purchase price for common household appliances and electronics. Using data that is compiled daily, Enervee calculates the lifetime operating cost and determines an energy efficiency score for each product.

The California startup is the brainchild of Matthias Kurwig and Don Epperson, who conceived the idea while shopping for appliances for their respective homes in 2010. "It was important for both of us to find energy-efficient options," Kurwig says. "That simple task turned out to be very challenging, as it required searching multiple sources."

Their vision, Epperson says, was to create "the first objective, data-driven platform that could score the energy efficiency of products in real time." In October 2012, they launched the Enervee score for televisions. Since then, Enervee's offerings have expanded to include scores for computers, air conditioners, and most common household appliances.

## How Enervee Works

Every day, the online platform collects retail prices and energy consumption profiles for tens of thousands of products from 18 data sources—pulling data directly from online shopping sites, manufacturers, and government certification agencies (including the U.S. Department of Energy, Federal Trade Commission, and California Energy Commission).

That data works in concert with a database of residential utility rates collected from more than 3,000 power companies, which is updated annually to capture rates from investor-owned, municipal, and cooperative utilities. Retail energy provider rates in deregulated markets are updated whenever they make changes, weekly or monthly.

Based on the local utility rate for your ZIP code and your personal usage (how often per day/per week you plan to use the product and how many years you plan to own the product), the website calculates the operating cost and the *actual* cost (purchase price plus operating cost) of the specific product.

The site analyzes the energy consumption and capacity of each product (i.e., size, volume, or processing speed) to determine its Enervee score—a 0 to 100 (best) rating of the product's energy efficiency. Scores are adjusted daily, as new data and new products become available. The score creates a baseline for apples-to-apples comparisons of products with different features and capacities.

Brand/Model	Efficiency	Capacity	Eco Impact	Energy Cost	Price
 Maytag M9BXXGMYY	96	18.9 cubic feet	23 CO <sub>2</sub> as gallons of fuel	\$33 over 1 year	starting from \$760 <a href="#">5 Offers</a>
 LG LTC20380SW	90	20.0 cubic feet	25 CO <sub>2</sub> as gallons of fuel	\$36 over 1 year	starting from \$806 <a href="#">4 Offers</a>
 Whirlpool WRT351SFYW	100	21.2 cubic feet	25 CO <sub>2</sub> as gallons of fuel	\$35 over 1 year	starting from \$809 <a href="#">4 Offers</a>
 Whirlpool WRT351SFYB	99	21.1 cubic feet	25 CO <sub>2</sub> as gallons of fuel	\$35 over 1 year	starting from \$809 <a href="#">7 Offers</a>

## Dollars & Cents

As with any service of this nature, there's always a question of objectivity. Enervee's product rankings are generated by an algorithm and are as objective as the data that feeds into the algorithm. While advertisers can pay to promote products and services on the website, Enervee stands by its objectivity, and says revenue and rankings are separate.

Website advertising is just one small piece of the pie. Enervee operates multiple revenue streams: partnerships with online publishers (i.e., Green Living Ideas blog); affiliate commissions (when website visitors click through to a retailer's website); utility referral commissions (new signups to retail energy providers in deregulated markets); data services (audience tracking/retargeting); and mobile app downloads (coming soon). In addition, Enervee offers a data platform on a subscription basis for utilities and government agencies.

## What's Next

Enervee continues to expand its product offerings with new categories, including computer monitors, projectors, and video game consoles. Also in the works is a mobile app for finding the most efficient local offers, and an Enervee score for automobiles. Enervee is working with Lawrence Berkeley National Laboratory to develop a first-of-its-kind international energy efficiency data standard for comparing appliances across different markets.

—Kelly Davidson

## The EnergyGuide Tag: Reading the Fine Print

Since 1980, EnergyGuide labels—which report an appliance’s estimated annual operating cost, compare the energy use of similar products, and list its energy use—have appeared on major appliances sold in the United States. The program, administered by the Federal Trade Commission (FTC), requires manufacturers to affix the EnergyGuide label to products.

However, according to a March 2013 report—*Overcoming Market Barriers and Using Market Forces to Advance Energy Efficiency* by the American Council for an Energy Efficient Economy—the program has failed to keep pace with the ever-evolving marketplace. Few new products have been added since the program started requiring labels in 1980. Televisions were only added in 2010, while clothes dryers and ranges are among the products still excluded. The report calls for reforms to the program, and better coordination of appliance standards and labeling activities among the FTC, the U.S. Department of Energy, and the U.S. Environmental Protection Agency.

The EnergyGuide label provides the estimated annual energy cost of the product along with a continuum comparison graphic to show how the annual energy use compares to similar models. One problem is that the rate used to determine the average national electricity cost is updated on a five-year schedule and does not reflect current or local cost. Your local utility rate could vary greatly, making a product more or less affordable over time. For

example, in 2012, electricity rates in the United States ranged from \$0.06 to \$0.38 per kWh. That, coupled with a long lead time (up to several months) required to produce and place EnergyGuide tags, means that the performance comparison shown on the yellow tag is likely outdated before products even hit the sales floor.

For the best comparisons of different products, focus on the products’ estimated kWh usage and ignore where they sit on the continuum graph, as the continuum of similar products on the market is constantly changing and likely changed by the time you read the tag. But, remember that this estimate is based on *average* usage assumptions—your actual energy consumption may vary depending on how often you use the product.

### The Limitations of Energy Star

The Energy Star label is a useful starting point to help you focus in on energy-efficient products, but the label’s presence does not mean a product is the *most* efficient on the market. While officials at the U.S. Department of Energy and the U.S. Environmental Protection Agency, which jointly run Energy Star, have been working to improve standards, a 2010 audit found that the program is vulnerable to fraud and abuse due to self-reporting by manufacturers. The audit found that some consumer products lacking Energy Star approval consume less energy than some that carry the label, since not all companies seek Energy Star certification.



Install the system **today** that they’ll ask for **tomorrow**.



**GridZero** lets users get the most out of their solar power and energy storage investment, no matter how much energy incentives, policies and even rates may change.

By intelligently balancing stored energy and utility power, GridZero overcomes surges and spikes, making it possible for a smaller, more cost-effective system to perform like a larger one and reduce grid dependency.

New OutBack Radian Series inverter/chargers also feature an **Advanced Battery Charging (ABC)** profile for compatibility with lithium-ion and other emerging energy storage technologies.

Add to that **six other Grid/Hybrid operating modes** plus a wide model range for diverse region and power requirements, and the result is a future you can bet on. Because whatever the grid scenario, OutBack guarantees you’ll stay in front of it.



#### OutBack Radian Series Inverter/Charger Family

Model	Market
<b>NEW</b> GS8048A (8kW, 120/240V)	For Selected North, Central and Latin American Countries
<b>NEW</b> GS4048A (4kW)	
GS7048E (7kW, 230V)	For Europe, Asia and other Global Countries
<b>NEW</b> GS3548E (3.5kW)	

The OutBack Radian Series inverter/chargers are **ideal for complex utility grid environments** such as California, Hawaii or anywhere renewable energy plays a significant role.

OutBack Power | Masters of the Off-Grid. First Choice for the New Grid. | 1 (360) 435.6030 | [www.outbackpower.com](http://www.outbackpower.com)



# Renewable Energy Events

## Northwest & Alaska

- **Jun. 27–29, SolWest Renewable Energy Fair**  
La Grande, Oregon, [solwest.org](http://solwest.org)
- **Jul. 26, NW SolarFest**  
Shoreline, Washington, [shorelinesolar.org](http://shorelinesolar.org)
- **Aug. 9, Alaska Renewable Energy Fair**  
Anchorage, Alaska, [realaska.org](http://realaska.org)
- **Aug. 17, Chena Hot Springs Renewable Energy Fair**  
Chena, Alaska, [chenahotsprings.com](http://chenahotsprings.com)

## Central

- **Sep. 20–21, Sustainable Living Fair**  
Fort Collins, Colorado, [sustainablelivingassociation.org](http://sustainablelivingassociation.org)

## Midwest

- **Jun. 20–22, The Energy Fair (aka MREF)**  
Custer, Wisconsin, [midwestrenew.org](http://midwestrenew.org)
- **Jun. 27–28, Michigan Energy Fair**  
Mason, Michigan, [grea.org](http://grea.org)
- **Aug. 23–24, Illinois RE & Sustainable Lifestyle Fair**  
Oregon, Illinois, [illinoisrenew.org](http://illinoisrenew.org)
- **Sep. 20, Clean Energy Fair**  
Missoula, Montana, [montanarenewables.org](http://montanarenewables.org)

## Northeast

- **Jul. 18–20, SolarFest**  
Tinmouth, Vermont, [solarfest.org](http://solarfest.org)

## Southwest

- **Sep. 27, Solar Fiesta**  
Albuquerque, New Mexico, [nmsea.org](http://nmsea.org)

## West

- **Sep. 6, Solfest**  
Holland, California, [solfest.org](http://solfest.org)

## For the Pros

- **Jun. 16–18, Small Wind Conference**  
Stevens Point, Wisconsin  
[smallwindconference.com](http://smallwindconference.com)
- **Jul. 6–10, Solar 2014 (ASES, in conjunction with Intersolar)**  
San Francisco, California  
[solar2014.org](http://solar2014.org)
- **Jul. 7–10, Intersolar North America**  
San Francisco, California  
[intersolar.us](http://intersolar.us)
- **Oct. 20–23, Solar Power International**  
Las Vegas, Nevada  
[solarpowerinternational.com](http://solarpowerinternational.com)



Courtesy: Jerry Nelson, JourneyAmerica.org

# U.S. Battery

is where Reliability and Necessity meet



[www.usbattery.com](http://www.usbattery.com)



# IronRidge Integrated Grounding System & FlashFoot Products



Courtesy IronRidge (2)



IronRidge ([ironridge.com](http://ironridge.com)) released its UL2703-certified, integrated grounding system for roof-mounted PV arrays. The system includes grounding clamps, a strap for rail splicing, and a lug to connect the module row to a grounding conductor. The grounding clamp secures two adjacent modules to a rail, using its "teeth" to pierce the anodized coating on modules and rails to electrically bond them together. These clamps eliminate adding grounding hardware between modules or between modules and rails. This integrated grounding system is used for 60- or 72-cell modules, with frame depths between 31 and 51 mm. (Note: Verify additional frame parameters for compatibility.)

IronRidge also introduced its FlashFoot, which integrates a flashing, lag bolt, and L-foot, and is used for mounting rails onto a composition shingle roof. Features include a pre-installed rubber bushing to make a watertight connection between the lag bolt and the L-foot, 12- by 12-inch flashing coverage, and an elevated sealing platform for increased water shedding away from the roof penetration. This product has a 20-year warranty.

—Justine Sanchez

## 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](http://www.apxsolar.com)



A+ rating

# OutBack Power Radian Inverters with GridZero & Advanced Battery Charge Modes



Courtesy OutBack Power Systems

OutBack Power ([outbackpower.com](http://outbackpower.com)) released its GS8048A and GS4048A Radian inverters for North America. These battery-based inverters include two new features:

- The *GridZero AC input mode* is used to power on-site AC loads primarily from the renewable energy source and/or the battery bank, minimizing grid-power usage. With GridZero technology, utility energy is used only when the batteries reach a specific depth of discharge. In this mode, the system does not sell power to the grid. This feature addresses the fact that solar incentives and buy-back policies of renewable energy are changing in markets such as Europe, Hawaii, and California, making “self-consumption” of renewable energy more desirable for some installations.
- The inverters’ *Advanced Battery Charge* mode can accommodate specific charging profiles for uncommon battery types, such as lithium-ion.

—Justine Sanchez

**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](mailto:residentialsales@arraytechinc.com) | 1.855.TRACKPV | [arraytechinc.com](http://arraytechinc.com)



**ARRAY**  
TECHNOLOGIES

# Operation Free

When Captain Brett Hunt separated from the U.S. Army after four years of service, he felt like a lot of military personnel do: “I wanted to find some way to continue to serve our country and be a part of a larger mission.” Hunt found that sense of purpose by volunteering with Operation Free (OF, [operationfree.net](http://operationfree.net)), a coalition of military veterans and national security experts that advocates for renewable energy (RE) as a matter of national security.

“By developing new technologies, fuels, and renewable sources of power, the United States can protect its troops while they carry out the mission abroad and provide security to its citizens here at home,” says Jaclyn Houser, advocacy director for Operation Free. OF began as a program of the Truman National Security Project, a progressive leadership institute in Washington, D.C. The group kicked off its campaign in 2009

with a 29-state bus tour during which veterans of the Iraq and Afghanistan wars spoke to communities about how fossil fuel dependence and climate change threaten national security. As part of the campaign launch, 150 veterans also flew to Washington, D.C., to meet with senators and White House staff to advocate for clean energy and climate legislation.

“Reducing our dependency on oil is an issue I am passionate about,” Hunt says. “Right now, we are dependent on the least-secure parts of the world for much of what fuels our economy. We can continue to put our economy and national security at risk by relying on a finite fossil fuel, or we can choose a safe, secure future powered by clean, renewable sources.”

Hunt is one of more than 5,000 veterans and national security experts working with OF. “No one wants to go to war less than our men and women in uniform. They know we’ve paid too much in blood abroad because of our energy choices,” says Mike Wu, OF’s advocacy policy director and also an officer in the U.S. Army JAG Corps Reserves.

For Hunt, who served in Iraq and Kuwait, the issue of America’s oil dependency is personal. “I would go on convoys at night to move fuel through dangerous territories. Fuel convoys were repeatedly the targets of roadside attacks that resulted in casualties. We risked our lives to transport and protect fuel needed to power generators. In those moments, I intimately understood how our dependence on oil makes our country vulnerable,” Hunt recalls.

In addition to pushing for RE investment at home, OF has been a key voice in advocating for policies that support the use of RE and energy-efficient technologies in the battle zone. While the military has made strides in recent years, more needs to be done, according to former naval officer Andrea Marr, who was deployed three times to the Persian Gulf during her five years of active-duty service.

“In the battle zone, virtually any maneuver involving fuel is dangerous,” says Marr. “It was difficult to reconcile that we were putting our lives on the line to protect rusty, dreadful-looking oil platforms in the middle of the Persian Gulf. I would look to the horizon and the flags blowing in the wind, and wonder how many lives could be saved if we used more renewable energy—in the battle zone and at home.”

In 2013 alone, the U.S. Department of Defense (DOD) spent more than \$20 billion on energy and consumed more than 5 billion gallons of oil. Motivated to reduce operational costs and improve energy security at home, the military

**Petty Officer First Class Scott Hampton sets up PV modules for a deployable water purification system at a disaster site in Biang, Brunei Darussalam.**



Courtesy U.S. Marine Corps; photo by Lance Cpl. Kasey Peacock

stepped up its commitment to reduce fossil fuel dependency, both on the battlefield and at bases stateside. Each branch outlined RE targets designed to meet the DOD's voluntary goal for 25% of total facility energy consumption to come from RE sources by 2025.

In the battlefield, the Army and Marines are using portable solar arrays to power critical equipment at remote camps, reducing the number of dangerous fuel convoys and the demand on traditional generators. Additionally, several bases in Afghanistan now rely almost entirely on solar for electricity.

Stateside, wind- and solar-powered military bases have reduced the military's reliance on civilian transmission infrastructure and fossil-fueled power plants. This allows bases to operate independently if needed, alleviating security risks posed by blackouts and other potential attacks. With its energy supply less dependent on fossil fuel, the DOD would be less vulnerable to global supply and price disruptions.

This shift to RE sources serves the military's larger goal of combating climate change and mitigating national security risks. However, the decision has met some opposition—on a number of occasions, members of Congress have tried to block budget authorizations for military programs aimed at developing non-fossil-fuel-based energy technologies.

OF veterans are working at the federal, state, and local levels to push skeptical lawmakers on policies that promote RE, particularly those addressing programs within and across branches of service. Drawing on their wartime experiences, they offer a unique perspective that is helping bridge the

## Going to Net-Zero

In February, the U.S. military flipped the switch on its largest solar project at Davis-Monthan Air Force Base in Tucson, Arizona. Covering 170 acres at two locations on the base, the 16.4 MW PV project is expected to provide up to 35% of the base's electricity and save the base up to \$500,000 a year.

Six other bases plan to achieve net-zero energy by 2020 as part of the Army Net-Zero Energy Initiative. Fort Bliss, Texas, and Fort Carson, Colorado, are striving to be net-zero energy, net-zero water, and net-zero waste by 2020. The Oregon National Guard is also working on net-zero energy plans for all of the state's installations.



Courtesy U.S. Marine Corps; photo by Lance Corporal Alexander Quillies

**U.S. Marine Corps Corporal Robert G. Sutton, left, and Corporal Moses E. Perez install new PV modules at Combat Outpost Shukvani, in the Helmand province of Afghanistan.**

partisan divide on climate change and RE investment. The veterans also speak to the economic advantages of energy security and job creation.

OF's stance, which asserts that climate change threatens the military's mission abroad and national security at home, echoes that of experts at the Pentagon and intelligence agencies—the world's rising sea levels, superstorms, catastrophic floods, and droughts have the potential to trigger resource conflicts and pandemics that could topple governments and destabilize entire regions. Security experts contend that such climate-induced events not only send ripples through the global economy, but also require U.S. military intervention that stretches resources thin and distracts from more critical threats, creating potential opportunities for terrorist attacks.

"Look no further than Hurricane Katrina or Superstorm Sandy. Key military resources had to be diverted to manage the aftermath of those storms. Or consider how the drought in the Sudan spurred conflict, or how the flood in Pakistan displaced millions, leaving a vast ungoverned area for terrorism to take hold," Hunt says.

While OF's mission may focus primarily on the military in the short term, Wu says the effect will be far-reaching in the long term. Through its procurement power alone, the DOD has the ability to transform markets. "As the world's single largest energy consumer, the U.S. military has the power to be one the greatest catalysts of change in the fight against climate change," Wu says.

—Kelly Davidson

# Campus Wind Power



Courtesy Appalachian State University

Ten years ago, students at Appalachian State University (ASU) voted to enact a new student fee with the sole purpose of funding renewable energy installations on campus. In 2009, the student-led ASU Renewable Energy Initiative (REI) commissioned its flagship wind installation on the highest and windiest spot on campus. Poised in the background of the football stadium, the

highly visible Northwind 100 turbine brought wind energy back to Boone, North Carolina—a town that hosted the experimental 2 megawatt MOD-1 wind turbine in the late 1970s.

At a tower height of 121 feet and a rotor diameter of 69 feet, the 100 kW turbine is the largest wind installation in North Carolina. The turbine feeds into the ASU grid and produces between 100,000 to 115,000 kWh per year. The Northwind was installed by Alteris Renewables, with assistance from ASU electricians and physical plant staff. A local RE installer, Blue Ridge Energy Works, was trained and contracted to perform service and maintenance on the turbine. Student fees contributed \$319,800 to the project and the university-owned utility, New River Light and Power, provided the remaining \$213,200.

“This is very much a student-led achievement,” says Crystal Simmons, student project manager for the turbine installation, “from the funds raised by the student body to the conversations by REI members about the turbine project.” ASU is home to the 30-year-old Appropriate Technology (AT) program—and students in the program performed the site assessment for the project, and modeled the turbine performance, aesthetic, sound, shadow flicker, and avian impacts.

Installing a real-world project on campus was a learning experience. Annual energy production estimates were based on a wind resource map; on-site measurements were not taken. The result was that annual production was overestimated at 147,000 kWh—nearly 40,000 kWh higher than actual output. The turbine is located in complex terrain, so the impact of turbulence along with an overestimated wind resource are likely factors in the difference. Local contractors respond promptly to issues such as resetting controller faults and maintaining the yaw brakes, which sometimes “squeak” due to the turbulent in-flow conditions on the rotor.

The Northwind 100 is green energy in action, a visual indicator that ASU students, staff, and administration are committed to producing clean, local, RE on campus. ASU continues to collect the \$10-per-year student fee earmarked for RE, and the REI continues working at a steady stream of campus projects, including a biodiesel distribution facility to provide fuel for the town’s bus fleet; PV arrays; solar thermal systems for dormitories; solar-powered trash compactors; and an EV charging station.

—Brent Summerville

## Overview

**Project name:** Appstate Wind Turbine

**System type:** Grid-tied wind-electric, Northwind 100

**Installer:** Alteris Renewables

**Date commissioned:** June 15, 2009 (the first Global Wind Day)

**Location:** Boone, North Carolina

**Resource:** Class 2—estimated 11 mph annual average at 98.4 ft. height

**System capacity:** 100 kW

**Rotor diameter:** 69 ft.

**Tower height:** 121 ft.

**Ave. annual production:** 108,000 kWh

# 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 © MK Battery 2014



[www.mkbattery.com](http://www.mkbattery.com)

MK Battery - An East Penn Manufacturing Co. Subsidiary



# Choosing a Wind Turbine Tower

Once you've decided on a wind turbine, your next choice is the type and height of tower. For best production, the turbine should be on a tall tower to maximize wind speed and minimize turbulence, but there are other factors that can affect your tower choice:

**Economics & Aesthetics.** The three basic tower types to consider are tilt-ups, guyed lattice, and freestanding. Most tilt-ups are made of pipe or tube and require guy wires for support. They are assembled on the ground and raised into position with a winch or tow vehicle. For turbines with a rotor diameter of 12 feet or less, this tower is usually the lowest-cost option. Guyed lattice towers are constructed on the ground and raised with a crane or assembled vertically, one section at a time, with a process known as stacking. These towers are mostly used for turbines with rotor diameters less than 25 feet and are the lowest-cost fixed tower option. Freestanding towers fall into two categories: self-supporting lattice and monopole. The self-supporting lattice tower is usually assembled on the ground and raised with a crane. These towers are typically used for turbines with a rotor diameter of 20 feet or more and require a fairly large foundation, making this option fairly expensive. Monopole towers are available for most turbine sizes and tilt-up versions are becoming more common. Although many people prefer the aesthetics of a monopole, these towers require the largest foundation of all and are usually the most expensive option.

**Building codes & zoning regulations.** Local building codes may dictate using a heavier tower and larger foundation than expected. Zoning regulations may limit you to a specific tower type or tower height, or impose other requirements that will affect project economics.

**Engineering.** Turbines exert many complex forces on the tower and its foundation. The larger the turbine, the more robust the tower and foundation need to be. The turbine, tower, and foundation function as a system, and need to be engineered to work together. Most turbine manufacturers offer or recommend an appropriate tower for their turbines.

**Site conditions.** Soil type affects foundation design and may limit tower options. Soft soil or bedrock tends to require more robust foundations than "average" soil. Uneven terrain can be a determining factor as well.

**Site access** is frequently overlooked. Can the site accommodate very heavy-wheeled equipment, such as a crane and concrete delivery truck? If it can't, then your tower options are quite limited.

—Roy Butler

## Tower Types & Characteristics

### Tilt-up

- Largest footprint of all the tower choices
- Moderate foundation in most soil types
- Usually the lowest-cost option for most turbines less than 12 feet in rotor diameter
- Built on the ground; no crane needed
- Best on reasonably level ground
- Can be lowered to service turbine

### Guyed lattice

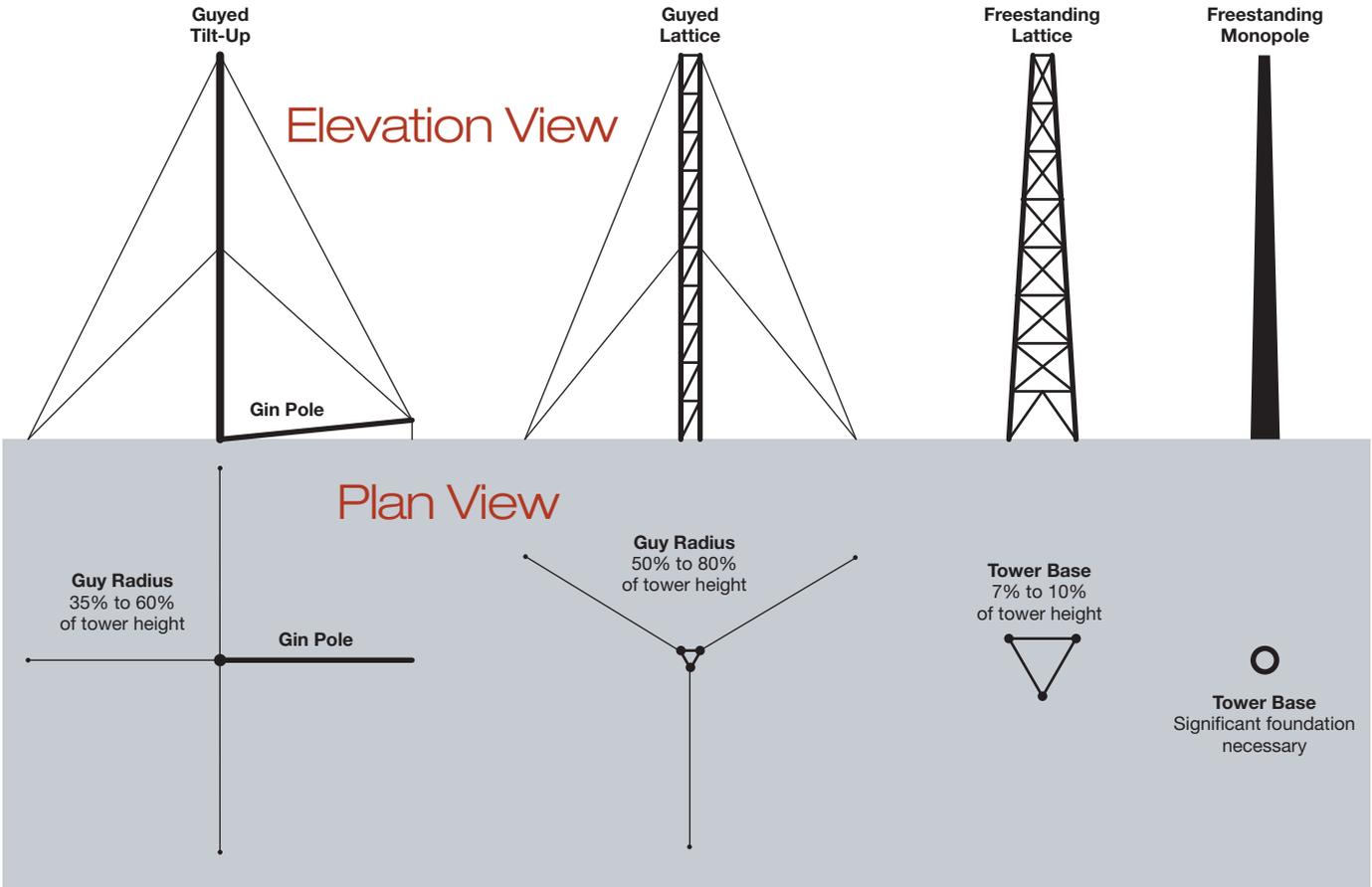
- Fairly large footprint with a guy radius that's 50% to 80% of the tower height
- Minimal foundation in most soils
- Least expensive stationary tower
- Crane or stacking installation
- Must climb to service turbine
- Typically used for turbines less than 20 kW

### Self-supporting lattice

- Small footprint
- Large foundation
- Moderately expensive
- Installed with crane
- Must climb to service turbine
- Typically used for turbines less than 50 kW

### Self-supporting monopole

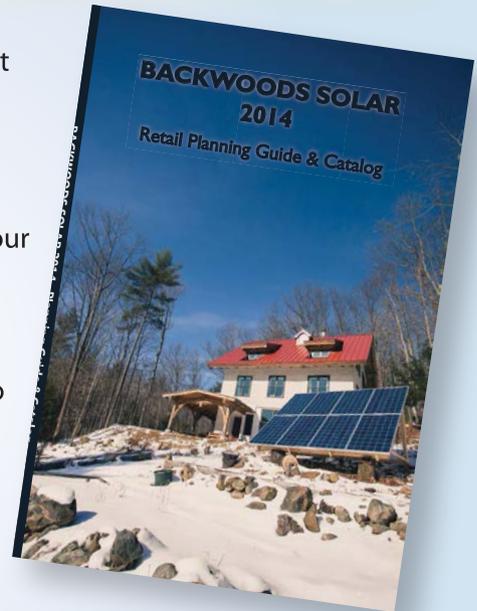
- Smallest footprint
- Largest foundation
- Most expensive
- Unloaded & installed with a crane
- Usually must climb to service turbine, although some are available with hydraulic tilting option
- Used on turbines of all sizes



## OUR NEW 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 2014 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

## The Runaway Hydro

My article on our original microhydro system (“Choosing Microhydro” in *HP101*) included all the trials and tribulations we had with it. In 2007, we installed a LH1000 low-head hydro by Energy Systems & Design (see “Water Rites” in *HP122*). It sits in a rather flood-prone site, and is exposed to spring floods. After having moved tons of rock by hand, pouring an intake, hydro pad, and weir (dam) in that position (not to mention recently turning 60), I haven’t had the heart, money, or time to move it. To protect the site from the force of floodwater and the inevitable debris that comes along with it, the LH1000 is housed in a stainless steel box.

Up until the southern spring of 2010, we just did what many hydro users do—fiddled with this and that to improve filtering, output, etc. While we love having the extra power to run tools, the vacuum, the washing machine, microwave, and most importantly, the cappuccino maker, without relying on combustion engines, hydros take a lot more “power plant control.” I set up the machine so that when we left for an extended period, it would take only a few minutes to detach and haul up the hill to our shed. However, if we were leaving for only a few days, we tended to leave it in, with all the flashboards buttoned up and the butterfly-valve intake shut.

We were gone for just a week visiting family, and had left the hydro at the river in the box. That’s when we came up with a doozy—a 100-year flood. It isn’t really about the water, which along the edge of the river, isn’t as powerful. It’s more about the logs and trees that have been sitting on the bank upstream for decades, and then come hurtling down.

We got a frantic phone call from our neighbor, but as we were 2,000 kilometers away, clearly it was too late, so I had to make do with a shot of single malt. When we returned, we found the box bent beyond use and the hydro gone.

With our turbine missing, we decided to just add more PV modules to our existing array. At 1.8 kW, it provides us with just enough electricity—usually. If the weather is cloudy, or during the short days of winter, we may have to forego the vacuum, microwave, and perhaps most importantly, my cappuccinos.

And then, a year later, a little miracle happened. A friend who was fishing just downstream of our place saw a glint in the gravel, and went to investigate (perhaps hoping for some gold in the local granite). After a bit of digging, he unearthed another sort of treasure: our turbine! We cleaned it up, epoxied the chipped plastic intake vane, replaced the bearings, and re-threaded the shaft housing into the vane base. We then re-installed it into a quick-and-dirty plywood box and placed it in the stream. The dang thing worked like a charm!

We replaced the stainless box with a newer, sturdier version with rebar and are installing an extra set of flashboards on top of the footbridge and weir to give the turbine an extra 12 inches of high-water protection. We’re also replacing the 2-by-4 log deflectors with rebar both on top and upstream of the box.

We now enjoy our cappuccinos once again—rain or shine—and we have more power than we know what to do with, no

clanking smoking engines ruining the calls of the kookaburras, and the cleanest, most consistent power in the valley. I still sit by the river and ponder how I could possibly improve the filtering, but now that the hydro is our backup rather than our only power source, I smile and enjoy my musings next to our little river, high water or low.

Jeffe Aronson • Victoria, Australia

## What You Are Waiting For...

I just finished reading the editorial, “What Are You Waiting For?” (“From the Crew” in *HP159*). After reading this piece, I thought to myself, “Well, Joe, ‘Why not?’ indeed. What *am* I waiting for?” As I sat there, I started to make a mental list of what I would need.

I would need to have an unshaded, south-facing roof. After consulting with my handy Boy Scout compass, I realized that the roof faced S13E. Close enough! However, to make it fully unshaded, I would have to remove 11 trees, one of them about six feet in diameter, shading a quarter of an acre. I would have to wait until I cleared the trees before determining how many panels I would need.

My most recent electric bill showed that over a 33-day period, I had used roughly 26.4 kWh per day. As I walked around my house, I started to notice that I’d inadvertently left on lights and a ceiling fan in an empty room. After turning these off, I started to think of other ways I could reduce my electricity consumption without significant lifestyle changes.

I’ve slowly replaced most of the incandescent bulbs with compact fluorescent bulbs. Now that I’m focusing on reducing consumption, I’m going to replace them all. As I walked through the house, I noticed daylight around my front door. I realized that although I’d weather-stripped the doors, I had failed to caulk around the frames, so I added “caulking my doors and windows” to my list. Additionally, I noticed that my thermostat’s setting for summertime cooling was a too low, so I adjusted it to 80°F.

I then went up to my attic and saw that it was insulated with 4-inch-thick fiberglass batts. I would need to add at least 4 more inches of insulation, as well as extend the insulation into the eaves of the house to improve the home’s thermal performance. In the process, I figured I would replace the old batts with new batting, so that everything would be new once the process was finished.

I walked back outside and realized that the “new” roof I had installed when I retired was now over 20 years old. Before installing PV panels, I would need to replace the roof, which was built on 2-by-4 trusses on 2-foot centers.

Courtesy Jeffe Aronson



**Jeffe Aronson and his hydro turbine that takes a licking and keeps on ticking.**

So I decided I would replace the roof with a metal standing-seam roof. After that, I would start thinking about thin-film laminates because of their appearance and lighter weight.

My next stop was at the bank. My banker said everything was in order, but the bank was reluctant to make a 20-year home improvement loan to an 86-year-old man.

Joe Kyle • Carthage, Texas

### Solar Drip-Irrigation

In 2009, we bought an acre of land in Homestead, Florida, 35 minutes south of Miami. Since the parcel had no electricity and no structure to accommodate a large PV array and the related inverters and water pump for a full-scale sprinkler system, I settled for a PV-powered drip irrigation system.

I wanted it to be as simple as possible with the least demand for equipment. The solution was to use a 275-gallon plastic tank (\$60 used), and a 2-inch electric valve (\$100) to release the water controlled by a timer (\$12). Electricity is supplied by a Unisolar PV136 module (\$125). The water pump is a 4-inch, 24 V, 1.6-gallon-per-minute well pump (\$145) at the bottom of the shallow well. The battery storage is two marine batteries (\$58 each).

The water tank has a 2-inch manual valve that goes to the electric valve control and then to 2-inch PVC main pipes, which branch into 3/4-inch flexible plastic tubes.

I have about 82 trees. Each tree is fed by a 1/4-inch drip tube coming from the 3/4-inch secondary tubes. All this is accomplished by gravity, and in 10 minutes each tree gets about 1.5 gallons of water—more than enough. It then takes the pump 1 1/2 hours to replenish the tank.

The battery bank never drops below 85%, and it gets recharged 100% before noon. The single module provides more than enough energy for the task.

Chunin Martinez • Miami, Florida

### Hydro Correction

I was reading the article “Hydro-Electric Evolution” and noticed PowerSpout got a mention, which is normally good, until I read this: “...but if their simpler, plastic Pelton runner has a lower efficiency, it may not be worth the cost-savings.” Chris Soler must not be familiar with our runner. Our glass-filled nylon rotors (we make both Pelton and Turgo types) are far from simple. PowerSpout’s low-head product has a stainless steel rotor.

For the record, our glass-filled nylon rotors have been tested at the Massey University test site for four years, 24/7, at 1.6 kW, and show very little wear. This is why all of our plastic rotors get a 5-year erosion warranty. The wear rate of glass-filled nylon is similar to that of bronze runners.

We have spent considerable time over 12 years building a cost-effective, award-winning, standard-compliant range of affordable hydro turbines that are made with renewable energy and a high recycled material content.

Michael Lawley • PowerSpout/  
Ecolnnovation, New Plymouth,  
New Zealand

## 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.

# Introducing Our New Solar Pair for 2014

Solar charger (SC-2030) and monitor (TM-2030) work together to provide exceptionally versatile solar charging and battery monitoring for small or medium sized offgrid systems.



**TM-2030 Battery Monitor**  
usually located in living area.



**SC-2030 Solar Charger**  
Usually located near batteries connected to TM-2030 with telephone cable.

**TM-2030 Monitor:** Almost identical to our TM-2025 except it works with the SC-2030 and:

- has new audible low battery alarm based on amp hours and battery voltage.
- new display shows “percentage of charge returned compared to last discharge”

**SC-2030 Solar Charger:** New 30 Amp PWM (pulse width modulated) charger for 12 or 24 v systems with temperature compensation option.

- **Highly efficient charging.** With 36 cell or 72 cell solar panels (often called “12v” or “24v” panels) usually as efficient as MPPT charger but at lower cost.
- **8 adjustable charging parameters** for charging exactly for your batteries.
- Many battery manufacturers including US battery and Trojan recommend that batteries should be recharged until 10-15% more charge is replaced than was previously removed. This solar charger (unlike most) **allows you to specify the overcharge amp hour percentage before going into “float”**.
- **Has a fourth charging stage that boosts voltage** (for wet cell batteries) to accomplish more charging during a limited solar day — also recommended by some battery manufacturers.
- **With TM-2030,** displays how many watts of otherwise lost solar power you can use for extra loads during afternoons when solar charger is tapering down.
- **Without TM-2030** connected works at a more basic level of charging.

**details at: [www.bogartengineering.com](http://www.bogartengineering.com)**

**BOGART ENGINEERING (831) 338-0616**  
19020 Two Bar Rd., Boulder Creek, CA 95006

## Sunspace Sizing

I am a student at Hocking College in Nelsonville, Ohio. For our energy class, I am assigned the task of designing and building a sunspace for a mobile, energy-efficient building (16 feet wide × 16 feet long × 10 feet high). How do I correctly size this sunspace and make it usable as living space?

Kelley Barstow • via email

It sounds like a great project! The sizing of the sunspace depends on what your objectives are. The most ambitious goal would be to heat the cabin using only the sunspace, and even include solar-heat storage. You'd need to make sure that the cabin is well-insulated and tight. This is a very tall order.

A less ambitious goal is to keep the sunspace environment warm enough for plants all day, and warm enough for people during the day and for a few hours after sunset. Within these constraints, you'd seek to generate a bit of space heating for the cabin. This is the way a lot of conventional sunspaces are sized.

For example, let's take a look at a less ambitious goal, and try to size a low-mass sunspace so that, on a sunny day, it generates heat for the cabin during the day and for a few hours after the sun sets. On cloudy days and for part of the night after a sunny day, the cabin would need another heat source. We'll assume:

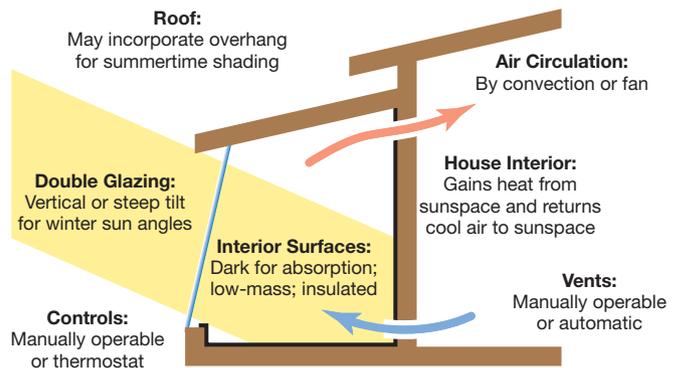
- Our goal is a low thermal mass sunspace (LTMS) that delivers most of the heat it gains to the cabin. So during a sunny day, the sunspace is comfortable to be in, but most of the incoming solar heat is routed to the cabin. At night, the sunspace cools off and is not suitable for plants or people.
- The sunspace has 130 square feet of south-facing and steeply tilted (or vertical) double glazing to collect solar heat. There are 50 square feet of R-2 windows in the cabin.
- The sunspace has a set of vents and fans to efficiently deliver heat to the house. It has a way to effectively close these vents at night to reduce heat loss from the cabin to the sunspace.
- The nonglazed surfaces of the sunspace—walls, ceiling, and floor—are well-insulated and have low thermal mass. The insulation slows heat loss to the outdoors, and the low-thermal-mass materials mean that the sunspace won't be absorbing the heat you want to go to the cabin.
- The cabin is sealed well enough to have an infiltration rate of 0.5 air changes per hour or less.

You'll need to match the cabin's heat loss to the sunspace's heat gain. Looking at a sunny, 20°F day, the cabin's heat loss (assuming the above construction details) comes out about 4,700 Btu per hour. (You can use the heat-loss calculator at [bit.ly/BIS-HeatLossCalc](http://bit.ly/BIS-HeatLossCalc).) Since you're using efficient lighting and appliances, with a couple of people included, the internal heat gains might be 400 Btu per hour. That would give a net heat loss of 4,300 Btu per hour.

If the average outdoor temperature for the day is 20°F, then the 24-hour heat loss would be 103,200 Btu per day (4,300 Btu/hr. × 24 hrs.). This is about equivalent to 1.4 gallons of propane burned in an 80% efficient furnace.

That's the simplified heat-loss calculation—you could be more accurate with a simulation that takes into account hourly temperature variations and other things. You could also do it for your actual weather for the whole heating season, day by day.

## Sunspace Characteristics



Our example sunspace solar heat gain looks like this: The solar insolation for a sunny winter day is about 300 Btu per square-foot•hour. If you assume that a LTMS can achieve 50% efficiency, then its solar heat output would be 19,500 Btu per hour (300 Btu/ft.<sup>2</sup>•hr. × 130 ft.<sup>2</sup> × 0.5 efficiency).

This is more than four times the per-hour heat loss from the cabin. That's good because:

- On a sunny day, the heat output in the early morning and late afternoon will fall below 19,500 Btu per hour because of the incidence angle between the sun and the glazing. For instance, a 45° incidence angle would cut it by 0.707 (cosine 45°). So, you don't get 19,500 BTU/hr. gain for every hour of the sunny day.
- On partly sunny days and on cold days when the temperature is less than 20°F, the sunspace will still be able to provide a decent amount of usable heat.
- Heat gain that is well above the cabin's heat loss should help raise the temperature of the thermal mass above normal room temperature, allowing it to "store" heat for radiation back into the space as it cools.
- The "extra" heat could be routed to a heat storage system to heat the cabin through the night.
- It gives you more freedom to optimize the layout of the sunspace for the activities you want to do there, even if that means giving up some solar gain.

You'll also need to follow the other design rules that are covered in the article "Low Thermal Mass Sunspaces" in *HP158* and at the link above. Of particular importance is summer venting—the sunspace will be an oven without it.

The simple building energy performance estimators that I use are easy to understand, but if you want to take it to the next level of simulation accuracy, you might want to check out eQUEST or EnergyPlus, which also offers a plug-in for Google SketchUp.

Both of these software packages are free, but both have fairly steep learning curves. Don't get so wrapped up in these simulations that you lose sight of the basic physics that are going on.

Gary Reysa • [builditsolar.com](http://builditsolar.com)



## \*INTRODUCING\*

PVI 3800TL, PVI 5200TL,  
PVI 6600TL & PVI 7600TL

### RESIDENTIAL INVERTERS

#### FEATURES

- 600 VDC
- Highest industry peak & CEC efficiencies
- Lightweight, compact design - smallest in the industry
- Quick and easy installation
- Wide operating voltage range
- DC disconnect

#### OPTIONS

- Web-based monitoring
- Revenue grade monitoring
- DC arc-fault detection and interrupt

# BETTER. LIGHTER. STRONGER.

Built for the real world

#### COME SEE US AT THESE UPCOMING SHOWS!



Booth 611  
June 23-25, 2014  
Boston Convention & Exhibit Center - Boston, MA  
Design Considerations & Inverter Training



Booth 8211  
July 8-10, 2014  
Moscone Center - San Francisco, CA

#### FULL PRODUCT OFFERING:

- 1Ph Residential Inverters (1.8-2.5 kW)
- 1Ph Transformerless Inverter (3.8-7.6 kW)
- 3Ph Transformerless Inverters (14-28 kW)
- 3Ph Central Inverters (50-500 kW)
- Utility-Scale Inverters (500 kW-2 MW)
- Disconnecting & Arc-Fault Combiners
- Web-based Monitoring

## Solar Space Heating

I'm researching solar space heating options for my home. Solar air heating seems simple enough, but when I search the Solar Rating & Certification Corp. (SRCC) database, only three collectors make an appreciable (though not stunning) number of Btu per day.

However, those three companies have pretty sketchy websites (like circa-1990s designs), with no real distribution network. I'm skeptical.

Why does it seem that solar water heating systems are used more prevalently for space heating?

Mike Taylor • via Facebook

There are at least two reasons why solar air collectors aren't as popular as liquid collectors and solar water heating systems. One is technical; the other economic.

First, air collectors are not as efficient as liquid collectors. Heat transfer is an important facet of collector efficiency. Air has lower density and lower specific heat, so it is not as good a heat-transfer fluid as water or an antifreeze solution. Air has a measure of heat content called specific heat (SpHt) of 0.24, while water has an SpHt of 1.0. Both characteristics are important for good heat transfer.

Many liquid collectors have efficiencies of about 75% (or slightly more), while air collectors don't exceed 65%. However, in air systems, the collector's efficiency is offset by the overall system efficiency, which is higher, since these systems operate at a lower temperature (~70°F) compared to a domestic hot water system (120°F to 140°F).

See "Getting Into Hot Water" in *HP123* for additional explanation of interpreting collector performance.

Air collectors are less expensive to manufacture than liquid collectors—they do not need expensive copper piping to contain the heat-transfer fluid. But their cost advantage and higher system efficiency isn't enough to offset the economic disadvantage of solar space heating, since it usually is required for only about half the year. Consequently, the system isn't generating a return on investment (ROI) in warmer weather. Also, the winter solar resource is much lower when compared to the yearly average resource, so space-heating systems have an even greater economic disadvantage compared to solar water heating systems. The bottom line: Since water-heating systems are working all year long, they have a better average solar resource that increases the ROI.

Lastly, many air collectors are incorrectly installed, with the cold-air return located in the ceiling. Air collectors have two duct openings—one for the supply air and one for the return air. The hot outlet air is usually installed in the home's ceiling, making ductwork short and allowing strong circulation with a small, energy-efficient blower. But installing the cold-air inlet also at the ceiling results in the heated air circulating only at the ceiling—not at the bottom half of the room where it is needed. Proper placement of the cold-air return to the collector—at floor level—is the key to a correctly installed system.

Air collectors can also be installed vertically on a south-facing wall. In this configuration, it is difficult to install them incorrectly, as they have openings on the bottom and top of the collectors, which thermosyphon the air. The cold air enters at the bottom (floor level)



# Made in the USA

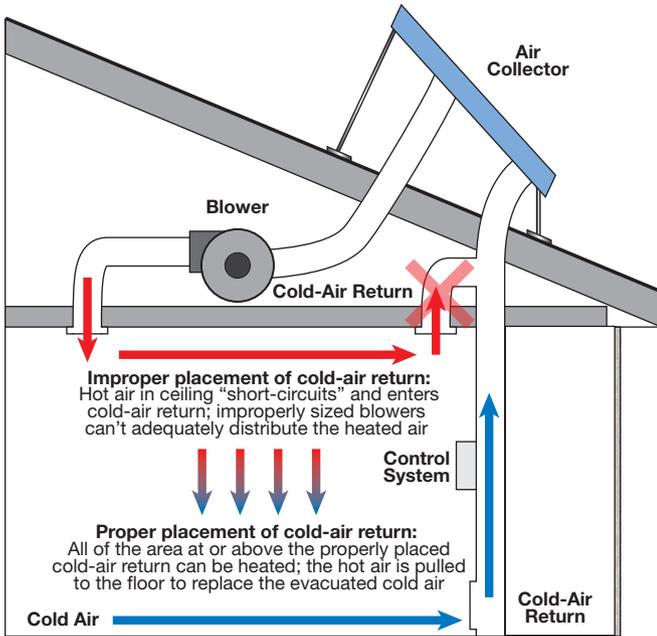
Iron Edison Battery Company and ENCELL bring you the first Nickel Iron battery built and sold in the USA since 1972. The future of clean energy storage is now Made in the USA.

- ★ Fused Iron™ by ENCELL technology
- ★ 10 Year Warranty
- ★ Integrated Watering System
- ★ Works great with every inverter

[IronEdison.com](http://IronEdison.com)

720-432-6433

## Improper & Proper Placement of Cold-Air Return in a Solar Heating System



and, as it rises through the collector, is warmed and exits at the top. Many installations incorporate a small fan or blower to increase the circulation.

There are thousands of air collector systems in the western United States, both wall-mounted and correctly installed rooftop systems. The high desert and mountain locations in these states have four-season climates with relatively good winter solar resources. But even when well-designed air collectors are installed correctly, the systems still face the economics of approximately six months of use with varying degrees of diminished solar resources.

Anyone evaluating the benefits of solar space heating should consider passive solar design—with new construction, this is normally the most cost-effective solar heating solution. It can also be an economical retrofit. Incorporating a structure like an attached sunroom, Trombe wall, or other passive design feature is always possible with new homes, and usually feasible with many existing buildings. The economical passive do-it-yourself solar projects described in detail by a frequent *Home Power* author Gary Reysa on his website ([builditsolar.com](http://builditsolar.com)) and *Home Power* articles are good places to start (see *HP98, 99, 109, 116, 117, 153, & 158*).

Chuck Marken • *Home Power* thermal editor



## INTRODUCING NEW VALUE FOR OFF-GRID SOLAR AND BACKUP POWER: CONEXT SW

A COST EFFECTIVE INVERTER/CHARGER DELIVERING RELIABLE POWER TO RESIDENTIAL AND REMOTE COMMUNITIES.

The Conext SW inverter/charger is a pure sine wave backup or off-grid power system with 120/240V input and output. Available in 2.5kW and 4kW it is perfect for both residential and community projects, it provides additional value in the form of:

- Integrated auto-transformer produces 120/240VAC output for demanding loads like sump pumps and motors
- Generator support to assist small single-phase gensets
- Best-in-class surge and temperature performance
- Power factor corrected charger with dead battery charging
- Full monitoring and configuration with Conext ComBox



Proudly Distributed by:



Contact Canadian Energy™, stored and renewable energy experts, to find out more about the Conext SW.

CDNRG.COM 1.888.AMP.HOUR

facebook.com/CanadianEnergy

YouTube youtube.com/cdnrg

@canadian\_energy

## Capturing Varying Wind Energy

A wind turbine generates a different voltage/amperage at different wind speeds, so how does it produce usable power over these varying speeds? Do the power inverters or converters regulate a variable input voltage to a constant output voltage for usage, such as to charge a bank of batteries or feed the grid?

Paul Johnson • via email

There are actually a few different ways to convert the variable-frequency, variable-voltage three-phase “wild AC” from a typical wind turbine into a usable form, and the best choice depends on your application.

In most off-grid and grid-tied with battery backup systems, the turbine’s wild AC output is rectified to DC, which directly charges the battery bank. The only components between the wind turbine and battery bank are the turbine brake switch, rectifier assembly, and a DC circuit breaker. The batteries provide “control” by regulating turbine voltage down to their own level. This simple strategy works well until the battery bank reaches a full state of charge and can’t store any more energy. Unlike a PV array, a wind turbine can’t be disconnected from the battery bank—doing so could cause the turbine to overspeed and possibly be damaged. Most wind turbines must have an electrical load on them at all times.

The most common solution is to install a diversion-load controller (also known as a “dump-load” controller) connected directly to the battery bank to send any surplus energy into air- or water-heating elements. This keeps a load on the turbine while preventing overcharging and still provides a good three-stage battery-charging regime. A typical PV controller would shut down the flow into

the battery bank to prevent overcharging, while a diversion-load controller simply dumps it directly from the battery bank.

For grid-tied wind systems with no battery bank, new wind turbine control technologies were developed using grid-tied inverters and maximum power point tracking (MPPT) electronics that send energy directly to your loads and sell excess generation to the utility. These inverters are more complicated than MPPT inverters for PV since the turbine still must always have a load on it. With grid-tied wind inverters, you must program the power curve of the wind turbine into the inverter so it can adjust how hard it loads the turbine in rapidly changing wind conditions. A dump load is still required in case the grid goes down.

MPPT control can also give substantial power boosts, and allows you to “tweak” power curve settings for maximum performance—gaining 15% to 20% is common. One controller manufacturer, MidNite Solar, has developed an MPPT wind controller for battery-based systems so you can dial in that same extra performance

Dan Fink • Buckville Energy Consulting

## write to:

[asktheexperts@homepower.com](mailto: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.



# 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
- Batteries
- Wind generators
- Pumps
- Inverters
- Accessories and more

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

**800-383-0195** ▪ **[www.solar-electric.com](http://www.solar-electric.com)**

ELECTRICITY FROM THE SUN SINCE 1979



# 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.

# 2014

# Wind Turbine Buyer's Guide

by Ian Woofenden  
& Roy Butler

Without question, wind is a tough renewable energy resource to tap. The best wind resource is high above the ground, requiring tall towers. And it's an unforgiving resource, pounding on the equipment, which needs to be robust and requires regular maintenance. Building machines that can be productive while withstanding the rigors of life at tower top is no easy task. Add to this that uneducated customers want to keep costs down, and we end up with unrealistic expectations and market pressure for lower-quality equipment. What's a potential wind energy lover to do?

## The Manufacturers

The criteria for inclusion in *Home Power's* wind turbine buyer's guide are straightforward. We include all the turbines sized to serve the home-to-ranch scale wind market that have U.S. sales and support, have a track record and warranty, and have shown to experienced wind energy professionals that they are viable machines. There are other machines marketed in the United States—but the ones included here have stood the test of time, and/or have certification to appropriate standards.

This is a moving target in our small industry, where companies enter the market, then change hands, change product lines, or go bankrupt. It's not our intention to slight any model or company, or to favor any. We are trying to apply our experience combined with some objective standards to give *Home Power* readers the best shot at capturing wind energy successfully.

The machines in the table are ordered by swept area/diameter, from smallest to largest. In this article, the companies are listed alphabetically by company name. Information was supplied by the manufacturers themselves when possible, or estimated from manufacturers' marketing materials.

**F**irst, learn enough about the resource at your site, system design, and the equipment available, so you can approach the project with your eyes wide open. Then be realistic about the cost. Buying "cheap" is not the best idea in most cases—but with wind energy systems, it's a very bad idea indeed. The results of buying and installing on the cheap are nonproductive, short-lived systems.

David Laino's article on wind physics in this issue will give you the science background on the wind resource, and it will help fend off misconceptions and scams that ignore the physical realities of capturing wind energy. This article gives you specifications on the viable wind turbines in the U.S. market today, with background on the companies. It's a good start in researching what turbines might be best for you.

But this article is just a start—we recommend you seek information from a variety of sources. An experienced wind installer is a strong resource—consult with wind experts in person or at renewable energy conferences and workshops. And the Internet is a remarkable tool for finding out which turbines are actually working, and whether manufacturers are responsive and supportive.

## Bergey Windpower Co.

[bergey.com](http://bergey.com)

Bergey Windpower Co. (BWC) in Norman, Oklahoma, was founded in 1977 by Karl and Mike Bergey. The family-owned company is a worldwide supplier of small wind turbines in the 1 to 10 kW capacity range.

BWC wind turbines are known for their mechanical simplicity, robustness, and reliability. BWC has pioneered key industry technologies such as integrated direct-drive generators, passive controls, pultruded fiberglass blades, and custom airfoils, and offers the longest warranties in the wind industry. BWC directly manufactures its own components, and produces tilt-up and stationary guyed towers.

BWC has shipped more than 9,000 units since production began more than 30 years ago. President and CEO Mike Bergey identifies "reliability and low maintenance" as the special qualities of BWC's turbine line.

Excel 10



Excel 1



Excel 6



[homepower.com](http://homepower.com)

## Endurance Wind Power

endurancewindpower.com

Endurance Wind Power (EWP) is among the world's largest manufacturers of small- and medium-sized grid-tied wind turbines. Founded in 2007 and headquartered outside of Vancouver, Canada, the company has a global installed base of more than 600 turbines. EWP manufactures turbines in the 50 to 225 kW range in Canada and the U.K. This privately held company is 40% owned by its employees, who share a long-term commitment to the products and the people who invest in them.

The first EWP turbines were 5 kW S-series machines, designed by David Laino and Dean Davis of Windward. The company started growing rapidly when it purchased a larger machine from Energie-PGE of Quebec, re-engineered it, and began building the 50 kW E-3120—first for the United States in 2009, and then for the U.K. in 2010. Cofounder and principal engineer David Laino says, "We don't merely assemble turbines, we try to deliver products that are designed to work with the people associated with them, whether it's the owner, installer, neighbor, or investor."



E-3120

Courtesy Endurance Windpower

## Eocycle Technologies

eocycle.com

Founded in 2001, Eocycle Technologies has been a pioneer in developing permanent-magnet electric generator and motor solutions based on the transverse flux topology. Eocycle's generators and motors are well-suited for a variety of low-speed, high-torque applications in diverse markets, including wind turbines. For the past several years, Eocycle has focused on developing and fabricating a 25 kW direct-drive wind turbine for grid-tied wind energy applications.

The privately owned company's first three-bladed production unit went into service in January 2012, and there was a two-bladed version prototyped for almost two years. The company has produced 12 units to date. Eric Lafleur, director of sales and marketing, says that the machine offers a "combination of dependable energy production, minimal maintenance, and very quiet operation under all weather conditions."



25

Courtesy Eocycle Technologies

Courtesy Evance

## Evance

evancewind.com

British Evance was founded in 1999 by four engineers who had developed a 300 kW turbine, and took what they had learned to develop the Iskra AT-5 5 kW turbine, which was refined to become the Evance R9000. Evance is a privately owned limited corporation with key investors.

Evance has installations in the United Kingdom and Europe, the United States, and Australasia, with a network of resellers and installers around the world. The first 5 kW turbine model was launched in 2004, with the R9000 (latest model) launched in 2009.

More than 1,800 Evance turbines have been installed, and the machine is available in on- and off-grid configurations. Darrin Russell, Evance's support coordinator for the Americas, reports that "every turbine installed is still in the field operating, and that the patented reactive-pitch blades with a steel shaft running the entire length of the blades has resulted in zero blade failures."



R9000

## Gaia-Wind

gaia-wind.com

Gaia-Wind is a manufacturer of small wind turbines for moderate wind speed sites. Headquartered in Glasgow, Scotland, the company has grown from its original roots in Denmark to have representation throughout the U.K. and Europe, as well as Japan, Australia, Israel, the United States, and the South Pacific.

The privately held company produced its first wind turbine in 1993, and has more than 1,000 wind turbines installed. In Denmark, 77 Gaia-Wind turbines have been running for more than 10 years. As of 2014, the first turbine manufactured has been operational for 20 years.

Gaia-Wind operations manager Craig Jones says, "Our wind turbine is designed to generate high levels of energy from medium- and low- wind-speed sites, and is ideally suited to farms, rural homes, businesses, and organizations with significant land banks. The Gaia-Wind 133 turbine is the first U.K. product of this capacity to achieve the Microgeneration Certification Scheme (MCS) accreditation, an internationally recognized quality assurance standard."

133

Courtesy Gaia-Wind

## Kestrel Renewable Energy

kestrelwind.co.za

For its first seven years, Kestrel Renewable Energy (KRE) was operated from a small factory in Johannesburg, South Africa. All design and development was done by the original owner, James Carpy. In 2006, Eveready SA acquired the company. All Kestrels are completely manufactured in South Africa.

All of the models in Kestrel's line have been produced since 2004 and were upgraded between 2007 and 2012 with investment from Eveready. In the last 15 years, more than 5,000 Kestrels have been put in service around the world. According to Carpy, the Kestrel line includes "patented, highly reliable blade pitch control; a sealed generator with proper thermal management, heavy-duty construction, robustness; and general high reliability."



e300i



e400nb

Courtesy Kestrel Renewable Energy (2)

## Kingspan Wind

kingspanwind.com

Kingspan Wind acquired some of the assets from former wind turbine manufacturer Proven Energy of Scotland, and has combined patented, high-performance technology with long-standing expertise in the energy sector. The company is part of Kingspan Environmental, specializing in renewable energy generation, water management, and pollution prevention.

Original Proven (now KW3 and KW6) wind turbines have been in service for more than 20 years. More than 4,500 turbines have been installed in more than 60 countries, and on each continent. Kingspan marketing specialist Beata Paciejuk reports that, "Kingspan Wind turbines offer maximum energy capture and provide consistent optimum performance even in the fiercest of storms, due to their patented blade hinge design."



KW6

Courtesy Kingspan Wind (2)



KW3

37



100-24

Courtesy Northern Power Systems

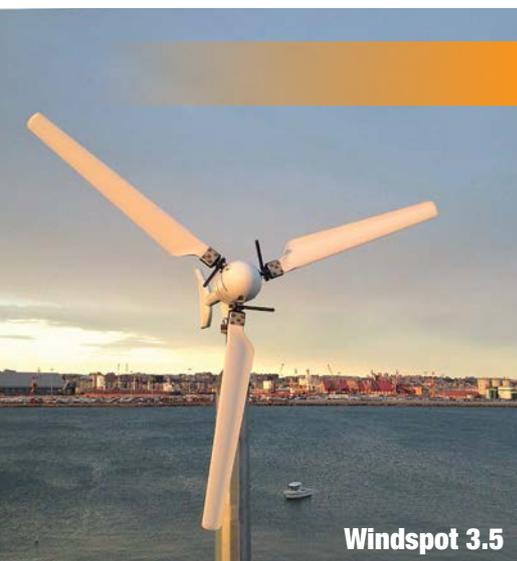
## Northern Power Systems

northernpower.com

Northern Power Systems (NPS) started in 1974 as North Wind Power Co. In 1978, North Wind developed its HR2 2.2 kW wind turbine. This small wind turbine soon gained international market acceptance as one of the most rugged, high-reliability wind turbines available. More than 600 HR2 (and its successor, HR3) wind turbines were sold over approximately 20 years of production.

In 2008, the Vermont-based, privately held company was acquired by its current owners, who have invested more than \$100 million into NPS's products and technology. Since then, NPS has sold more than 400 of its 60 and 100 kW grid-tied wind turbines.

Jesse Wijnberg, NPS global marketing manager, says, "Originally developed in partnership with NASA and designed for remote and isolated sites, NPS turbines have an innovative, gearless direct-drive design; permanent-magnet generator; best-in-class reliability; and pleasing aesthetics."



Windspot 3.5

Courtesy Sonkyo Energy

## Sonkyo Energy

usa.windspot.es

Sonkyo Energy produces the Windspot turbine and is a Spanish company that completed its first installation in 2009 and sold its first commercial units in mid-2010. The private corporation released three small wind turbine models—all three-blade, pitch-controlled, upwind, passive-yaw turbines. The company has more than 25 distributors, with offices and warehouses in Spain, Taiwan, and the United States. Turbine certifications are held for the United States, U.K., Japan, France, and Denmark. The company has installed about 1,000 wind turbines.

Sales manager Javier Vidal says, "Our products demonstrate simple efficiency and reliability at an affordable price. The greatest innovation in our wind turbines is a new, patented, variable pitch system. This straightforward design and the use of high-quality materials, such as stainless steel, anodized aluminum, and bronze, result in a smooth working mechanism even in the gustiest of situations."



VT10

Courtesy Ventera Wind

## Ventera Wind

venterawind.com

Ventera Wind was founded by the late Elliot Bayly, a legend in the small wind world who designed turbines under the Whirlwind and Whisper brands. Bayly's Ventera technology was purchased by North Coast Wind & Power, a privately held Ohio-based company, and Ventera Wind was formed in September 2011. Unlike most acquisitions in this industry, Ventera Wind has chosen to honor all previous warranties of Ventera Energy.

Ventera's original 10 kW wind turbine went into service in 2007. The new company modified the original version on several occasions to improve performance and durability, and to reduce noise. More than 200 turbines were in service as of December 2013.

Ventera Wind touts their turbines as being environmentally friendly due to their lighter weight and use of recycled metal. President Joseph Woods says, "All of the unneeded weight is designed out of the turbine; the main frame is made with 100% recycled aluminum; and there is some recycled material in the blades. Ventera Wind has done significant upgrades to the wind turbine. Every warranty claim is reviewed, with our asking, 'What can we do so this never happens again?' This has led us to our current model, which we predict to have a life expectancy of up to 30 years."

## The Table

The turbines in the table are sorted by size. The information in the table was supplied by the manufacturers, and we encourage buyers to confirm claims with information from impartial users and others who have direct, real-world experience.

**Name & website** are listed so you can explore their published information, and we encourage you to do so.

**Rotor swept area** in square feet lets you compare turbine collector sizes. This is the disk described by the spinning rotor—the area that intercepts the wind and collects energy. While there is wide variation in rotor effectiveness and efficiency and the gear behind them, the swept area is a great place to start when considering wind turbines. It's a reasonable comparative measure between turbines.

**Rotor diameter** is also handy for describing turbine size, though it's not as intuitive for comparison's sake. Dividing diameter in half to get the radius, the basic formula of  $\pi \times \text{radius}^2$  calculates swept area from rotor diameter.

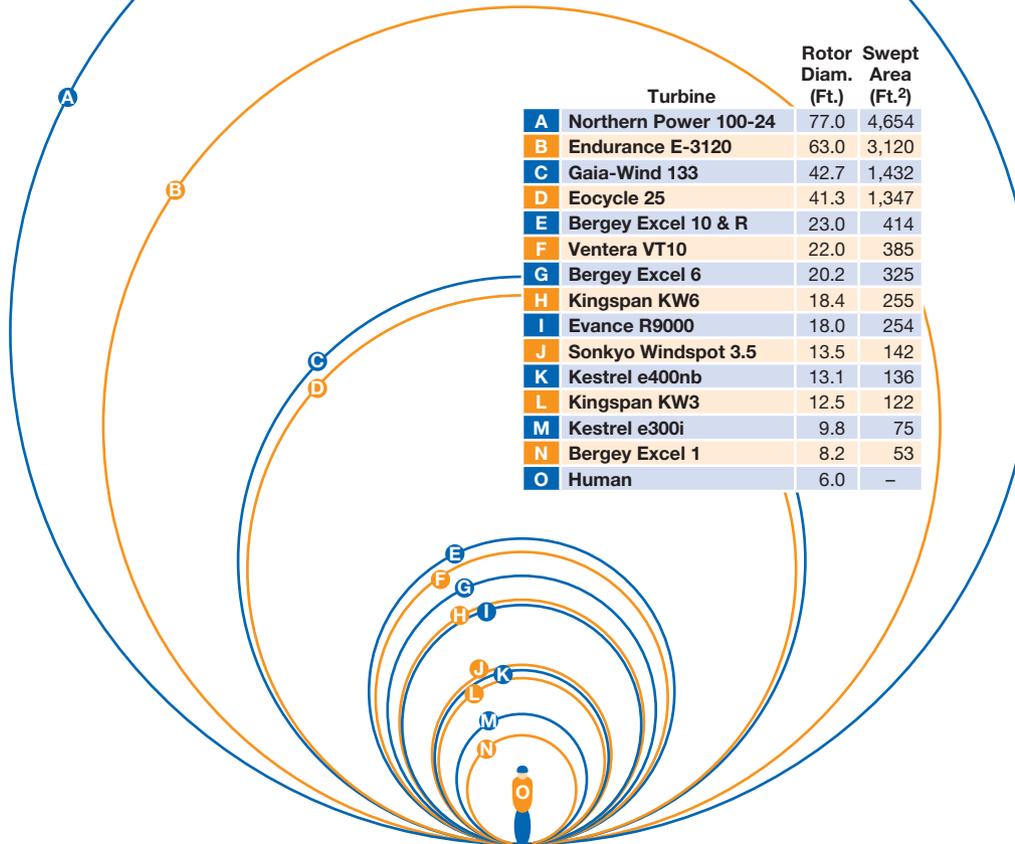
**Tower-top weight** may indicate the robustness of the turbine, and also is necessary information for installation equipment and infrastructure. Heavier turbines are typically more durable.

**Certification** indicates which certification(s) the turbine has, or if certification is in process. See the "Why Certification is Important" sidebar for more information.

**AWEA rated power** is in kW at 11 meters per second (25 mph). Note that this is power at only one point on the power curve. Comparisons between machines at any one point on the curve are not apples to apples. More useful are *energy* (kilowatt-hours) measurements at the average wind speed at tower top at *your* site.

**AWEA rated AEO** (annual energy output) in kWh at a 5 meters per second (11 mph) average wind speed. This is useful information for comparing, but is only at one average wind speed, while residential wind sites may range between average wind speeds of 7 to 13.

## Rotor Diameter & Swept Area



## Certification is Important

Certifying small wind turbines to meet established testing standards helps ensure consumer protection and promote small wind industry credibility by verifying data on wind turbine safety, function, performance, and durability. Not only does it allow the consumer or installer to evaluate turbines on a level playing field, it also helps prevent deceptive marketing and false claims. Various state renewable energy funding agencies now use certification to help determine a turbine's suitability within their incentive programs.

Various testing standards are in place around the world. For example, the AWEA 9.1 standard was developed for North America. In the U.K., the Microgeneration Certification Scheme (MCS) uses the Renewable U.K. Small Wind Standard. Because manufacturers of wind turbines typically operate internationally, global harmonization efforts are underway with a goal best described as "test once, certify everywhere." Reciprocity agreements between certification bodies help ensure that much of the work performed by one party is acceptable for certification by the other.

The newly formed Interstate Turbine Advisory Council (ITAC), an alliance of state clean energy programs and utility incentive providers, maintains the Unified List of Wind Turbines. Turbines on this list must be certified to either AWEA or MCS standards, and must also meet ITAC's warranty and business performance criteria.

Once turbine testing is complete, the test data is then examined by a certification body, such as the Small Wind Certification Council (SWCC), Intertek, or TÜV—a European certification organization. If the turbine has successfully met all the qualifications, a summary report is generated, which includes a turbine's rated power, annual energy production, power and energy curves, acoustic data, and duration testing, as well as a mechanical strength analysis, and safety and function testing.

—Roy Butler

# Wind Turbines

Turbine	Rotor Swept Area (Sq. Ft.)	Rotor Diameter (Ft.)	Tower-Top Weight (Lbs.)	Certification	AWEA Rated		Estimated AEO (kWh) at:		
					Power @ 11 m/s (kW)	AEO @ 5 m/s (kWh)	8 mph	9 mph	10 mph
<b>Bergey Excel 1</b> bergey.com	53	8.2	75	No	1.0 <sup>1</sup>	1,850 <sup>1</sup>	420	610	840
<b>Kestrel e300i</b> www.kestrrelwind.co.za	75	9.8	165	No	1.0	2,200	973	1,315	1,726
<b>Kingspan KW3</b> kingspanwind.com	122	12.5	420	No	2.5	4,700	1,704	2,438	3,494
<b>Kestrel e400nb</b> www.kestrrelwind.co.za	136	13.1	551	SWCC	2.5	3,930	890	1,895	2,817
<b>Sonkyo Windspot 3.5</b> usa.windspot.es	142	13.5	407	Intertek	3.2	4,824	1,040	2,455	3,635
<b>Evance R9000</b> evancewind.com	254	18.0	660	SWCC	4.7	9,160	3,467	5,039	6,856
<b>Kingspan KW6</b> kingspanwind.com	255	18.4	1,213	SWCC	5.2	8,950	2,400	4,950	7,200
<b>Bergey Excel 6</b> bergey.com	325	20.2	772	SWCC	5.5	9,920	3,963	5,582	7,470
<b>Venterra VT10</b> venterawind.com	380	22.0	500	No	7.0	11,800 <sup>1</sup>	5,037	7,630	9,369
<b>Bergey Excel 10</b> bergey.com	414	23.0	1,200	SWCC	8.9	13,800	4,924	7,124	9,850
<b>Bergey Excel-R</b> bergey.com	414	23.0	1,200	No	7.5 <sup>1</sup>	13,800	4,549	6,723	9,292
<b>Eocycle 25</b> eocycle.com	1,347	41.3	4,960	Pending	23.0	37,229 <sup>1</sup>	11,230	18,992	25,625
<b>Gaia-Wind 133</b> gaia-wind.com	1,432	42.7	1,984	MCS	10.7	27,502	10,700	16,275	21,840
<b>Endurance E-3120</b> endurancewindpower.com	3,120	63.0	8,800	SWCC Power Perf. <sup>2</sup>	56.8	116,935	41,516	65,214	88,913
<b>Northern Power 100-24</b> northernpower.com	4,654	77.0	17,600	TUV/ ITAC	83.5	170,000	na	104,900	130,750

<sup>1</sup>Reported by manufacturer. <sup>2</sup>AWEA standards only cover turbines up to 2,153 sq. ft.; this turbine has SWCC Power Performance Certification instead.

**Estimated AEO** is *predicted* for 8–14 mph average wind speeds. These can give you an idea of what energy production to expect at your site, assuming:

- Accurate measurement or prediction of the average wind speed at tower top.
- The numbers in the table are accurate—seek confirmation from unbiased sources before buying any machine (see “Source of AEO”).

This section of the table is perhaps the most useful because it can help you be realistic about what a wind turbine might produce at *your* site. Rated power (watts) or power at any specific point on the turbines’ power curves cannot give you this information.

**Source of AEO** is the source of the annual energy output data. The sources include data derived from the field-verified energy curves on the certified turbines—i.e., Certified Energy Curve; manufacturer-supplied data, such as from Windcad,

Bergey’s proprietary, Excel-based spreadsheet calculator; and the use of an AEO calculator, depending on the turbine.

**Rpm** is the turbine’s rotational speed at rated power. This may indicate two important aspects of the wind turbine’s performance. A lower speed for a similarly sized rotor usually translates into less wear and tear on the turbine, and less noise.

**Governing system** is the type of overspeed control. Turbines should have a method to protect themselves in high winds. Because wind power increases with the cube of wind velocity, enormous forces bear on a turbine in high winds. The top end of an accurate power curve can show you how well a machine protects itself. At regulation wind speed, the power curve of a furling machine will show a significant drop as the turbine turns itself out of the wind and slows down. In high winds, a machine with active blade pitching will show a flat line on the power curve, with little or no power reduction. Turbines with auto shutdown are designed to come to a complete stop.

# Compared

Estimated AEO (kWh) at:				Source of AEO	Rpm at Rated Power	Governing System	Grid-Tie Only (GTO) or Battery-Based (BB)	Governing Wind Speed (mph)	Cost for Turbine & Controls	Warranty (Yrs.)
11 mph	12 mph	13 mph	14 mph							
1,110	1,400	1,710	2,040	Windcad / Cert. En. Curve	490	Furling	BB	29	\$4,595	5
2,131	2,551	2,966	3,356	Estimated	650	Blade-pitching	GTO/BB	27	5,544 <sup>3</sup>	5
4,417	5,627	6,614	7,842	Manufacturer	300	Blade-pitching	GTO/BB	27	21,000 <sup>5</sup>	5
3,739	4,789	5,841	7,034	Cert. En. Curve	500	Blade-pitching	GTO/BB	27	8,579	2
4,790	5,975	7,393	8,672	Cert. En. Curve	250	Blade-pitching	GTO/BB	27	9,500 <sup>3</sup>	2
8,811	10,785	12,809	14,791	Cert. En. Curve	200	Blade-pitching / active yaw	GTO/BB	27	23,295 <sup>3</sup>	5
9,050	10,825	13,050	15,025	Cert. En. Curve	340	Blade-pitching	GTO/BB	27	31,000 <sup>6</sup>	5
9,536	11,667	13,850	16,325	Windcad / Cert. En. Curve	400	Furling	GTO	31–45	21,995	5
11,625	13,924	16,644	20,074	Manufacturer	250	Blade-pitching	GTO/BB	28	24,000	5
13,026	16,499	20,248	24,712	Windcad / Cert. En. Curve	400	Furling	GTO	31–45	31,770	10
12,114	15,008	17,922	21,125	Windcad	400	Furling	GTO	31–45	26,870	10
34,160	44,471	53,775	64,700	Manufacturer	90	Stall / active yaw	GTO	56	99,750	2 (ext. avail.)
27,450	30,990	35,870	40,530	Cert. En. Curve	400	Auto shutdown	GTO	56	110,000	5
112,611	137,334	162,289	186,458	Cert. En. Curve	42	Stall control / air brakes	GTO	56	272,375	5
159,600	185,550	238,700	254,875	Cert. En. Curve	57	Stall control	GTO	56	365,000 <sup>4</sup>	2 (ext. avail.)

<sup>3</sup>For battery-charging option. <sup>4</sup>Includes the 30- or 37-meter monopole or the 48-meter lattice tower; sold with tower. <sup>5</sup>Price includes 11 m tower. <sup>6</sup>Price includes 15 m tower.

**Governing wind speed** (mph) is the speed at which the machine is fully governed. Conservative designers choose to govern at lower speeds, knowing that long-term reliability is more important than capturing rare high winds.

**Grid-tie only (GTO) or battery-based (BB)** indicates whether the machines are designed for direct batteryless connection to the utility or are for battery charging. Battery-based systems can also be utility-intertied, but besides needing batteries, may need additional equipment. GTO machines will not operate without a live utility connection.

**Cost** is shown in U.S. dollars, but doesn't include shipping. Prices include various controls and sometimes even towers or more. Inquire with manufacturers for details of what you'll get for your dollars.

**Warranty** details should be carefully scrutinized to see what is covered, and what the fine print reveals.

## Do It Right or Not At All

Too many wind energy system owners end up disappointed because of poor research, unrealistic expectations, and less-than-robust design and installation. Here's our final advice, distilled from decades of experience installing, living with, and teaching about wind energy—and commiserating with other users:

**Don't buy cheap!** Wind turbines should last at least a few decades, but they live and work in a severe environment—and you can't just slap a bandage on them when they break. Get the very best you can afford.

**Understand the resource.** Get measurements or accurate predictions of the tower-top average wind speed on your site. Without this, you'll only be able to guess how much energy a wind turbine might produce.

**Go with tried and true.** Our combined (40+ years) of experience in the small wind industry has shown us that people, products, and companies come and go. It's hard enough to get reliable products and excellent support from the experienced companies in the industry. Expecting magic from a new designer or manufacturer is a recipe for disappointment or disaster.

**Install it well.** Even the best equipment from the best companies will be compromised if not installed properly. Cutting corners because of cost, convenience, or someone's "better idea" can cripple a "good" system.

**Maintain it!** One myth about small wind is that there are products that you can put up and then ignore. It's impossible to find such a beast. *All* wind turbines require regular inspection and maintenance. It may be only a loose bolt that you or the technician finds, but tightening it could make the difference between another productive year and a catastrophic failure. If you don't visit your wind turbine periodically, it will eventually come down to visit you.

**Enjoy!** We have wind turbines because they make electricity. But we may have other motivations too, including clean energy goals, a preference for local energy and independence, and just plain enjoyment. If you come to small wind with a lighthearted, forgiving attitude, you will ride out the inevitable challenges more gently, and appreciate the benefits even more.

## Access

Ian Woofenden (ian.woofenden@homepower.com) lives with and talks about small wind from his home in Washington's San Juan Islands. He is author of *Wind Power for Dummies*. Along with article coauthor Roy Butler and four others, he is one of the owners and coordinators of The Small Wind Conference, the premier annual event for the industry.

Roy Butler (roy@four-winds-energy.com) is the owner of Four Winds Renewable Energy. His home and business have been off-grid, powered by wind and solar electricity, since 1997. Roy is active in the small wind industry, sitting on a variety of boards and providing training for several organizations.

### Resources:

AWEA standards page • [bit.ly/WindStandards](http://bit.ly/WindStandards)

Intertek • [www.intertek.com/wind/small](http://www.intertek.com/wind/small)

ITAC • [bit.ly/ITACTurbines](http://bit.ly/ITACTurbines) • Unified list of wind turbines

Microgeneration Certification Scheme • [microgenerationcertification.org](http://microgenerationcertification.org)

Small Wind Certification Council • [smallwindcertification.org](http://smallwindcertification.org)

TUV • [bit.ly/TUVnelCert](http://bit.ly/TUVnelCert)



**"A GREAT VALUE"**  
**"BULLET PROOF"**  
**"RELIABLE"**

### HuP® Solar-One Batteries features include:

- Warrantied 80% Depth of Discharge (DOD) for 2100 cycles & 50% DOD for an estimated 4000 cycles. (More cycles & usable battery capacity)
- 10-year factory warranty: 7 year FREE cell replacement and 3 year prorated. (Still the best warranty)
- HuP® technology using the thickest positive plate (0.31") in the RE industry.
- Solid copper buss bars, stainless steel fasteners, and terminals with more than 9 square inches of surface area.
- 10 sizes from 845 A/H to the NEW 2490 A/H at the 20hr rate. (Reduces / Eliminates Paralleling)
- FREE shipping within the lower 48 states.
- Single, modern, and centralized distribution center with a continuous high flow of product ensures the freshest batteries.
- RE service for more than 17 years with over 99% customer satisfaction.



**HuP®**  
**SOLAR ONE®**  
**Batteries**

Contact your RE professional or  
Northwest Energy Storage  
800-718-8816 ▪ 941-474-0110  
[www.hupsolarone.com](http://www.hupsolarone.com)



# PowerSpout Hydro Turbines

- Online calculation tool for turbine/pipe/cable selection
- Eligible for ROOFIT – England and Wales
- On and off grid versions available
- Prices from \$799 to \$1999 each
- Global dealer network
- Freight included USA

**INCREASE IN FLOW**

**INCREASE IN HEAD**

## SPECIFICATIONS

- Head 1-130m (3-425 ft)
- Flow 0.1-55 l/s (2- 870 gpm)
- Warrantees up to 3 years and extendable
- FCC, CE, C-tick and international standards compliant
- Up to 1.6kW each and stacked up to 16kW for higher power applications

For more information visit our web site at [www.powerspout.com](http://www.powerspout.com)

## 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 every 10 seconds
- ✓ Brand with logos
- ✓ Highly Educational
- ✓ Cost effective, installs in minutes

- ✓ Dealers and installers manage all their installations from one view.
- ✓ Solar hot water and solar PV installers system status pages available.

**SPLASH** | Systems | Status | Account | Contacts | Fingerprints | Log Out

My System Statuses

Name	Now		Yesterday		Today		Lifetime		kWp	Status
	SW	kWp	SW	kWp	SW	kWp	SW	kWp		
Cathedral Grammar School	5.647	0.369	48.17	3.148	48.17	3.149	15234.97	995.75	15.3	<input type="radio"/>
CGS1	1.883	0.369	16.1	3.157	16.1	3.157	5075.84	995.263	5.1	<input checked="" type="radio"/>
CGS2	1.844	0.362	16.02	3.141	16.02	3.141	5073.55	994.814	5.1	<input type="radio"/>
CGS	1.917	0.376	16.05	3.147	16.05	3.147	5085.58	997.173	5.1	<input checked="" type="radio"/>
TOTAL	11.333	1.476	96.34	12.593	96.34	12.594	30566.28	3983	30.6	



Choose **SPLASH** to monitor your commercial or home systems today.

Dealer and distributor enquires welcome.

[www.splashmonitoring.com](http://www.splashmonitoring.com)

# The Right FIT

*Hardware Solutions for PV  
Systems on Pitched Roofs*



**Comment  
& Discuss**

this article @  
[homepower.com/161.44](http://homepower.com/161.44)

by Jeff Tobe

Courtesy ZEP Solar

Equipment innovations and new *National Electrical Code* criteria have led to wider choices in PV mounting systems. Here's a guide to help determine what mounting system is right for your modules.

Roof installations are often the most cost-effective option for residential PV applications and therefore typically the first area evaluated on a property, and that's the focus of this article. However, not all rooftops are appropriate for solar—there may be roof obstacles, such as vents and chimneys, which create too much shading; the underlying structure may not be sound; or the roof's location and/or orientation may not be suitable. (Look for upcoming articles on ground-, pole-, and awning-mounting systems in future issues of *Home Power*.)

### Mechanical Evaluation

The mounting product must be able to meet the location's wind and snow loads. Most building jurisdictions around the country have adopted some version of the *International Building Code (IBC)*, which provides guidelines and methodology for evaluating structures for their ability to withstand expected snow loads as well as the forces from wind and seismic events. Manufacturers of PV mounting equipment often supply an engineering analysis and calculations showing that their product meets certain load requirements. Within this engineering analysis, the manufacturer often supplies tables that summarize the engineering analysis into helpful reference charts. System installations with parameters outside the assumptions made in the report require additional evaluation to determine appropriate design, a service that many rack manufacturers offer.

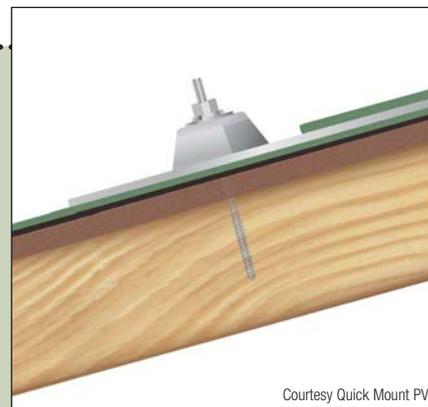
**Load ratings.** The first step in evaluating rack options is to collect basic site information necessary to utilize the manufacturer's load-rating charts. Site details include: building (or array) height from grade; wind exposure category; basic wind speed; snow load; and roof pitch. With this information, the rail span distance can be determined from the manufacturer's load charts. Wind exposure classifies surrounding terrain into categories depending on the amount of open space around the building. Most mounting products are rated to at least a category C exposure level, which applies to rural locations with lots of open topography around the building area. Basic (or design) wind speed is defined as the greatest 3-second burst of wind speed recorded for the area. This can be obtained by contacting the local building department. Snow load ratings are also available from local building departments. However, in mountainous regions, also take into account snow load advice from locals, since snowfall can vary widely depending on elevation and microclimate. Roof pitch defines the tilt for the PV array and can be measured with an inclinometer.

Most rack manufacturers provide professional engineered structural guidelines for the installation of their product, indicating the product has been evaluated to IBC requirements. Pre-approved product engineering analysis reports, specific to a state or region, provide assurance that a particular mounting product and installation parameters

## Example Lag-Screw Calculation

- Consult the rack manufacturer's design guide to determine uplift force (lbs./ft.<sup>2</sup>) in your area for your roof. This example assumes 50 lbs./ft.<sup>2</sup>
- Determine PV array area in square feet:  
10 modules × 15 ft.<sup>2</sup> per module = 150 ft.<sup>2</sup>
- Calculate force on PV array:  
50 lbs./ft.<sup>2</sup> × 150 ft.<sup>2</sup> = 7,500 lbs.
- Determine force per attachment point:  
7,500 lbs. ÷ 12 attachment points = 625 lbs. per attachment
- From the chart, look up lag screw withdrawal (pullout) capacity for <sup>5</sup>/<sub>16</sub>-inch-diameter lag screw & southern pine rafter:  
307 lbs. pullout capacity per inch of thread depth
- Determine lag penetration depth:  
625 lbs. ÷ 307 lbs./in. = 2.04 in. of thread depth required

Larger-diameter lag screws or more attachment points will allow shallower thread depth, if needed.



Roof-mount post showing <sup>5</sup>/<sub>16</sub>-inch screw threads biting into a rafter.

Courtesy Quick Mount PV

## Lag-Screw Withdrawal Design Values

Wood Type	Specific Gravity	Pullout Capacity (Lbs. per In. Thread Depth)				
		1/4 In. Diam.	5/16 In. Diam.	3/8 In. Diam.	7/16 In. Diam.	1/2 In. Diam.
Southern pine	0.55	260	307	352	395	437
Douglas fir, larch	0.50	225	266	305	342	378
Lodgepole pine	0.46	199	235	269	302	334
Redwood (close grain)	0.43	179	212	243	273	302
Spruce	0.42	173	205	235	264	291

Source: American Wood Council

Notes: Side-grain penetration; thread depth does not include tapered tip or the threadless portion of the screw shank. Table values include a 1.6 safety factor.

## Frameless Modules

Frameless PV modules, such as Lumos Solar’s LSX series and Trina Solar’s PDG5s, are gaining traction beyond traditional thin-film options. Trina Solar’s frameless modules (and Silicon Energy’s Cascade series, which are only framed on two sides) have a standard sheet of glass on top of the cells but instead of a plastic back-sheet, use another layer of glass on the back. Double-glass construction earns these PV modules a Class A fire rating, and they may be the only modules suitable for installation in certain jurisdictions (for example, in urban-wildlife edge zones in California).

Frameless PV modules have both aesthetic and economic advantages. Without the frame, they can have a very low roof profile, and with “clear” or “black” back-sheets, they blend in better with the roof. Rail mounts for frameless modules include integrated wire management, providing excellent weather and critter protection and good cable organization (without cable clips and wire ties). Frameless PV modules can also eliminate an equipment-grounding conductor for PV modules, and eliminate attaching ground lugs, orienting WEEBs, and managing long runs of ground wire. With no frame edge and lip for debris or snow to catch on, these modules can stay cleaner and more easily snow-free.

However, frameless module mounting systems must be matched to the specific module, while mounting systems for framed PV modules have the advantage of being relatively product-neutral. Look for more universal mounting solutions to be developed to deal with frameless modules.



Shawn Schreiner

have been reviewed by a third party to meet site-specific load conditions. It can decrease the amount of time and cost associated with this portion of the permitting process.

Local jurisdictions may enforce additional codes. For instance, the 2012 *International Fire Code (IFC)* has new requirements for setbacks and access pathways that may limit the available roof area for installing PV modules.

### Installation Details

Once the necessary structural and engineering criteria have been met, the next step is to analyze the mounting product for ease of installation.

**Roof-mount rail span.** The load design calculations determine rail span—the distance between attachment points required for each rail. This distance also dictates the location and number of roof attachment points—a key aspect of array layout. Stronger rail systems can allow greater spans between the attachment points, reducing the number of roof penetrations as well as the installation time. Fewer attachments also translate into material and cost savings. Typical rail spans can range from 4 to 10 feet, although this will vary by location. Installations with heavy snow or wind loads often have a rail span closer to 4 feet to account for increased force on each attachment point. While roof-mounted systems installed in milder climates may be able to span 6 feet or more between attachment points. With basic

## Example Rail Span & Cantilever Length

Wind Speed (mph)		Snow Load (Lbs. per Ft. <sup>2</sup> )										
		0	10	20	30	40	50	60	70	80	90	100
90	Span (in.)	96	92	80	72	66	62	58	52	50	46	44
	Cantilever (in.)	48	46	40	36	33	31	29	26	25	23	22
100	Span (in.)	88	86	76	68	64	60	56	52	50	46	44
	Cantilever (in.)	44	43	38	34	32	30	28	26	25	23	22
110	Span (in.)	80	80	72	66	62	58	54	52	50	46	44
	Cantilever (in.)	40	40	36	33	31	29	27	26	25	23	22
120	Span (in.)	74	74	68	64	60	56	52	50	48	46	44
	Cantilever (in.)	37	37	34	32	30	28	26	25	24	23	22
130	Span (in.)	68	68	66	60	56	54	52	48	46	44	44
	Cantilever (in.)	34	34	33	30	28	27	26	24	23	22	22
140	Span (in.)	64	64	62	58	54	52	50	48	46	44	42
	Cantilever (in.)	32	32	31	29	27	26	25	24	23	22	21
150	Span (in.)	60	60	60	56	52	50	48	46	44	42	42
	Cantilever (in.)	30	30	30	28	26	25	24	23	22	21	21

Source: DPW Solar, for P8 Preformed Line products

information regarding local conditions including roof pitch, building height, wind speed, exposure category, and snow load, the rail span can be determined by utilizing the tables and charts provided by the manufacturer.

Using the example rail span table, we see that the maximum rail span between attachment points is 92 inches, given the following conditions:

- Basic wind speed: 90 mph
- Snow load: 10 psf

A snow load of 20 psf would require reducing the maximum rail span to 80 inches.

**Attachment details** will depend greatly on the roof material and the specific mounting product. There are four basic residential roof surfaces: *asphalt shingles*, *metal roofing*, *tile*, and *slate*.

Asphalt roof installations require attachment to the building rafters or trusses via using lag screws or hanger bolts (a lag-type screw with an end threaded to receive a nut instead of having a head). In areas with heavy snow loads, using two hanger bolts per attachment may be necessary. The hanger runs up through a mounting base and attaches to the L-foot or standoff post. This entire assembly needs to be properly flashed before attaching mounting rails. Attachment hardware and flashing options may be offered as accessories or these products can be purchased from manufacturers that specialize in flashing components. Quick Mount PV products cover a wide variety of roofing applications including a couple of options for asphalt shingle roofs. Ejot is another option for attachment and flashing products.

Metal roofing comes in three different types: standing seam, corrugated, and exposed metal fastener roofs (aka classic rib profile or Pro-Panel). Mounting a PV rail system



Courtesy Quick Mount PV (2)

**Quick Mount PV offers flashing solutions for many roof types. Left: The Quick Hook for tile roofs is designed for flat and S-shaped tiles, and requires roofing battens.**



**The QBBase and Shake & Slate mount is made for wood shake and slate roofs, and used with 18- by 18-inch flashing.**

to a standing-seam roof means no roof penetrations—special clamps are attached to the “rib” profile of the standing seam area where two roofing pans are connected. The clamp provides an attachment point for connecting rails or directly mounting modules. S-5! offers a variety of products to match various standing-seam profiles as well as an option for rail-free mounting. EcoFasten Solar offers standing-seam clamp products and SnapNrack also has an option for its roof-mount product.

Exposed metal fastener and corrugated metal roof panels require specialized solutions. Many products require attachment to metal purlins below the roofing surface. Renusol offers a product for this roof type that enables attachment directly to the rib profile via roofing screws. Hanger-bolt attachment systems may not be appropriate for these metal roof types due to challenges and inconsistencies between the layout of rafter and rib profiles.

For tile roofs, standoffs, which may be tile roof hooks or posts threaded onto a hanger bolt, must be tall enough to clear the profile of the tile. Tile roof hooks can often be installed without drilling or notching tile pieces, simplifying the installation process. However, with this option, verify the deflection that may occur from snow and wind loading at the site. Excessive deflection can cause clearance issues underneath the array and may be a concern for module warranty regarding permissible deflection.

**Leveling rails & securing modules.** Once the attachment points are set, the rails are leveled and bolted down (see “Leveling & Squaring Your PV Array” in *HP150*). On a less-than-level roof surface, specifying adjustable attachments may be important in a mounting product. One unique solution is Zep Solar’s leveling foot, which enables fine adjustment to the foot height through a jackscrew integrated into the foot assembly. Other products, such as offered by



**This flashed mount uses a hanger bolt to screw into the roof structure and attach to the rail.**

Courtesy Quick Mount PV

**Mount hardware for standing-seam metal roofs relies on the roofing panels that are secured to the underlying roof structure.**



Courtesy S-5!

SnapNrack, have leveling capability as part of the interface between the rail and mounting foot or post.

Securing PV modules to the rail seems straightforward—set a module on the two rails and clamp it down. However, performing these seemingly simple tasks while working on a pitched roof or scaffolding high above the ground can be challenging. Products with fewer parts and “captive” hardware, such as Zep Solar’s integrated mounting products, offer ease and speed-of-installation advantages. For typical rail systems, look for hardware like DPW Solar’s RAD bolt, which can be placed into the rail at any point. The RAD bolt also has a “twist and lock” feature to ensure proper orientation and avoid pullout during the torquing process.

**Hardware options.** Additional hardware considerations include rail splices and module clamps. Universal end clamps are relatively standard these days and universal mid-clamps are also becoming prevalent, which can help reduce part inventories and minimize complications from matching clamp sizes to specific modules. Telescoping rails can eliminate the need for cutting rails to length, reducing installation labor.

Corrosion concerns can also influence rack selection. Ensure hardware materials are properly rated to withstand environmental conditions at the site. Mudge Fasteners offers a line of Dura-Con components that meet anticorrosion criteria. Stainless steel has superior corrosion resistance compared to galvanized products and can match the PV system’s 30-plus-year life. However, stainless hardware can also be prone to “galling,” which essentially welds the bolt and nut together if impact drivers are used. Antiseize coatings can be applied during assembly to prevent galling and aid future disassembly—but this can be messy and time-consuming.

Significant corrosion can develop anywhere the copper ground wire comes into contact with aluminum rails, module frames, and other rack components. Over time, this may cause high resistance at connections and potential failure points within the grounding system, reducing the

**This mounting system provides both vertical and horizontal rail adjustment, using one bolt to secure the rail and clamp the rail hardware to the post.**



Jeff Tobe

intended level of protection. In humid climates, dripping water from copper ground conductors can be enough to damage surrounding components. One solution suitable for coastal climates is Wiley’s WEEBs (see “Grounding Options,” below) and other integrated grounding products that provide a bond between the module frame and mounting rail while minimizing the amount of exposed copper wire.

**Grounding methods.** Three equipment grounding methods are common:

- The classic method is to attach a ground lug to each PV module and run a bare copper ground wire between them all, terminating at the combiner box or a rooftop junction box. Rails also require a bond to ground and can be included in the run with separate ground lugs. But



Courtesy SnapNrack

**Well-designed captive hardware allows placement anywhere along the length of the rail.**

**A universal midclamp (right) and end-clamp (below).**



Courtesy Dave Strenski (2)

## Making PV Even Prettier

For residential roof applications, improving the appearance of the PV array involves matching existing rooflines and material colors. Black anodized mounting components and module frames blend well with many asphalt shingle roof surfaces. Array skirts offer a finished look while minimizing debris and critter access, but may reduce airflow around the array and somewhat affect performance.

Another detail influencing overall aesthetics is the amount of space between the array and roof. Ultimately, the gap size will balance function (improved airflow for better module cooling) and aesthetics. For good performance versus aesthetics, a space of 4 to 6 inches is recommended.



Array skirts can dress up an array but can impact airflow, decreasing array performance.

of the PV array. Corrosion concerns are minimized due to the protected contact point and the overall reduction in copper wire. However, not all module and mounting products are listed for this grounding method—some module frames and rails may lack adequate surface area for the teeth on the WEEB to properly seat between the module frame and mounting rail.

- A newer equipment grounding method, such as from Zep Solar, integrates the equipment-grounding function into the assembly of the mounting system. Railless mounting systems have the mounting and grounding means built into the module frame and associated hardware that make a grounding connection and serve as the mechanical



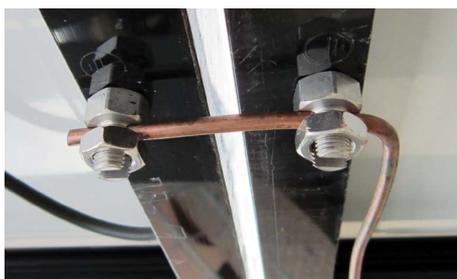
Courtesy Zep Solar

**Railless mounting systems incorporate the mounting and grounding means into the module frame and hardware.**

this is a time-consuming method and costly to install on a residential roof installation. In addition, the connection between the bare copper wire and ground lug is exposed to the elements and can be vulnerable to corrosion, especially in marine environments.

- Another method uses a “washer electrical equipment bond” (WEEB)—stainless steel washers with piercing teeth that bite into both the rail and the module frame to form an airtight bond when tightened. The WEEB is placed between the module frame and mounting rail before tightening down the module, and eliminates the need to make ground-wire connections on the underside

**A neatly installed module ground wire. Care must be taken to ensure the copper doesn't touch the rails, module frames, or other nonstainless hardware.**



Jeff Tobe (2)

**Ground straps help ensure grounding is continuous through rail splices.**

attachment. A single stainless ground lug, which can be installed virtually anywhere on the module frame, grounds the entire array or subarray. When installed close to the combiner or junction box, a couple of feet of copper ground wire may be all that is necessary.

Another method is for traditional rail-mounted systems to incorporate module clips with piercing teeth to establish the electrical bond. This may be the most straightforward grounding method of all, eliminating almost all possibility of installation error and providing a good solution to this long-time installation challenge. IronRidge has an auto-grounding module clip with teeth that pierce both the anodized rail and module frame (see “Gear” in this issue). Several other products, such as Zilla’s Top Clip, eliminate the need for installing a ground lug on every module.

Because these integrated grounding products are new to inspectors and AHJs, there can be confusion regarding compatibility between various modules and rack products. To provide some clarity, Underwriters Laboratories (UL) has proposed a new testing standard (UL2703) to accompany the NEC requirement that all mounting systems employing integrated grounding must be listed for that purpose. This proposed standard incorporates electrical safety and corrosion testing, but defers the mounting system’s structural aspects to the IBC.

**Wire management.** Effective wire management strategies are essential to a smooth installation that remains trouble-free for years to come. Integrated wire management trays or channels for protecting the module interconnect and home-run wiring are available. Depending on the product, there may also be room for the bulky microinverter cables or multiple sets

of home-runs. For example, SnapNrack rails have a wire management channel with a protective cover that slides into the extrusion to contain homerun wiring.

If the mount does not include effective wire management, then additional strategies will be necessary. Stainless steel clips are available in various sizes and configurations to accommodate USE-2 and PV wire, as well as most module frames. Heyco offers a variety of wire-management cable clips. Common solutions for roof-mounted systems include some combination of cable clips and wire ties. Many rack products have an open channel, which can help secure conductors. Hellerman Tyton offers a variety of wire management solutions as well.

**Other considerations.** DC optimizers and microinverters introduce new challenges for rack systems, since few rail profiles are large enough to accommodate their bulky conductors. Stay within the allowable bending radius of the cable (defined by Article 300 of the NEC) and properly secure all connection points to minimize stress on the connections. Additional wire management strategies will likely be needed. Burndy, Heyco, and Hellerman Tyton offer wire clips specifically for these larger cable sizes. Wire trays, EPDM clamps, and wire ties with protective coatings are additional options.

### Online Configuration Tools & Purchase Factors

Some manufacturers offer configuration tools to help system integrators specify proper rack components. Depending on level of sophistication, the user may be able to change virtually any design aspect with the simple click of a button. Start out by selecting module manufacturer and model.

**Wire management built into the rails makes for a neater, quicker installation. The plastic clip helps keep the cabling confined within the rail.**

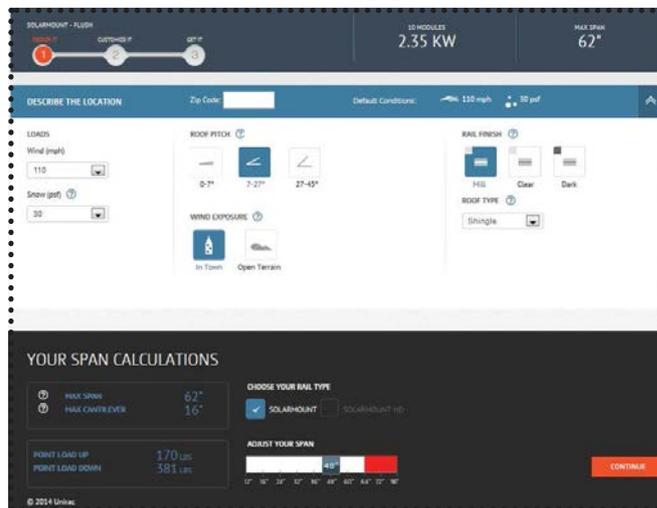
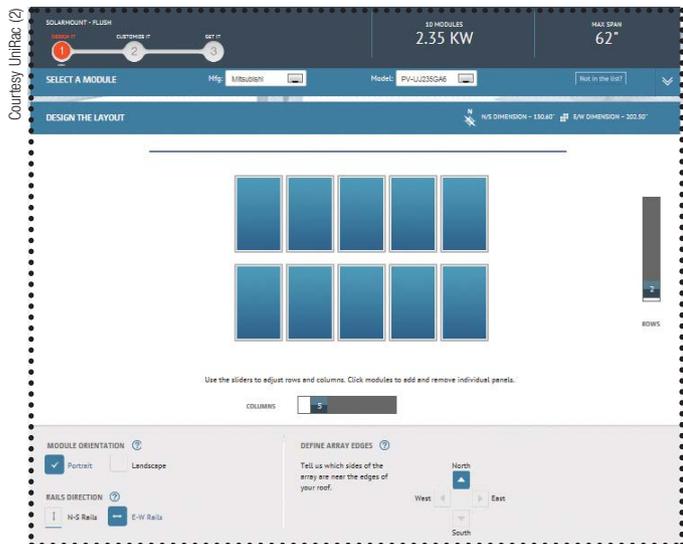


Courtesy SnapNrack



Jeff Tobie

**Like PV modules, microinverters or module-level MPPTs require grounding and wire management.**



Some rack manufacturers offer free online configuration tools for designing a mount system.

Next, PV array layout is confirmed by determining the module columns and rows as well as orientation (portrait or landscape). Some programs also allow the designer to define edge zone areas of the array layout.

Environmental inputs include snow load, wind speed, exposure category, and roof pitch. Default values are sometimes based on your ZIP code and most of these tools enable operator adjustment for customized solutions. Some often display key output parameters, such as rail span and expected force per attachment point, for quick comparison between various options. Designers can also select accessories for the mounting system, which may include grounding options, flashing and attachment options, edge screen, and microinverter kits.

Once all of the design criteria have been entered, a bill of materials can be generated along with a total. This information can be exported as PDF and/or data files for use in the overall design package.

Warranty and reliability should be important considerations in purchasing decisions. As with any product, the warranty is only as good as the company behind it.

### Access

Jeff Tobe (jeff@solarenergy.org) is a PV curriculum developer and instructor at Solar Energy International (SEI). He helped develop SEI's PV lab training facility in Paonia, Colorado, and works on renewable energy projects for indigenous communities. He is an IREC certified PV Instructor, is NABCEP-certified in Technical Sales, and is a NABCEP-certified PV installer.

### Manufacturers:

- Direct Power & Water • [dpwsolar.com](http://dpwsolar.com)
- EcoFasten Solar • [ecofastensolar.com](http://ecofastensolar.com)
- Ecolibrium Solar • [ecolibriumsolar.com](http://ecolibriumsolar.com)
- Ejot • [ejot-usa.com](http://ejot-usa.com)
- Hellerman Tyton • [hellermantyton.us](http://hellermantyton.us)
- Heyco • [heyco.com](http://heyco.com)
- IronRidge • [ironridge.com](http://ironridge.com)
- Lumos Solar • [lumossolar.com](http://lumossolar.com)
- Mounting Systems • [usa.mounting-systems.info](http://usa.mounting-systems.info)
- Mudge Fastener • [mudgefasteners.com](http://mudgefasteners.com)
- Quick Mount PV • [quickmountpv.com](http://quickmountpv.com)
- PV Racking • [pv-racking.us](http://pv-racking.us)
- Renusol • [renusolamerica.com](http://renusolamerica.com)
- S-5! • [s-5.com](http://s-5.com)
- Silicon Energy • [silicon-energy.com](http://silicon-energy.com)
- Snake Tray • [snaketray.com](http://snaketray.com)
- SnapNrack • [snapnrack.com](http://snapnrack.com)
- UniRac • [unirac.com](http://unirac.com)
- Zep Solar • [zepsolar.com](http://zepsolar.com)
- Zilla • [zillarac.com](http://zillarac.com)



# BATTERY SYSTEM MAINTENANCE & REPAIR

by Carol Weis & Christopher Freitas

Good design and installation practices are essential to a well-functioning inverter–battery system, but that is only a start. This article will review the ongoing battery maintenance that is crucial to a system’s longevity.

## Adding Water

For flooded lead-acid (FLA) batteries, it is critical to check the electrolyte level on a regular basis. As batteries charge, some water in the electrolyte is converted to hydrogen and oxygen gas, and released through the vent caps. The electrolyte needs to be replenished to the proper level by adding distilled water.

In cool climates such as Washington State, a system with a moderate C/10 charge rate should be checked every one to two months. In hot climates like Haiti, the electrolyte level needs to be checked at least twice a month.

Recording the date and the amount of water added to the battery allows you to identify usage trends and spot potential problems. Batteries in hotter climates will use more water than ones in cooler climates, as will systems with heavy discharging and higher charging rates. When a battery starts requiring more water, it is typically a sign that it is failing—or that something has dramatically changed in the charging or load profile. Keeping track of the changes in water consumption will help determine when it’s time to replace the battery or investigate other problems.

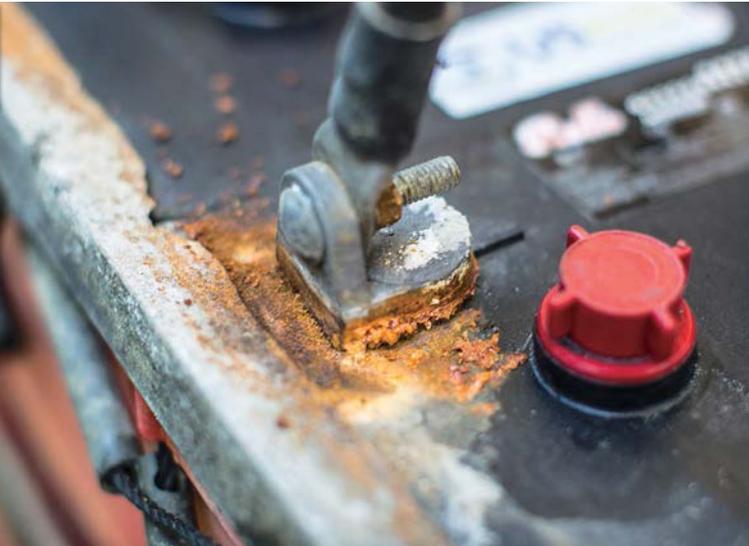
The correct electrolyte level is usually about 1/4 inch below the vent tube. Adding water to a battery cell should be done only after charging the battery to 100% or after an equalization charge has been completed. However, if the plates inside the battery are close to being exposed (which can cause permanent damage to the battery), add enough water

to keep them covered before recharging. However, be careful not to overfill during recharging or equalization. Otherwise, the electrolyte can overflow, making a hazardous mess. Losing electrolyte and replacing it with distilled water results in dilution, effectively reducing the battery’s capacity and, therefore, its performance. Automatic watering systems and recombination caps can reduce the time required for refilling batteries. However, most of them require removal before doing an equalization charge on the batteries.

**Add distilled water to the batteries to about 1/4 inch below the bottom of the fill tube. Always wear eye and skin protection.**



Courtesy whattookyousolong.org for USAID (2)



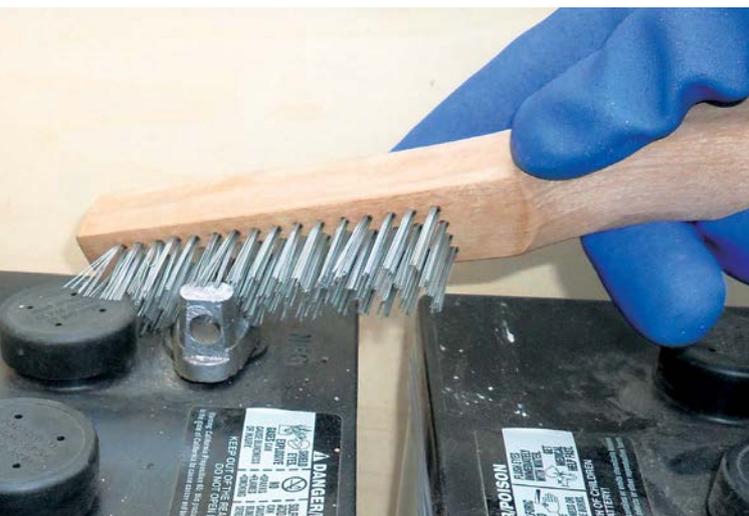
**Corrosion between a battery terminal and the metal frame of a battery rack creates a potential path for current, which could create a ground fault or shock hazard.**

### Cleaning Battery Terminals

Corrosion can occur on and between the cable lugs and the battery terminals, creating higher resistance that impedes the flow of current when charging or discharging. Corrosion can also occur between battery terminals and the metal casing of the battery rack, potentially resulting in ground faults and creating a shock hazard.

If even only one terminal has corrosion, the high resistance on that series-connected string of batteries will result in less charging and discharging. Specifically, the other battery strings will compensate for the loss of total capacity, and be charged and discharged at higher rates. This will create imbalances within the battery bank, reduce system performance, and decrease the life and performance of the entire battery bank.

**Take the time to make all battery terminals and cable lugs clean and bright before connecting the cables.**



Carol Weis (2)

Courtesy: whatlookyouare.org for USAID (2)



**Excessively corroded battery connections can have enough resistance to affect a battery's performance, both when charging and discharging, and result in reducing a battery's performance and life.**

During the monthly inspection, check all battery connections for corrosion. If there's a metal rack or enclosure, also check for corrosion between the terminals and the metal. If caught early, it can be removed with a wire brush without much effort. If excess corrosion is found covering the terminal and hardware, shut down the system by removing all charging and discharging connections from the battery, disassemble the battery hardware and cables, and thoroughly clean the terminal, hardware, and cable lug. A baking soda and water mixture can be applied to the corroded areas, which can then be scrubbed with a wire brush. However, be extremely careful that none of the baking soda mixture gets into the battery cells, as it will neutralize some of the electrolyte, reducing the battery's performance. Finally, rinse all of the baking soda off with clean water and dry with a clean rag.

Before reconnecting the battery cables, wire-brush the terminals until the lead is shiny, tighten the connection, and then cover the terminal and cable with an anticorrosion coating—the best is a spray-on type that dries upon contact. Common petroleum jelly can also be used, but it can attract dust and dirt, and will be a sticky nuisance to deal with when checking the terminals for tightness.

**Petroleum jelly can protect terminals against corrosion, but also may attract dirt and makes using a wrench on them messy.**





Courtesy Laura Walters

**Accidental short-circuiting between battery terminals can damage a battery and result in severe injury—always use insulated tools when working with batteries.**

## Checking Connections

The bolt and nut connection needs to be tight enough to fully compress the split-type lock washer (which should always be included, along with two flat washers). The bolt should be tight enough that the cable lug cannot be moved on the terminal when pulled. Battery manufacturers will specify torque values for their terminals. Typical torque levels for 1/4-inch hardware is 6 foot-pounds; for 5/16-inch hardware it's 11 foot-pounds. Be careful when using metal wrenches on the battery as it is very easy to accidentally cause a short circuit to adjacent terminals. Using specially made, insulated tools or, at the very least, wrapping the handle of the wrench with insulating tape, is highly recommended. Some tips for making battery connections are:

- ❑ Always use stainless-steel hardware to connect cables to terminals.
- ❑ Always clean the terminal posts and cable lugs so that they are shiny prior to installing the connections.
- ❑ Always include flat washers to prevent the bolt and nut heads from digging into the soft lead terminals and copper cable lugs (but do not place them between the cable lug and the battery terminal).
- ❑ Always include a split-type lock washer to help keep the bolted connection tight.
- ❑ Always use an anticorrosion coating over cleaned connections, and reapply the coating after retightening or replacing cables.

## INITIALIZATION CHARGING FOR NEW BATTERIES

When installing a new battery bank, check and record each battery's voltage, specific gravity (SG), and polarity. This will provide a basis for later comparison. Next, fully charge the battery bank according to the manufacturer's recommendations. This "initialization" or "activation" charge ensures that the battery cells start at an equal voltage and that all sulfation is removed from the plates. Different manufacturers recommend different charge parameters for the initialization charge, so be sure to check the specifications for your particular battery.

## Recharging & Equalizing the Batteries

One of the most critical factors in maintaining good battery health is regularly charging the battery to a full state of charge. Ideally, this should be done once a week.

No matter the cause—an undersized PV array, running excessive loads, or not having a secondary energy source for extended cloudy periods—undercharging batteries can permanently harm them over time. When batteries are not fully charged, sulfate crystals form on the lead plates' surfaces. This reduces the contact area between the lead and the electrolyte, decreasing the battery's capacity. Sulfate crystal buildup can become an irreversible condition that will worsen until the battery is unusable.

An intentional overcharging—called equalization—helps remove the sulfation from the battery's plates. Equalization charging is a process where the battery is intentionally overcharged to bring weaker cells up to parity with stronger cells and should only be done with FLA-type batteries. During equalization, the battery's cells will gas vigorously, mixing up the electrolyte and eliminating stratification. Most sophisticated inverter/chargers and PV charge controllers have an equalization function, which allows the charging source to charge the battery for a timed period and achieve a preset, high-voltage setpoint. During equalization, closely monitor the electrolyte's level and temperature—and be prepared to shut down the charging when the equalization is finished or if the temperature exceeds 125°F (52°C).

During the monthly or quarterly maintenance checks, measure and record the battery's voltage and each cell's specific gravity. A SG difference of 0.025 or higher between cells indicates an equalization charge is needed. To perform an equalization charge on an FLA battery:

- ❑ Draw a diagram or label each battery cell with a reference number.
- ❑ Charge the batteries through the bulk and absorb stages before starting the equalization process.
- ❑ Measure and record the voltage and SG of each battery and cell.

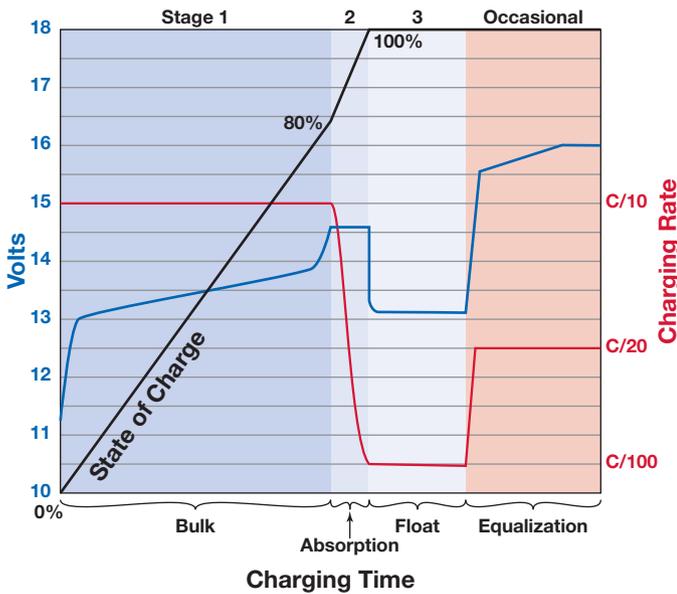
**A battery meter is crucial to monitoring your battery bank's electrical state.**



Courtesy whattookyousolong.org for USAID

# CHARGE & EQUALIZATION

For a 12-Volt FLA Battery



- Choose the cell on each battery string with the lowest SG reading as a pilot cell—these will be the cells tested to determine when equalization is complete.
- Check the electrolyte level in each cell to make sure the battery plates are covered.
- Initiate the equalization charge.
- Check and record SG readings of the pilot cells every half hour.
- Check electrolyte levels to ensure that they never fall below the top of the plates.
- Check temperatures of the batteries' electrolyte every 30 minutes to make sure it never exceeds 125°F (52°C). Stop equalization if this temperature is exceeded.
- Stop equalization when the SG reading in the pilot cells stays constant for three readings.
- Water each cell to 1/4 inch below the vent tube and replace the caps.

## Typical Specific Gravity & State of Charge

Specific Gravity	% Full
1.255 – 1.275	100%
1.215 – 1.235	75%
1.180 – 1.200	50%
1.155 – 1.165	25%
1.110 – 1.130	0%

# SAMPLE EQUALIZATION TABLE

24 V System: Two Strings of 6 V Batteries

		Pilot Cells: SG*								
		Start SG	0.5 Hours	1.0 Hours	1.5 Hours	2.0 Hours	2.5 Hours	3.0 Hours	End SG	
String 1	Battery 1	A	1.268						1.274	
		B	1.258						1.270	
		C	1.270						1.275	
	Battery 2	A	1.263						1.272	
		B	1.252						1.268	
		C*	1.235	1.239	1.244	1.248	1.255	1.265	1.265	1.265
	Battery 3	A	1.255						1.270	
		B	1.259						1.275	
		C	1.257						1.273	
	Battery 4	A	1.248						1.265	
		B	1.259						1.270	
		C	1.265						1.275	
String 2	Battery 5	A	1.260						1.272	
		B	1.245						1.270	
		C	1.240						1.268	
	Battery 6	A	1.255						1.273	
		B	1.250						1.270	
		C	1.252						1.273	
	Battery 7	A	1.270						1.272	
		B*	1.229	1.237	1.239	1.250	1.257	1.258	1.258	1.258
		C	1.250						1.269	
	Battery 8	A	1.268						1.273	
		B	1.266						1.274	
		C	1.258						1.267	
Max. Temp. (°F)		65	68	75	82	88	94	96	98	

\*This example assumes which are the two pilot cells—yours will likely be different.

Not all users will want or be able to check the electrolyte's SG on a monthly or quarterly basis. A more general method is to set a predetermined routine equalization maintenance on a monthly, quarterly, or biannual basis without checking either voltage or SG. To keep it simple once the equalization process has started, charge time can be set depending on the battery bank and charger's size, and how often the batteries are charged to 100%. The amount of time typically will range from two to five hours.

## Daily Monitoring

If it's your first time dealing with a battery-inverter system, it will take some time to understand the ebbs and flows of the system's readings in a "normal" day of charging and discharging, and recognize if something is wrong. Checking the battery's voltage and state of charge every day can provide a valuable orientation to the system—you'll begin to understand what is (and isn't) normal.



Courtesy whattoockyoualong.org for USAID

Keeping good records is part of good battery maintenance, and can help you identify trends and spot problems if they occur.

## WHY BATTERIES FAIL

Batteries can fail for many reasons, so it is important to make the right choices during design, installation, charging setup, and maintenance. Here is a list of the most common causes of battery failures.

**Poor system design.** Incorrect ratio of charging source to load; not enough or too many batteries for charging source and load; incorrect cable sizes or type.

**Poor installation practices.** Inadequate ventilation of battery box or putting it in direct sunlight; loose crimps on cables; loose connections at terminals; no initialization charge; incorrect battery temperature sensor placement.

**Overcharging batteries.** Incorrect inverter or charge controller setpoints; no temperature compensation; excessively hot environment; too high a charge rate for the type or size of battery.

**Undercharging batteries.** An increase in loads; not enough charging capacity for reaching 100% SOC; no temperature compensation for cold conditions.

**Not reacting quickly enough to a battery cell failure.** When one battery cell fails, this often results in the remaining battery cells being severely overcharged and overheating.

**Lack of maintenance.** Not cleaning corrosion on terminals; lack of watering; not checking and maintaining the correct battery temperature sensor placement; not keeping cable connections tight.

**Lack of training.** Not providing the appropriate instructions and materials to end users or maintenance technicians; not providing an easy-to-understand operator guide in the local language with clear, graphic instructions.

**Overdischarging batteries.** New loads added to the design; loads used for more time than the original design; new people interfacing with the system who do not understand the system's limitations.

## Monthly Maintenance Checklist

Using a monthly battery-inverter maintenance checklist can help you stay organized and help you pinpoint recurring issues with your battery system.

### Battery/Inverter:

- Clean corrosion from battery terminals and cable ends.
- Clean tops of batteries.
- Clean the inverter fan filter.
- Check electrolyte levels, and add water if necessary.
- Keep track of water additions—an increased need for water may indicate increased cycling or a failing battery.
- Check to see if surge (lightning) protectors are intact.
- Check inverter(s) for error and event indicators.

**Battery Temperature Sensor**—Each month, visually inspect the battery temperature sensor (BTS), its cable, and its connection to the inverter:

- Check the adhesion of the sensor on the battery case.
- Verify that the sensor is in the proper place on the battery's side.
- Verify that the sensor is in an interior location in the pack or enclosure.
- Check for breaks, nicks, or tears in the cable from the BTS to the point of connection at the inverter or charge controller.
- Make sure the BTS cable's inverter connection is not damaged or corroded, and that its protective insulation is still intact.
- Verify that there's no dust, dirt, corrosion, or insects in the BTS's connector at the inverter.
- Verify that the BTS is connected to the correct inverter.
- Verify a reasonable battery temperature is displayed, based on ambient or battery temperature.

## Common Battery Problems & Solutions

**The battery bank has a mixture of strong and weak individual batteries, and is close to the end of its life.** Group the strong batteries in one string and group the weak batteries in another string. This will ensure a more even charging and will allow the strong batteries to contribute more when the system is discharging.

**One cell or battery has a low voltage and a low specific gravity.** Remove that cell or battery and charge it separately using a power supply or battery charger. Another option is to equalize the entire bank, but this may require too much time and can put a lot of stress on the good cells in the battery.

**A battery is requiring frequent watering.** When there is a failing battery or cell, the "good" cells in the battery

*continued on page 58*

## THE OTHER END OF THE CABLES

# ...INVERTER MAINTENANCE

With minimal maintenance and kept in the right environment, modern inverters can operate for more than a decade. You can ensure reliable, long-term performance by keeping them clean, keeping electrical connections tight, and ensuring that they have enough airflow to keep them cool.

### Clean the Air Filter

Some inverters have a cooling-air intake with a protective filter to keep out debris. Over time, the filter can become clogged. Periodically remove the filter and—away from the inverter—shake it to remove any loose material. The filter can be further cleaned by washing it with water or blowing it out with compressed air.

### Check for Rodent & Insect Damage

Good installation practices can prevent insect and rodent problems. In tropical areas, which have many insect issues, using a sealed inverter is a good idea. Mounting the inverters vertically (with the AC compartment at the top) can also stymie rodents, which may be attracted by heat. A vertical configuration also allows better airflow around the inverters. Keeping all of the covers on the inverter's DC and AC boxes also prevents damage from chewing or nesting critters.

### Check the Wires & Cables

The entire system's performance is dependent on proper wire size and type, and the quality of the connections. At least once a year, thoroughly inspect all of the connections—with all sources of power off—as follows:

- Do a "pull test" to make sure that wires are secure in the terminal blocks.
- Look for wire insulation discoloration at connections. This can indicate a high-resistance connection.
- Look for signs of melted terminal blocks. This indicates a loose connection or excessive current.
- Properly retorque all screw terminals and bolted connections to the manufacturer's recommended specifications.

An example of a dust filter that needs a good cleaning by removing it, and shaking, blowing, or washing it out.



Courtesy Laura Walters

Attracted to the glow of the LED indicators, these moths worked their way into the inverter's wiring compartment and could cause damage over time.



Courtesy Laura Walters



Christopher Freitas

Periodic inverter maintenance includes verifying and/or retightening terminal screws to the manufacturer's torque specification using a torquing screwdriver.

**Check indicators and review data.** Any error or warning messages or indicators need to be recorded, along with the date and time they occur. If the error or warning condition persists, the information should be provided to appropriate technicians who can help troubleshoot.

Depending on the configuration and components included in the system, stored data may be useful in analyzing the system's performance and for troubleshooting problems. The method for accessing the data and the format of the data varies with each manufacturer, but most offer a method for downloading the data to a connected computer or saving the data onto an SD card for transfer to someone who can complete an analysis.

Check monitors regularly for battery voltage and state of charge, as well as any error codes.



Courtesy whatnoyoure solving.org for USAID



**Left: Overcharging can result in excess gassing and loss of water. Exposed plates will oxidize and the battery will be permanently damaged.**



**Right: Undercharging can result in electrolyte stratification and/or sulfation (shown) and a damaged battery.**

Carol Weis

Courtesy Surette Battery

can be a viable option. Be sure to fully charge the new cell or battery before adding it, and check all of the cells frequently to ensure that there is not a problem with the new cell or battery becoming out of balance with the others. In an older battery, a failed cell or battery indicates that the entire battery is at the end of its life and needs to be completely replaced.

**Poor crimps on cable lugs or loose connections on battery terminals.** Loose connections or poor crimps on cable lugs will cause high resistance. This causes the battery's voltage to appear higher when recharging, resulting in the charger shutting off before the battery is at a 100% full level. It will also cause the voltage to appear lower when the battery is discharging, resulting in the inverter shutting off earlier than it should when running loads. Check that all the cable lugs are properly crimped and that all the connections are tight.

## Access

**Carol Weis** (cweis@sunepi.org) is a NABCEP-certified PV installer and ISPQ Master PV trainer. She writes curricula and teaches national and international PV classes to technicians and end users. She has worked as a licensed electrician and solar installer in Colorado, and was part of Solar Energy International's PV technical team for 15 years.

**Christopher Freitas** (cfreitas@sunepi.org) is an engineer and project manager for international RE projects. He was a cofounder of OutBack Power Systems and was the director of engineering at Trace Engineering.



*continued from page 56*

string will become overcharged and will often require more frequent watering compared to the rest of the battery. The damaged cells cause the other good cells in the battery to be overcharged. Investigate the entire battery bank to identify which cells are having problems.

**One failed cell.** If the battery bank is in good overall condition (verified with voltage, specific gravity, and load testing) and is less than two years old, replacing just the failed cell or battery

  
mounting systems

## Sigma II GO Kits

Open terrain racking in a new, easy-opening package

- For installations up to 50 kW
- Prepackaged version of the popular Sigma II
- Available for ballast, post-on-pier, post-in-pier and earthscrew foundations
- Wide range of configurations available
- Extensive preassembly makes installation fast and easy

**Mounting Systems, Inc.**  
PV mounting systems for any application  
Global engineering- Manufactured in the USA and Canada

Mounting Systems, Inc. • Toll-free 1-855-731-9996 • info-us@mounting-systems.com • [www.mounting-systems.com](http://www.mounting-systems.com)

**Come see us!**  
PV America East  
Booth 128  
& Intersolar NA  
Booth 9511





# INSTALL AN OFF-GRID SOLAR PV SYSTEM WHILE ON VACATION!

*"Probably the most well-balanced trip I've taken and an unforgettable experience. Buy the ticket, take the ride."*  
 - Jesse Nickerman, Volunteer

**Sign up for a trip to Nicaragua:**  
 August 9-17, 2014  
 October 25-Nov 2, 2014

[gridalternatives.org/international](http://gridalternatives.org/international) | [international@gridalternatives.org](mailto:international@gridalternatives.org)



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



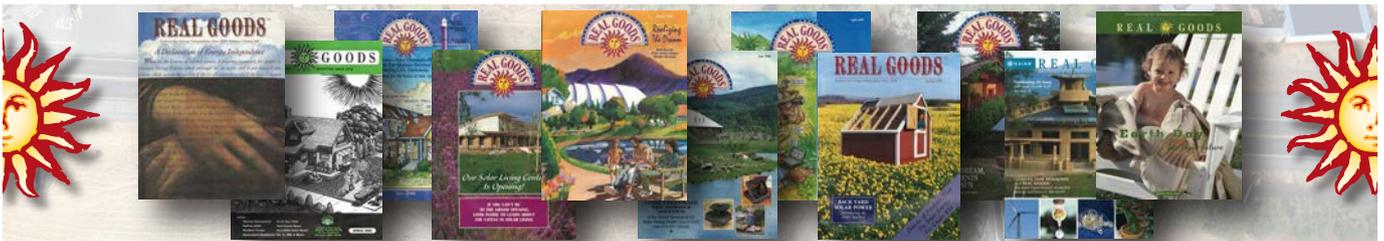


**WWW.REALGOODS.COM**

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



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.



## CELEBRATING 35 YEARS OF SUSTAINABLE EMPOWERMENT

# SWH Collector Diagnosis



## with Thermal Imaging



Having issues with solar water heating (SWH) collector performance? A thermal imaging camera can simplify the diagnosis.

### Story & photos by Vaughan Woodruff

Last year, a homeowner with a five-year-old SWH system contacted me for a second opinion. She told me that the designer claimed she was expecting too much, but she was sure that the system had produced more hot water when it was first installed.

Upon arrival, I performed an initial system inspection. The fluid pressure was within the normal operating range for an antifreeze-based, closed-loop system. The differential controller settings were reasonable, and the flow meter indicated that the pump was circulating the heat-transfer fluid (glycol) at an appropriate flow rate. After verifying that the temperature sensor in the storage tank was properly installed and operating, I headed outside to inspect the collectors on the roof.

### Collector Maintenance Issues

Diminished collector performance can result from a variety of factors. In systems in which potable water is heated directly by the collectors, calcification in the collector or pipes may occur due to high-mineral-content water. Deterioration of the absorber surface may occur depending upon the quality of the absorber coating and the age of the collector.

Most flat-plate collectors tend to be quite durable but will show deterioration toward the end of their service life. These issues may include leaks where the riser tubes are joined to the headers or failure of the bond between the riser tubing and the absorber plate. There may also be issues related to failure of the glazing seal.



**A barium getter coating is used to sustain the vacuum in an evacuated tube and can identify tubes that have lost their vacuum. The shiny barium in the tube on the left indicates that the vacuum is still intact. The getter in the tube on the right has turned white, indicating that it has been fully exhausted and that the vacuum has failed.**

Evacuated-tube collectors are inherently less durable. This is primarily due to the type of glass used (nontempered borosilicate or soda-lime glass) and the need for the collectors to maintain a vacuum to ensure proper performance. A crack or leak around the seal of an evacuated tube will lead to the loss of vacuum, rendering the tube ineffective. When evacuated tubes are manufactured, a barium getter is fired inside the vacuum. If there is oxygen remaining in the tube after the vacuum has been created or there is a small leak, the getter will serve to maintain the vacuum by consuming this oxygen. The getter is typically made of barium, which is silver. As the getter absorbs oxygen, it becomes barium oxide and turns white. The silvery surface is an indicator of the integrity of the vacuum.

While the barium getter can provide visual confirmation of whether or not the vacuum is intact, it is not always simple to observe whether the getter is still present. For instance, some tube manufacturers apply the barium on the tubing behind the absorber. With collectors mounted on tilted racks, the getter can be observed from behind. But the getter on parallel-mounted collectors, which lie close to the roof, may be difficult to observe. Other manufacturers apply the barium getter to the lower end of the tube.



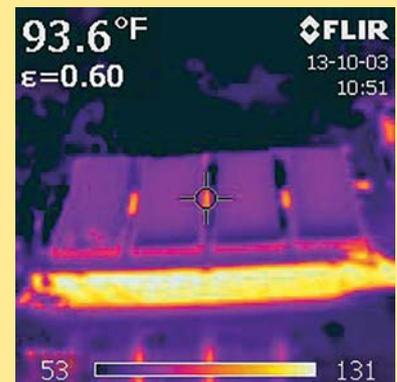
**A neoprene boot or other style of end cap is typically placed over this end of the tube to help protect it where it is secured to the mounting rack. The boot also can conceal the getter.**

## Camera Settings

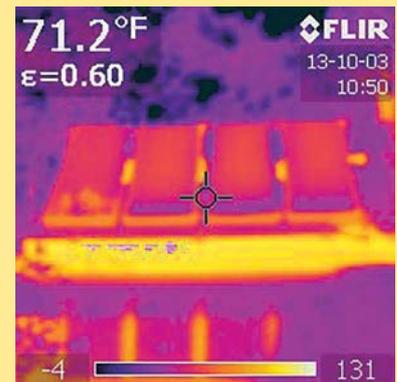
Like a standard digital camera, an infrared (IR) camera has automatic settings. Instead of adjusting for different levels of light, these settings are based on the levels of infrared radiation.

Two of the settings are the *span* and the *level*. The span is the range of temperatures being measured. When the span is large, it is more difficult to differentiate between small temperature variations. For instance, if the span is set at 50°F, there will be less color distinction between temperatures that differ by 10°F than there would be if the span were set at 15°F.

The level is the temperature at the center of the span. If the span is 20°F and the level is 80°F, for example, the camera will display temperatures ranging from 70°F to 90°F. An image's span and level can be adjusted using the manual settings on an IR camera. Adjustment may provide a better contrast of colors than in automatic mode.



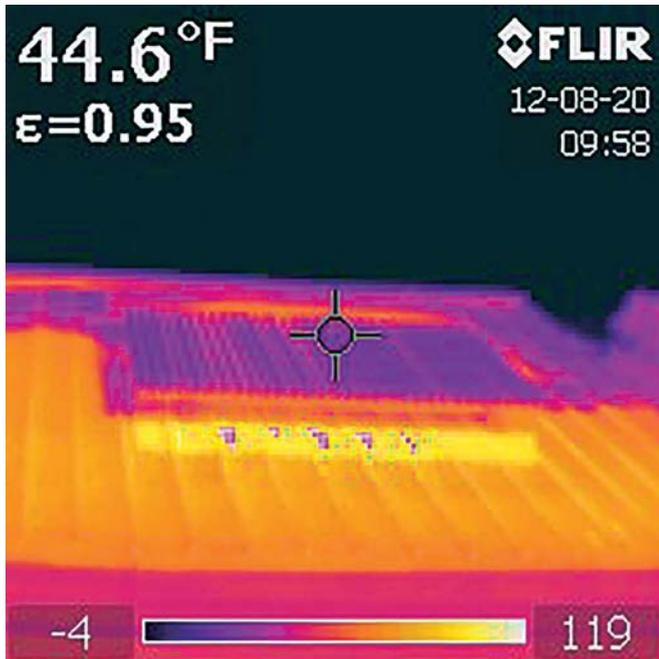
**Two images of the same flat-plate collectors, taken with different span and level settings. By adjusting the camera's settings, details in the important temperature ranges can be accentuated.**



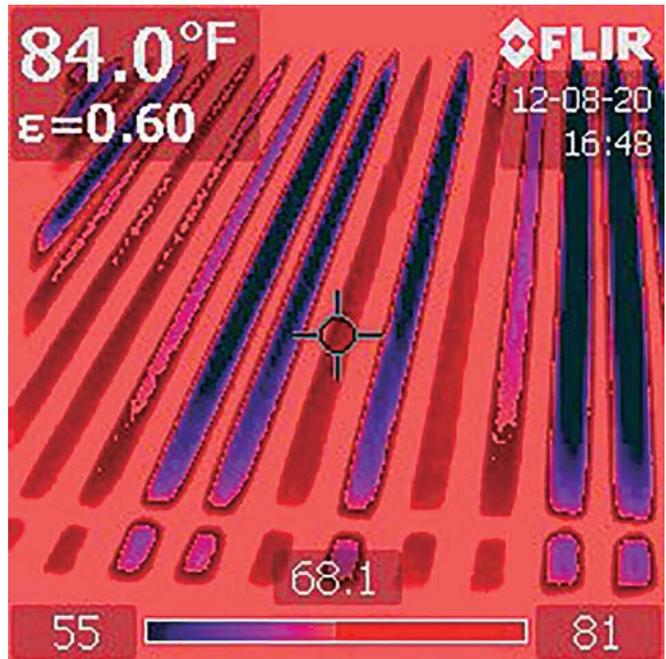
## Troubleshooting with the IR Camera

Infrared cameras are particularly effective at diagnosing issues with evacuated-tube collectors *without* needing to go on a roof. Where standard cameras capture visible light, IR cameras capture infrared radiation and indicate the heat with color or shades of gray. A properly configured IR camera can indicate the surface temperatures of various objects, including solar collectors.

Although not as prevalent, issues with flat-plate collectors can be diagnosed with IR camera technology. If there is a significant variation in flow between two banks of collectors,



An infrared image of a collector (taken from the ground) shows problem tubes, which appear as a lighter pinkish-purple color. After adjusting the camera's span and range, an image taken at closer range (from the rooftop) reveals more details.



The evacuated tubes that show up on the IR image as dark blue or purple have a lower surface temperature, which indicates the integrity of the vacuum and heat pipe. The dark-red tubes indicate a failed vacuum, heat-pipe issue, or both.

the bank with the higher flow will have a cooler surface since the heat is being removed faster compared to the bank with the slower flow rate. In large banks of flat-plate collectors, the flow through the collectors may be uneven. An IR camera can diagnose whether the center of the bank is hotter than the outer edges as a result of uneven flow rates. In older flat-plate collectors, an IR camera may be able to assist with diagnosing the detachment of the absorber from the riser tubing or failure of the glazing seal by illustrating temperature variations on the collector glazing or indicating higher temperatures around the seals.

IR cameras are especially helpful in diagnosing problems with evacuated-tube systems, since evacuated tubes that have lost their vacuum will have a warmer surface temperature than ones that are intact. This is due to the loss of insulation that occurs when the vacuum has failed. If the getter is difficult to observe due to the boots on the tubes or its location, or if accessing the roof is a challenge, an infrared camera can save time and avoid the risks of climbing on the roof.

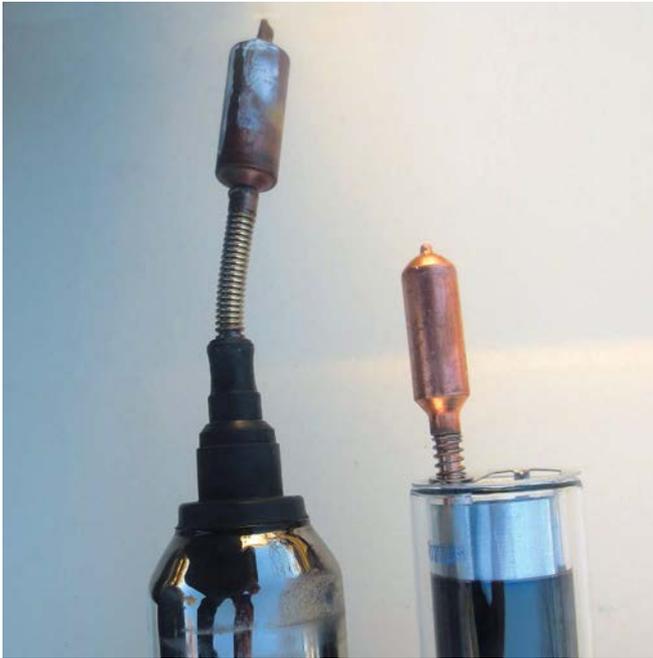
An infrared camera can also be used to diagnose issues that are not visible. For example, some brands of evacuated-tube collectors have showed manufacturing or durability issues with their heat pipes—thin copper tubes that contain a small amount of liquid within a vacuum. The vacuum allows the fluid to boil at roughly 85°F. The vapor rises to the condenser bulb, where it transfers heat to the cooler heat-transfer fluid in the manifold. This condenses the vapor into liquid, which sinks back to the bottom of the heat pipe. But if the heat pipe loses its vacuum, the fluid won't boil until it reaches a much higher temperature, causing the heat-pipe efficiency to drop dramatically.

As a result, since much higher temperatures are required to vaporize the liquid, the tubing in a failed heat pipe is hotter than one that is working properly. However, the condenser bulbs are cooler, because the vaporization and condensation cycle is not occurring. This additional heat is revealed by the IR camera when compared to one that is working correctly. This difference is also detectable at the condenser bulb, which is unable to reach standard operating temperature since the fluid in the heat pipe is often unable to boil and accumulate the same level of heat in the condenser bulb.

When I received my client's initial call, I was well aware that the model of evacuated tubes in her system had a history of heat-pipe failures. Since the roof was easily accessible, I removed a random selection of tubes from the array to compare their performance to a new tube. Before I placed the tubes in the sun, I wrapped the condenser bulb of each heat pipe with black stretch-and-seal silicone tape, which won't leave a residue on the condenser bulb.

Visual inspection revealed small cracks in some of the heat pipes, likely due to freezing of the fluid inside. Other failures occurred at the seam between the heat pipe and the condenser bulb; these failures were revealed by the IR camera.





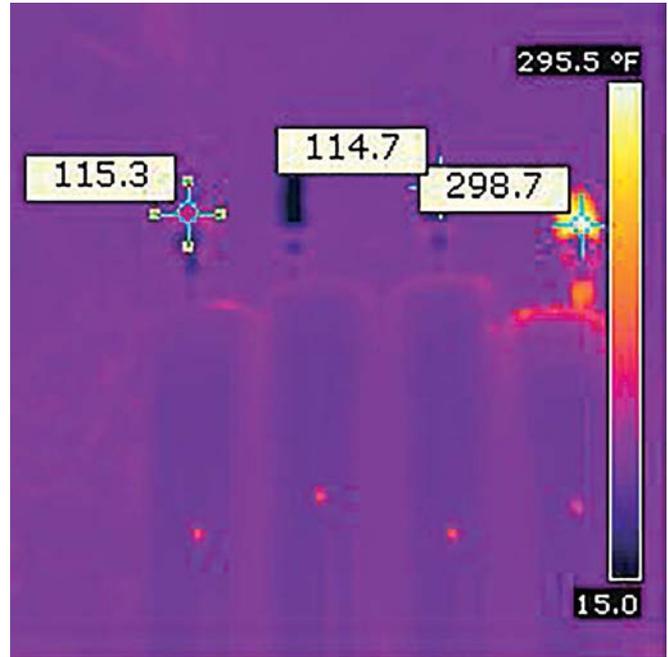
Two different types of condenser bulbs. The heat pipe on the left uses a snap switch that isolates the condenser bulb from the heat pipe if overheating occurs. The condenser bulb on the right does not have this feature and transfers heat to the manifold continuously.

The infrared radiation measured by the camera is a combination of the IR radiation emitted by, transmitted through, and reflected by a surface. Since the copper heat pipe is smooth and shiny, it reflects a significant amount of IR radiation. Without the silicone tape, it would have been difficult to measure the actual condenser bulb temperature due to the reflected infrared radiation from the cold sky. Flat, black surfaces are less reflective, hence the black silicone tape.

Upon an initial visual inspection, I spotted a few heat pipes that had a small rupture at the bottom of the heat pipe, likely due to a freeze failure. Outside of the minority of the heat pipes that exhibited this issue, most of the heat pipes appeared fine. However, the IR camera indicated otherwise. After allowing the tubes to sit in the sun for 15 minutes, I measured their temperatures with the IR camera. The new heat pipe had a condenser bulb temperature of nearly 300°F. The condenser bulbs from the three evacuated tubes I had removed at random from the array had temperatures ranging from 115°F to 120°F. The huge difference in temperature illustrates the importance of the vacuum in the heat pipe. Without the vacuum, the fluid in the heat pipe is unable to boil and cannot provide significant heat to the condenser bulb.

A few months later, I received a call from another homeowner about a poorly performing system—a single 30-tube collector mounted parallel to a standing-seam metal roof. I was unable to observe the barium getter in each tube since it was hidden by the absorbers, and access to the array was precarious.

From a ladder, I was able to take IR photos of the tubes. I manually adjusted the camera's span and level (see "Camera



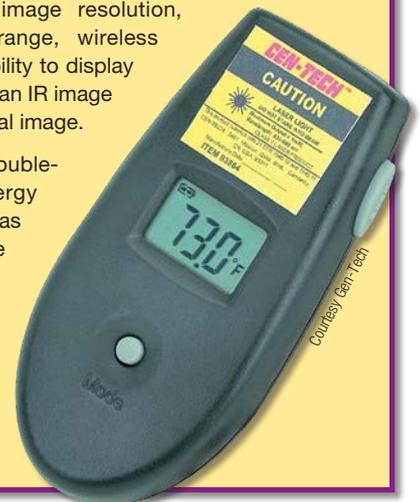
The temperature of the condenser bulb in the functional heat pipe (far right) exceeded the temperatures of those in the failed heat pipes. The IR camera is reading the temperatures of the silicone wrap; the dark areas shown on the heat pipes in the IR photo are where the copper is reflecting the cold sky.

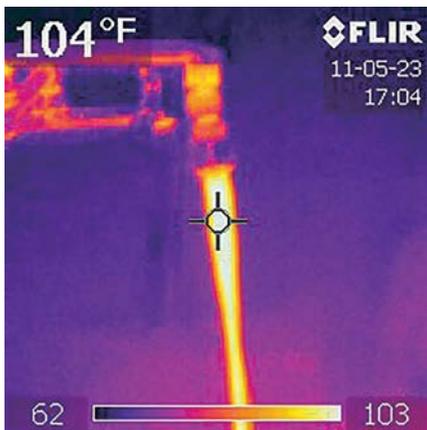
## IR Thermometers vs. Cameras

Infrared (IR) camera technology is similar to a handheld infrared thermometer, which can be used to measure the temperature, but only at a specific point. The advantage of an IR camera is its ability to display all temperatures within a camera field of view, making it easier to identify temperature irregularities within a larger swath.

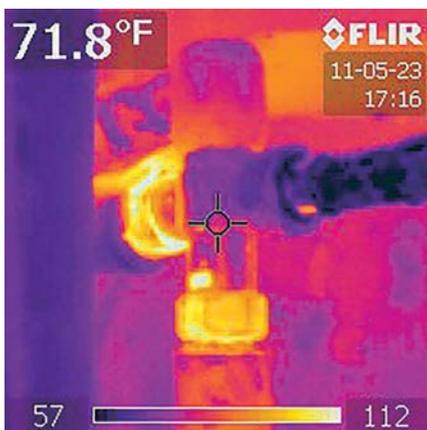
But this added functionality comes with a price. An IR thermometer can be purchased for \$40 to \$100, while a one-day rental of an IR camera will likely cost \$150 or more. New IR cameras start at roughly \$1,200. More expensive models provide features such as greater thermal image resolution, wider temperature range, wireless connectivity, or the ability to display a picture-in-picture of an IR image within a standard digital image.

Firefighters, solar troubleshooters, and energy auditors use IR cameras regularly. If you are considering using an IR camera for one-time diagnostics, consider borrowing or renting the equipment.





Using an IR camera to check water temperature at a hot water fixture. The water temperature was well below the temperature expected from the mixing valve.



The mixing valve was set to its highest setting, yet it was only delivering 105°F water. Replacing the valve resolved the issue.

Settings" sidebar). I also reduced the emissivity setting for the surface to 0.60 so I could compare individual tubes. While this setting does not provide absolute temperature readings of the glass surface, it was sufficient for comparing the relative temperature of the vacuum tubes. The IR camera allowed me to pinpoint the failed tubes without having to get on the roof.

The photos were enough to file a warranty claim, and I didn't have to access the roof until I had the replacement tubes. Once I was able to observe the getter, I discovered that all but one of the failed tubes had lost their vacuum. The other tube was likely the victim of a stuck snap-switch in the heat pipe that isolates the condenser bulb from the rest of the heat pipe when temperatures exceed the preset maximum.

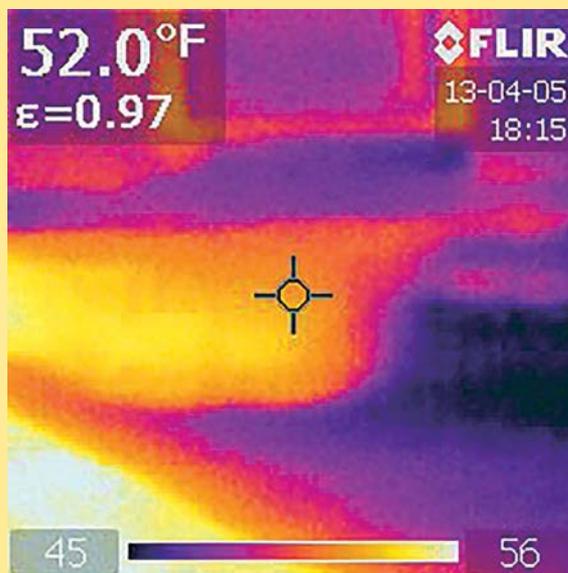
Without an IR camera, I would have had to install fall protection, access the roof, and rotate individual tubes to look for indications of a failed vacuum. This approach would have only identified the eight tubes that lost their vacuum; I likely would have missed the tube with the heat-pipe (snap-switch) issue.

Applications are not limited to collector arrays. An IR camera can also help identify issues like failed mixing valves or excessive heat loss in a system.

## Identifying Roof Leaks with an IR Camera

Moisture that has penetrated a roof membrane will cause thermal irregularities in a roof, so IR cameras can help diagnose roof leaks. For example, after the sun has set, areas of moisture under the roofing may show up on an IR camera as hotter spots—because the water dissipates heat slower than the surrounding, drier areas.

This information can be valuable to a solar installer and the client. If roof leaks are present prior to installation, the IR camera can document them, and the customer can be encouraged to replace the roof. This can also protect the installer from liability—if a leak becomes apparent after installation, the documentation will verify that the leak was not caused by the installer.



This image was taken 30 minutes after the sun stopped hitting the roof surface. The "warmer" (orange and yellow) colors indicate water under the surface, since water dissipates heat more slowly than the surrounding materials. With the IR camera, this leak was diagnosed as a flashing issue between two different roof pitches, and was resolved before installing a solar pool-heating system.

### Access

Vaughan Woodruff owns Insource Renewables, a Maine-based renewable energy company focused on the design and construction of solar energy systems. He also provides training for Solar Energy International and is working with the New York State Energy Research and Development Authority to train code officials on solar heating technology.



# 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



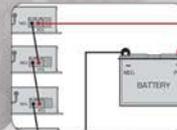
## DEPENDABLE, PROVEN CHARGING SOLUTIONS FOR SOLAR BATTERY INVESTMENTS...

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](http://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](mailto:denisl@wildblue.net)  
[www.harrismicrohydro.com](http://www.harrismicrohydro.com)

Manufactured by LoPower Engineering

P.O. Box 1567  
Redway, CA 95560



# DETERMINING BATTERY STATE OF CHARGE

By Measuring Specific Gravity

by Christopher Freitas

**S**pecific gravity (SG) is defined as the ratio of the density of a material to the density of a reference material—with liquids, this is usually pure water. For lead-acid (LA) battery electrolyte, the amount of acid dissolved in the water determines the SG. A battery electrolyte’s density is a direct indicator of the battery cell’s state of charge (SOC)—and can also reveal the relative health of that cell compared to others.

With flooded LA (FLA) batteries, each battery cell’s SG should be measured and recorded at the time of installation, but only after an initialization charge. These initial readings will serve as a reference for comparison over time, and will also verify that the battery is in good condition. If there is a significant imbalance between the SG of the cells in a newly initialized battery or if the electrolyte does not reach a “full” SG reading after charging, contact the battery manufacturer or supplier.

## TYPICAL SPECIFIC GRAVITY & STATE OF CHARGE

Specific Gravity	State of Charge
1.255 – 1.275	100%
1.215 – 1.235	75%
1.180 – 1.200	50%
1.155 – 1.165	25%
1.110 – 1.130	0%

Once the batteries are in service, each cell’s SG should be measured annually to identify problems like unequal charging or if the battery is not getting fully recharged. These identified problems can then lead to discovering their causes, such as incorrect setpoints; high-resistance connections in battery strings; an inadequate charging source; or even a loss of electrolyte due to overfilling cells during watering.

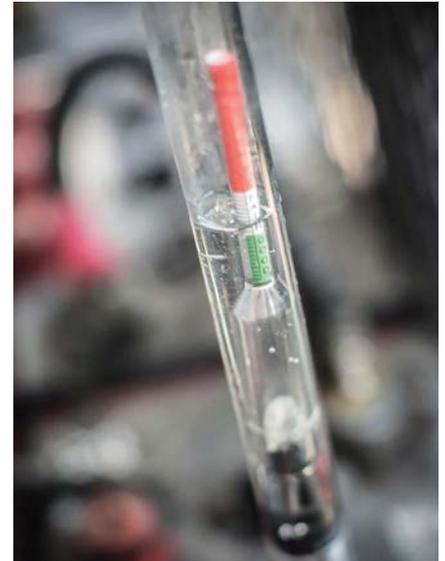
Charging the battery to a full SOC before testing the SG will result in more accurate readings, as the electrolyte will be better mixed and cell voltages more balanced. After this charge, but prior to taking the SG reading, do not top off the battery with water in an attempt to replace the electrolyte lost to gassing or your SG reading will be inaccurate.

Stratification of a battery, where the electrolyte becomes denser at the bottom of a cell and less dense at the top, occurs frequently on tall, high-capacity LA cells that are not fully recharged. This condition can only be detected by testing the SG. If left to persist, stratification will damage the battery by corroding the lead plate at the bottom while allowing the top of the plate to become sulfated and inactive.

Typically, the SG of a fully charged LA battery’s electrolyte is 1.265 to 1.275. (Batteries with other types of chemistries will have different SG values.) That is, the electrolyte is 26.5% to 27.5% denser than water. Often, the measurement is multiplied by 1,000 to eliminate the decimal point. This also reduces the tendency of people to round off the value when recording it.



A technician checks the batteries' specific gravity using a glass-type hydrometer.



A color-coded and numeric scale on the float indicates the cell's state of charge.

Courtesy: whatrockyouusing.org for USADID (3)

## Measuring SG Using a Hydrometer

To measure SG, you need a hydrometer or refractometer. Low-cost hydrometers are readily available, but refractometers and higher-quality hydrometers may need to be specially ordered.

A hydrometer consists of a glass float inside a glass tube reservoir. A rubber bulb at the top is used to draw the electrolyte from the battery. A section of the float is calibrated with a scale so that when it is submerged in water it will read a value of 1.000 (or 1,000). When the liquid being tested has a higher density, the float sits higher in the liquid, indicating a higher SG value on the scale. When reading the scale on a hydrometer, be sure that the scale is read using the bottom level (the meniscus) of the liquid's surface.

When drawing the battery electrolyte into the hydrometer, first squeeze the rubber bulb and then insert the hydrometer into the vent opening on the battery. This reduces introducing air into and bubbling the electrolyte. Keep the tip of the hydrometer in the cell while slowly releasing the rubber bulb, drawing the electrolyte into the glass tube. There is enough electrolyte in the tube once the float is lifted off the bottom. Hold the hydrometer completely vertical when taking the reading.

If there is not enough electrolyte drawn into the hydrometer, squeeze the bulb slowly to remove the liquid and try to compress the rubber bulb more completely to draw

up more electrolyte from the cell. Once the reading of the SG is complete, be sure to return the electrolyte to the same cell that it was removed from.

Since the density of a liquid changes with its temperature, the SG measured with a hydrometer needs to be adjusted, or compensated. Quality hydrometers have a built-in thermometer with an easy-to-use scale for making this adjustment. The thermometer's temperature is referenced to a value that is either added or subtracted from what is indicated on the float. Verifying a hydrometer's accuracy should be done regularly by taking a reading of distilled water—which should measure 1.000. Be sure to adjust for differences in water temperature.

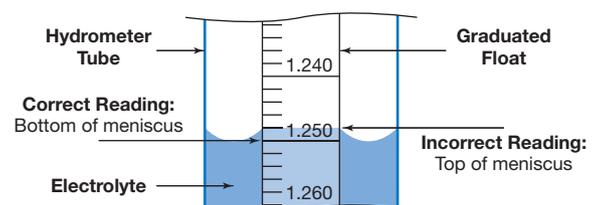
Sometimes, a battery cell's electrolyte level is too low to allow a hydrometer to draw up enough electrolyte. Distilled water will need to be added but, before taking a SG reading, you will need to charge the battery for several hours to ensure that the electrolyte is fully mixed. Otherwise, the acidless water will float on the top of the more dense electrolyte, giving an inaccurately low SG reading.

After completing all readings, be sure to rinse off the hydrometer in clean water and allow it to dry before putting it away. Be especially careful of setting down the hydrometer on a dirty surface, since dirt in the hydrometer can interfere with an accurate reading and contaminate the battery electrolyte. Keeping the hydrometer inserted into a bottle of distilled water between uses is the best way to keep it clean, protect it from being dropped or knocked over, and to reduce the amount of acid that gets on your clothing.

## SAFETY FIRST

Always wear eye protection whenever working around batteries. A full-face shield is the best protection against splashing or if an arc occurs. Remove all metal watches and jewelry before working on a battery. Chemical-resistant gloves are also needed when you might be in contact with battery electrolyte. A sleeved rubber apron can further protect clothing from acid.

## Reading a Hydrometer





Courtesy whattookyoualong.org for USAD (2)

**A refractometer uses only a drop of electrolyte to measure specific gravity, and is more accurate and easier to use.**

### Using a Refractometer to Measure SG

While a hydrometer is an off-the-shelf tool to measure SG, it has some shortcomings. First, the scale on the float can be difficult to see in poor light. Second, because the surface of the liquid is curved, it's possible to get inaccurate readings depending on what part of the meniscus is used when reading the scale. The float can also be tilted in the tube, causing it to hang up on the side and making it hard to read accurately. And finally, the relatively large volume of electrolyte required to fill the hydrometer makes it easier to end up with acid on your hands and clothing, or on the outside of the battery.

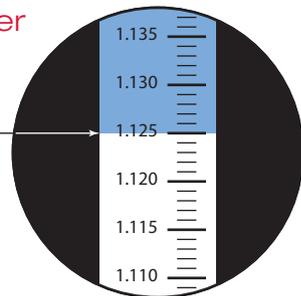
Refractometers, however, only require a small drop of the electrolyte to measure the SG, making them much less messy and easier to use. The level on the scale is much easier to read and they can be used in low-light conditions. They also have excellent accuracy and provide consistent results, unlike float type hydrometers.

A refractometer uses the “angle of refraction” of light through a small drop of the liquid being tested. The angle will vary depending on the density of the solution.

To measure SG, use the sampling dropper to obtain some electrolyte from the cell. Then, open the refractometer’s illuminator flap and put a drop or two of electrolyte on the measurement prism’s surface. After closing the flap, look through the eyepiece. Read the value where the shadow boundary line meets the scale. It may be necessary to point the refractometer toward a light source (the sun or a lamp), but during the day, ambient light is usually sufficient. When you’re done, wipe the prism and flap with a clean, soft cloth and rinse the dropper with distilled water. Store the refractometer in its protective case as it’s a somewhat fragile device that can have its calibration affected if dropped or jostled. Use all of the same safety precautions and equipment as previously discussed in the hydrometer section.

### Reading a Refractometer

**Shadow Boundary:**  
Designates specific gravity



**A technician checks the specific gravity using a refractometer and reading its illuminated internal numeric scale.**

The refractometer will retain its accuracy as long as it is kept close to the nominal temperature used as its reference (77°F). Many refractometers also include a built-in temperature compensation mechanism. However, allow the instrument to equalize with the environment before using and protect it from temperature extremes.

Like a hydrometer, you can verify the accuracy of the measurement of a refractometer in the field—all you need is some distilled water. The reading should equal 1.000 or 1,000, depending on the scale of the instrument.

### Access

Christopher Freitas (cfreitas@sunepi.org) is an engineer and project manager for international RE projects. He was a cofounder of OutBack Power Systems and was the director of engineering at Trace Engineering.



**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](http://WWW.SOLARPATHFINDER.COM/SPV)

# Sustain. Ability. Renewable Energy Systems

## CROWN RENEWABLE POWER BATTERIES

Crown Battery's 2-, 6- and 12-volt solar and wind power systems. Once you compare all the other renewable energy batteries, you'll find there's no comparison.

Recognized as **High Quality & Best Available** by serious system users.

419.334.7181  
[www.crownbattery.com](http://www.crownbattery.com)

## Energy Systems & Design

Microhydropower since 1980

506-433-3151 YouTube channel: ESDhydro  
sales@microhydropower.com  
[www.microhydropower.com](http://www.microhydropower.com)

### WATER BUDDY®

The little machine that can!

- ~ Outputs as high as 300 watts
- ~ Heads from 10-200 feet
- ~ 12/24 or 48/120 volt models

Imagine the possibilities:  
Camping, pond lights, charging batteries, backup...

Starts at **\$695**

I only weigh **8 lbs!**

### STREAM ENGINE®

Tried, true, and upgraded!

- ~ Upgraded rotor means more power
- ~ High power magnet option means even more power!
- ~ Wide operating range 10 feet of head & up
- ~ 12, 24, 48 volts & higher!

**BUY DIRECT FROM THE MANUFACTURER**

## Butler Sun Solutions, Inc. Solar Water Heating Appliances

NOW YOU HAVE A CHOICE

### Solar Wand™

SOLAR SIX PACK™ HYBRID

**For DIY or Contractor**

- No Overheating
- Less Install Time
- Plug & Play
- Hard Freeze Safe
- Single Tank
- Complete Kits
- Fits Your Tank
- Fits Your Needs
- Fits Your Budget

### PV Wand™

PHOTOVOLTAIC DC HYBRID

- No Overheating
- Less Install Time
- Plug & Play
- Hard Freeze Safe
- Single Tank
- Complete Kits
- Fits Your Tank
- Fits Your Needs
- Fits Your Budget

OUR SOLAR-WAND™ PUTS THE SUN INTO YOUR TANK

OUR PV-WAND™ PUTS THE SUN INTO YOUR TANK

Both Qualify for 30% Federal Tax Credit

Made in USA

UL Listed

[www.butlersunsolutions.com](http://www.butlersunsolutions.com) 858-259-8895

$$\text{Energy} = \text{Power} \times \text{Time}$$

# Wind Energy Physics

$$C_p\text{-max.} = 59.3\%$$

by David Laino

$$\text{Power} = 1/2 \times \text{air density} \times \text{swept area} \times \text{wind speed}^3$$

**Comment & Discuss**

this article @  
[homepower.com/161.70](http://homepower.com/161.70)

**Wind turbine design** encompasses multiple disciplines, but perhaps the most important—and often the least understood, even by would-be turbine designers—is fluid dynamics. Understanding the physics laws that govern wind power, presented here, can help consumers make wise wind turbine technology choices.

## The Energy Equation

The purpose of a wind turbine is to convert kinetic energy (energy of a moving mass) of the wind into electrical energy. Energy *conversion* is common to all machines because they must obey the law of energy conservation—energy cannot be created or destroyed, but only changed from one form to another. For example, your car converts the chemical energy stored in fuel (if it's an electric car, batteries) to kinetic energy, moving it down the road. A wind turbine also obeys this law when it extracts the kinetic energy in the wind and converts it to electrical energy.

The amount of kinetic energy in any moving mass is calculated with this equation:

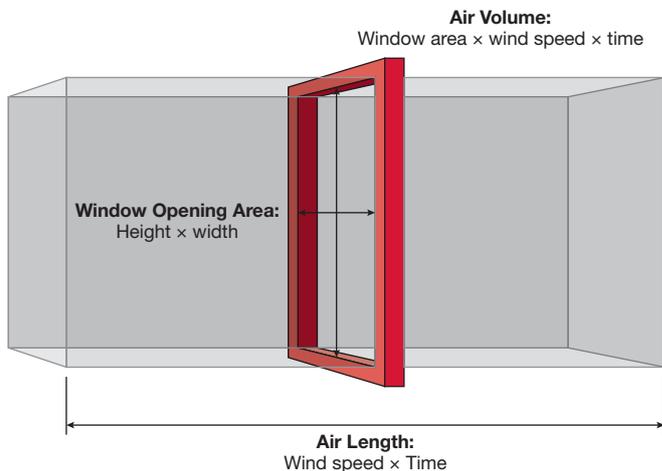
$$\text{Kinetic energy} = 1/2 \times \text{mass} \times \text{velocity}^2$$

For wind energy, the velocity in the equation is wind speed. The mass is for a particular volume of air. Consider the example of wind blowing through an open window. The illustration describes how a volume of the air passing through the window relates to window area, wind speed, and time. This makes sense if you consider that the larger the opening, the harder the wind is blowing, and the longer the window is open, the more air volume will flow through it.

The mass of this volume of air is arrived at by multiplying the volume by the air density. Putting this all together, we write our equation for wind energy as:

$$\text{Kinetic energy} = 1/2 \times \text{air density} \times \text{area} \times \text{wind speed}^3 \times \text{time}$$

## Volume of the Wind





The swept area of a turbine is its aperture window that captures the wind. The area is directly proportional to the amount of wind energy available to the turbine.

## Power in the Wind

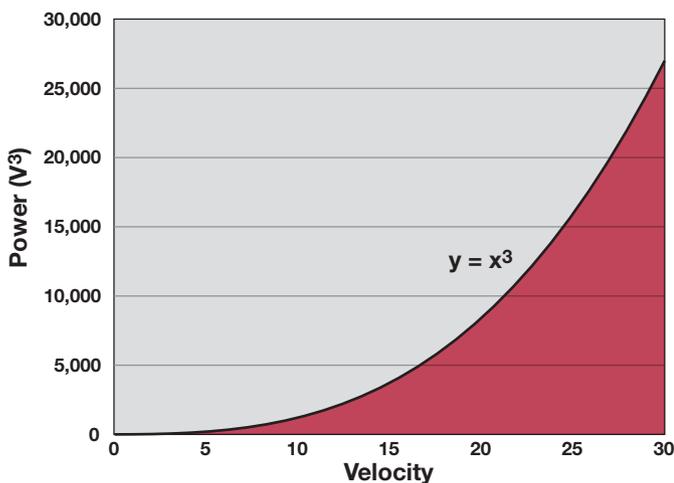
Although a wind energy system's final objective is to generate energy, it is more convenient to describe its size in terms of power. The relationship between power and energy is a simple one—energy is power multiplied by time. This is why power is defined in watts and energy in watt-hours. The terms *power* and *energy* are often confused and even used interchangeably in casual discussions, but in a technical analysis, it is important to make the distinction.

If we are interested in the power in the wind, we divide the energy by time. This gives us the governing equation for power available in the wind passing through an area as:

$$P_{\text{wind}} = \frac{1}{2} \times \text{air density} \times \text{area} \times \text{wind speed}^3$$

We see that the amount of wind power is dependent on three variables. The first is *air density*, a quantity defined by Mother Nature, over which we have no real control. Another is *swept area*, that is, the projected area perpendicular to the wind that the turbine intercepts. One thing is clear from the equation: everything else being equal, a larger swept area can generate more power.

## Wind Power Curve



The third (and most important for siting wind turbines) variable is *wind speed*. You can see that it's cubed in the equation, meaning small changes in wind speed yield larger changes in available power. A 26% increase in wind speed (from 10 to 12.6 mph) doubles the available energy, while a 20% drop (from 10 to 8 mph) cuts it in half. This is why it is critical to put a wind turbine on a tall tower where it can intercept strong wind.

## Wind Turbine Job Description

As a wind turbine extracts kinetic energy from the wind, it does not consume air mass (only nuclear reactions consume mass), so it must be "consuming" the wind speed. In other words, the wind approaches the turbine at one speed and leaves at a lesser speed. This is how any wind turbine extracts energy from the wind—by slowing it down. The difference between the wind speed before and after it passes through the turbine defines the energy the turbine has extracted from the wind. This is the fundamental function of the wind turbine, and some turbines do it better than others.

## Wind Turbine Efficiency & Limits

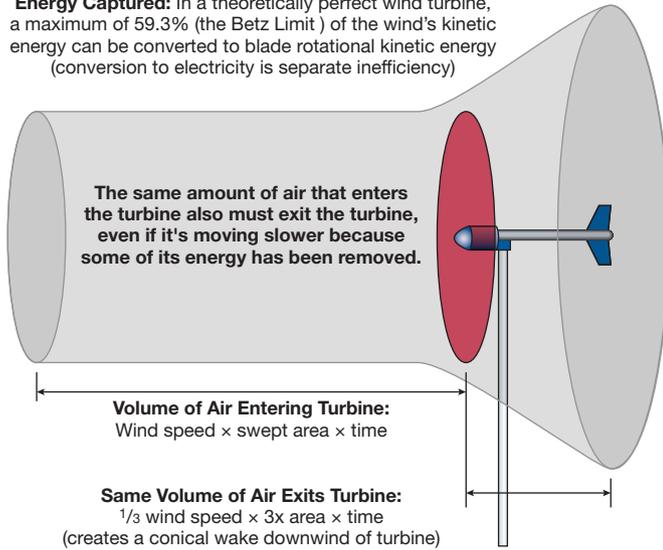
It is not feasible to extract all of the power available in the wind—and no wind turbine can harness more energy than is available in the wind. Avoid any wind turbine that claims it can—no wind turbine can slow wind down to a speed of less than zero.

If a wind turbine were to extract all the available power in the wind—that is, slow the wind to a stop and capture all its power—we would say that turbine is 100% efficient. However, any wind turbine that did this would stop the wind, and then there would be no air movement from which to extract more power! An effective wind turbine must find a balance, slowing the wind enough to maximize power capture, yet still allow enough wind to pass through so it can keep capturing more.

Efficiency is defined as the ratio between the output power and the input power. For wind turbines, aerodynamic

## Available Energy

**Energy Captured:** In a theoretically perfect wind turbine, a maximum of 59.3% (the Betz Limit) of the wind's kinetic energy can be converted to blade rotational kinetic energy (conversion to electricity is separate inefficiency)



efficiency is referred to as the power coefficient,  $C_p$ , so the governing equation for wind turbine power output is:

$$P_{\text{output}} = \frac{1}{2} \times \text{air density} \times \text{area} \times \text{wind speed}^3 \times C_p$$

We know  $C_p$  cannot be 100%, but what is the upper limit? In 1919, German scientist Albert Betz took the above governing equations for wind power, and used them to determine how much a theoretically “perfect” wind turbine could extract from the wind. His answer, which is referred to as Betz’ Law or the Betz limit, states that when the wind is slowed by two-thirds (wind speed out =  $\frac{1}{3}$  wind speed in), the wind turbine reaches its theoretical maximum possible efficiency,  $C_{p\text{-max}}$ , of 59.3%.

It is critical to note that Betz’ Law is derived from the governing equations, and not from any assumptions about wind turbine type. Therefore, the Betz limit is not restricted to any particular type or style of wind turbine, as some people mistakenly believe. The Betz limit is a physical limit that applies to *all* wind turbines.

### Wind Turbine Types

In the real world, no wind turbine can ever even reach—let alone exceed—the Betz limit. But which turbines do the best, and how well do they do?

Harnessing wind power is an endeavor humans have been undertaking for thousands of years, so not surprisingly just about every type of machine design has been attempted.

### Turbine Types & Typical Power Coefficients

Type	Maximum Efficiency, $C_p$
Savonius	15%
American multiblade	17%
Dutch windmill	30%
Darrieus	35%
High-speed propeller	45%

## What a Drag

There is a fundamental difference that separates the Savonius-type wind turbine from all the others in the efficiency table. The Savonius extracts power from the wind by leveraging the force of aerodynamic *drag*, while all the others leverage the more powerful aerodynamic *lift* force. While all surfaces exposed to airflow generate both lift and drag, lift offers far greater potential. A simple example of the difference between these forces is found in sailing. A sailboat going downwind can only go as fast as the wind pushes or “drags” it. However, a sailboat cutting across the wind can achieve speeds of more than twice the actual wind because of the lift force generated by the smooth flow over the sails. Any wind turbine that relies on blades being pushed or dragged downwind will be less efficient than one with blades that utilize lift.



Drag turbines like this Savonius design can only spin at a theoretical maximum equal to the wind speed. Turbines using aerodynamic lift spin faster and perform better.

Courtesy Paul Gilpe

Some of the more common types are the Savonius, Darrieus, Dutch windmill, American multiblade (water-pumper), and modern propeller styles. The efficiencies of these machines has been determined by theory and confirmed by experience (see “Turbine Types & Typical Power Coefficients” table).

The propeller-style wind turbine achieves the best efficiency, so it is not surprising that this is the most commercially successful wind turbine type. Engineers use the superior efficiency of the propeller wind turbine, and combine it with a large rotor area—the other governing parameter that they have direct control over—to optimize performance of their designs.

## “Breakthroughs” & “New” Concepts

There is a persistent myth that wind power is a new technology ripe for innovation. This thinking leads to wild claims of doubling (or more) the efficiency of “old” propeller designs. This, frankly, is impossible. At 45% aerodynamic efficiency, modern propeller designs are already achieving more than 75% of the theoretical Betz limit, leaving little room for “breakthroughs” in the aerodynamic efficiencies of wind turbines. Using our understanding of wind turbine fluid dynamics, we can expose some common wind turbine hype.

It can be counterintuitive that a propeller-style wind turbine rotor achieves the best efficiency. After all, those three (typically) thin blades let so much of the wind pass between them. Wouldn't more blades help? That seems logical on the surface, and leads some designers to include an array of blades. This idea, however, ignores the laws of fluid dynamics. Remember, the wind turbine must strike a balance between slowing the wind and allowing it to pass. And it turns out that fewer, thinner blades spinning fast does this best. The American multiblade is effective at what it does—mechanically pumping water—but efficiency is not its goal.

**Believe it or not, one-bladed turbines have the highest potential power coefficient, but they are difficult to keep balanced. Two- and three-bladed turbines are the proven standard, balancing aerodynamic efficiency and stability during turbulent winds.**



**Ducts and shrouds are common attempted augmentations to divert more wind into, or increase wind speed through, the turbine's blades. However, the nature of fluid dynamics makes the wind adept at flowing around these obstructions rather than through them. Savvy turbine designers use larger swept area to increase power input instead of trying to trick the wind.**

“Augmenters” attempt to leverage the cubic function of wind speed in the energy equation by speeding up the wind into the rotor through ducts or shrouds. This method is akin to the nozzle on a hose that effectively turns a fat, trickle of water into a forceful, faster stream. The difference with wind is that it is not confined to a hose, so it does not *have to* pass through the nozzle. And in fact, because the wind turbine at the end of the “nozzle” is trying to slow the wind (remember, that is its job), the wind simply sees the augmented turbine as an obstruction and passes around it rather than going through it—taking the path of least resistance. Although a duct does serve to increase the capture area of a wind turbine, a more effective way to accomplish that goal is with longer blades.

One of the benefits touted for vertical-axis turbine designs, such as the Savonius and Darrieus rotors, is that they can take wind from any direction. While it is true that these designs can be simpler because they do not need moving parts to respond to changes in wind direction, the benefit stops there. Wind only blows in one direction at any given moment. Although wind does indeed change direction, sometimes abruptly, the flow through a vertical-axis turbine takes time to react to this changing flow—even if it is not as evident as with a propeller rotor reorienting itself. The claim that vertical-axis designs are better suited for the directional turbulence experienced on short towers is strictly a myth. With any wind turbine design, efficiency increases with steadier wind flow, which is another reason to place any wind turbine, regardless of type, on a tall tower.



Courtesy: Paul Gipe (2)



**Left:** Multiple blades only help in getting the turbine started in low-wind situations. After that, one blade's wake quickly interferes with the blade following it.



**Right:** Many "innovative" designs just complicate a system that would work better if simplified. Luckily, most kooky designs never leave the prototype stage.

Courtesy David Laino (2)

### Physics Rule

Keep in mind the fundamentals of wind energy physics next time you are evaluating wind turbine claims. There are two points most worth remembering:

All wind turbines extract kinetic energy from the moving air by slowing it down, and those that find the best balance between slowing the wind and not disrupting its flow are the most efficient—up to the Betz limit of 59.3%.

The governing equations are dependent on two factors we have some control over—wind turbine swept area (bigger captures more energy) and wind speed (which is a huge

factor because it is cubed in determining power). Use these factors to your advantage when choosing and siting a wind energy system.

### Access

David Laino (dlaino@endurancewindpower.com) puts his aeronautical and mechanical engineering knowledge to use at work designing wind turbines for Endurance Wind Power, and for fun, sailing on the Chesapeake Bay in Maryland.



# 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

# FINALLY

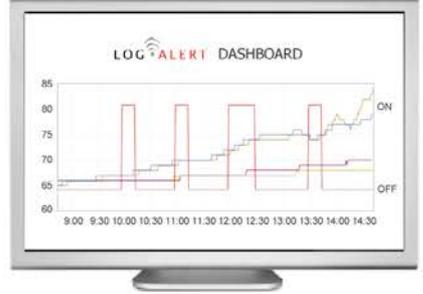
## An affordable data logger & a FREE internet dashboard!

**Only \$199** Wireless  
\$239

Plug & Play with Custom Email/Text Alerts  
 Have Many Wireless Sensor Pods to One Portal  
 Daisy Chain Many Inexpensive Sensors  
 PV & Solar Water System Kits (priced above)  
 Countless Customizable Applications







**LOG ALERT** www.log-alert.com

# 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](http://www.BatteryLifeSaver.com)

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

## 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](http://www.solmetric.com)

**SolarTech**  
International, LLC



Setting a Higher Standard  
in Solar Pool Heating



- OG100 SRCC rated
- Leading-edge technology
- High quality
- Low cost
- Maintenance free
- Patent pending

**UNSURPASSED DURABILITY**  
**YOUR ULTIMATE SOLAR POOL HEATER**  
**RESIDENTIAL & COMMERCIAL APPLICATION**

15-year warranty, including  
freeze damage to the collector

**520-749-3538**

[www.solarheatmypool.com](http://www.solarheatmypool.com)

**steca**  
Elektronik

## YOUR PERFECT CHOICE



**Steca TR A503 TTR U**  
**Solar Thermal Controller**  
5 inputs, 3 outputs  
Data logging



**I am the heart of your  
solar thermal system.**

**SOLAR POWER 14** INTERNATIONAL  
October 20-23, 2014  
Las Vegas, USA  
Booth No. 2004

PV Off Grid	PV Grid Connected	Solar Thermal
Battery Charging Systems	EMS-Provider	Cable Technology

[www.stecasolar.com](http://www.stecasolar.com)  
Steca Elektronik GmbH



# PV Overcurrent Protection

by Ryan Mayfield

In “Code Corner” in *HP159*, we discussed Section 690.8 of the 2014 *National Electrical Code (NEC)*—requirements for circuit sizing and current calculations. The next section—690.9, Overcurrent Protection—was also updated and goes hand-in-hand with 690.8.

Generally, 690.9 requires that conductors used throughout PV systems be protected in accordance with Article 240. Section 690.9 references Article 240 in its entirety, so we need to comply with all rules there—except where Article 690 makes a specific change for PV systems, which occurs twice.

The critical sections on sizing the PV overcurrent protection devices (OCPDs) can be found in Part I, “General Requirements of Article 240.” Section 240.4, “Protection of Conductors,” requires protection of conductors according to their ampacity, as specified in tables in 310.15. However, some modifications as outlined in sections 240.4(A) through (G) may apply to certain PV systems. In 240.4(B), there is an allowance to protect conductors with OCPDs that have ampere ratings greater than the conductor’s ampacity, provided three conditions are met as outlined in 240.4(B) (1)-(3). The first rule in this section does not apply to PV systems, as the rule is directed to conductors supplying power to receptacles. The second rule stipulates that if the conductor’s ampacity is equal to a standard OCPD’s ampere rating, it must be matched—you cannot use the next-size OCPD. The final rule is that the OCPD used does not exceed 800 A. To help with this determination, OCPDs are available in “standard sizes” or specific ampere ratings such as 15, 20, and 25 A. The complete list of standard OCPD ratings for both fuses and circuit breakers can be found in 240.6.

To summarize, 240.4(B) allows determining conductor ampacity per 690.8 and protecting conductors with an OCPD that exceeds that ampacity value. For example, after conditions of use are considered, if the ampacity of a 12 AWG THWN-2 conductor equals 17 A, per the *NEC*, you can protect that conductor with a 20 A OCPD. However, if the calculation results in a conductor ampacity of 15 A, you are required to use a 15 A OCPD, since 15 A is a standard OCPD rating.

Section 240.4(D) covers OCPD requirements for small conductors. See the table for the maximum OCPD size that

**This array has three source circuits, with an OCPD (aka “series fuse”) for each. Those fuses protect each circuit from potential current from the adjacent strings.**



Orion Thornton

is allowed for small copper conductors. This is a common *Code* requirement that applies to all electrical installations, not just to PV. This rule establishes the largest OCPD you can use with these specific conductors, but you should still verify that the conductors used in your PV systems are properly protected per 690.8 and 690.9.

For example, if you apply the required adjustment and correction factors to a 12 AWG conductor and calculate 17 A of ampacity, it is OK to place it on either a 15 A or 20 A OCPD. If that same 12 AWG conductor was corrected down to 14 A, though, you would be limited to using a 15 A OCPD for proper protection. The ampacity tables in 310.15 also reference 240.4(D) for the small conductors to make sure these requirements aren't overlooked.

Clarifications were added in section 690.9(A) in 2014 that will likely help installers with determining the exact circuit placement for OCPDs. For circuits connected to current-limited devices, PV modules, and the AC output of grid-tied inverters, the OCPD shall be placed at the source of potential overcurrent. The OCPD for source circuits, then, shall be placed at the combiner (i.e. the location where additional current is available from the other series strings). Note: Depending on where the combiner is located, source circuit conductors may run through a building before landing on an OCPD. For a grid-tied inverter output circuit, the OCPD needs to be at the point of utility interconnection—the source of potential overcurrent.

Section 690.9(A) includes an important exception for smaller grid-tied, batteryless PV systems. This is not new to the *NEC*, but an important section to review. This exception eliminates the need for OCPDs in two specific cases. The first is where there are no external sources connected to the circuit, such as parallel modules or strings, batteries, or backfeed from inverters. In essence, this means you have a single string of modules connected to an inverter with 0 A of backfeed capability. In this scenario, there is no external overcurrent source on the conductors and the inverter cannot convert AC to DC and send it back to the array. Without a source of overcurrent, there is not a need for an OCPD.

The second case that eliminates the need for OCPDs is when there are external sources of potential backfeed current, typically from parallel strings of modules. To exercise the exception, the short-circuit current from those sources cannot exceed the ampacity of the conductors and the maximum OCPD rating specified on the PV modules—known as the maximum series fuse rating. The important part of this exception is to count only the external sources as possible overcurrent. We do not need to consider the current produced by a module or string as a source of overcurrent.

This second exception is what leads to the industry standard of one or two strings connected to a batteryless grid-tied inverter not requiring OCPD for the PV source

## Max OCPD Size for Small Copper Conductors

Wire Size (AWG)	OCPD Size (A)
14	15
12	20
10	30

circuits. In these cases, if a fault occurs within one of the strings, the only possible source of external current is the second string placed in parallel.

Consider a PV module with an  $I_{sc}$  rating of 8.8 A and a series fuse rating of 15 A. If you consider the maximum short-circuit current the second string can impose on the first string ( $8.8 I_{sc} \times 1.25 = 11$  A), the external source cannot provide more current than the modules' and conductors' ratings. This is because, in a normal condition, all the components are required to carry at least that same amount of current.

In the case of a third string in parallel, there is the potential of two 11 A sources, or 22 A that can be pushed back toward the fault. In that case, the conductors may be carrying too much current. In this example, the module's maximum series fuse rating has been exceeded. There are cases where three strings of modules in parallel do not need OCPDs, but those are the exception. For example, many thin-film modules have low  $I_{sc}$  ratings but have been listed with a relatively high series fuse rating that may allow three or more strings in parallel without the need for OCPDs. Consider three strings of modules, each with an  $I_{sc}$  of 4.4 A and a series fuse rating of 15 A. In this scenario, the amount of potential external fault current for the two external strings 11 A ( $4.4 \text{ A} \times 1.25 \times 2$ ). Since this is less than the 15 A series fuse rating, OCPDs would not be required here. Most system designers and installers stick with no OCPD for one and two strings—but as soon as a third string is added, OCPDs are added as well.

If your PV circuits require OCPDs, you need to use 690.9(B) to determine their ampere rating. Although this shows up as a change in 2014, the only real change is the relocation from 690.8. The *NEC* requires that you multiply the maximum circuit current calculated in 690.8 by 125% to account for the continuous nature of PV circuits. This results in an OCPD that is 156% larger than the  $I_{sc}$  rating.

This calculation will dictate the minimum OCPD size required to protect the circuit. In the earlier example, the module has an  $I_{sc}$  of 8.8 A, so the smallest OCPD we can use to protect a circuit with a single string of modules would be  $8.8 \text{ A} \times 1.25 \times 1.25 = 13.75$  A. This isn't a standard OCPD size, so we would round up to the next standard size, which would be 15 A (based on 240.6). This corresponds with the maximum OCPD size listed by the

module manufacturer. In this case, the minimum and maximum size is the same.

The final check is to ensure that the conductor chosen per 690.8 is properly protected by the required OCPD. This means that after conditions of use are applied, the conductor's ampacity needs to comply with the rules of 240.4.

The OCPDs in the PV source and output circuits must also have the proper DC voltage ratings. Verify that the DC rating of the OCPD will exceed the maximum system voltage of your system. For any residential PV applications, this will result in installing 600 VDC fuses in the combiner boxes.

One final note is the accessibility of PV circuit OCPDs. Many electricians and authorities having jurisdiction are familiar with the requirement that OCPDs be readily accessible (per 240.24). But in 690.9(D), the rule is that the OCPDs "shall be accessible but shall not be required to be readily accessible." This allows placing combiner boxes with OCPDs on the roof and/or behind modules if so desired.

When sizing conductors and OCPDs for PV systems, consider both 690.8 and 690.9 to make the proper calculations. Walking through each section step-by-step

will help eliminate mistakes and help determine proper equipment ratings. In *Code Corner 163*, I will go through detailed examples to help clarify this all-too-confusing process.

### Access

Ryan Mayfield (ryan@renewableassociates.com) is the principal at Renewable Energy Associates, a design, consulting, and educational firm in Corvallis, Oregon, with a focus on PV systems.



## 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](http://www.apmhydro.com)



Join us for workshops & exhibits on renewable energy & sustainability! Enjoy local food, kids' programs, a fun-run, bands, beer, and Keynote OR 1st Lady, Cylvia Hayes!

## June 27-29th

Union County Fairgrounds  
**La Grande, OR**



[www.oregonrural.org/solwest](http://www.oregonrural.org/solwest) 541-975-2411

## 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

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

[www.hydrocapcorp.com](http://www.hydrocapcorp.com)

## DC differential temperature controllers



**3 models improve performance of PV pumped solar thermal systems**

[www.ArtTecSolar.com](http://www.ArtTecSolar.com)

## Appalachian Energy Center

APPALACHIAN STATE UNIVERSITY

### 2014 Workshop Series

June 7	Distributed Wind Energy Workshop
June 13-14	1-1/2 Day Photovoltaic System Fundamentals
June 27	NC Residential Energy Code Training
July 11-12	1-1/2 Day Solar Thermal Water Heating Fundamentals

For details, CE credits, more workshops, and to register:

[energy.appstate.edu](http://energy.appstate.edu)

millerjm1@appstate.edu, 828.262.8913

## 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](http://www.hydroscreen.com) or call (303) 333-6071 e-mail [RKWEIR@AOL.COM](mailto:RKWEIR@AOL.COM)

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



### 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](http://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](http://www.RightHandEng.com)

(425) 844-1291



Authorized *Rolls* Battery Dealer  
[www.raestoragebattery.com](http://www.raestoragebattery.com)

The best off-grid battery for over 25 years

- Unsurpassed cycling
- Industry's largest liquid reserves
- Widest product range
- 10 & 15 year average life span
- 7 & 10 year warranties\*



6 VOLT S-550  
428 AH @ 20 Hr

**NOW AVAILABLE**  
4500 SERIES 6V S-500EX and 2V S-1400EX  
OFFERING EXTENDED CAPACITY AND CYCLE LIFE OVER TRADITIONAL L14 MODELS

\* 4000 & 4500 Series - 7 yr warranty 5000 Series - 10 yr warranty

Phone 860.828.6007 Fax 860.828.4540 POB 8005 Berlin, CT 06037



The most advanced charge controllers for small and midsize solar applications



MPT-3048

MPT-2024

12/24/36/48-volt, 30-amp 12/24-volt, 20-amp

Remote displays and computer interfaces available

- 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](http://www.roguepowertech.com) | Made in the USA since 2009

Rogue Power Technologies | Ashland, OR 97520 | 541-621-5663

## A SWAMP COOLER IS NOT A HAPPY HOUR BEVERAGE

Ultra Low Energy DC Cooling For Arid Climates



Watch for new lower cost models  
[www.southwest-solar.com](http://www.southwest-solar.com)

Made in USA  
520.885.7925

# Out to Pasture

by Kathleen Jarschke-Schultze



On the last day of 2013, my husband Bob-O and I shut the doors of Electron Connection, our off-grid renewable energy design and installation business. We had been talking about and planning this moment for a decade. Retirement is new to us. When asked, however, we still know what day of the week it is. When we don't know the day, will we have arrived?

We realize how lucky we are to be in a position to retire. We appreciate the twists and turns of life that have allowed us to reach our modest goals. Of course, as you age, it is always in your mind that you will retire some day. Unless you have a job that pays into your retirement years, though, you have to plan and save whatever you can.

## Do the Math

Bob-O and I have worked hard to be in a good place financially and mentally for this new lifestyle. We paid into our individual retirement accounts for years and we paid off our land and house, so we have a place to live and garden.

We have been keeping track of what we call our "nut." We have a spreadsheet on which we enter the various monies that are expended each year to maintain our lifestyle. Every year, our property taxes go up, so we record that. The yearly filling of our propane tank, the money spent on firewood to heat our home, life insurance, health insurance, vehicle insurance and registration, Internet services—they all are updated on the spreadsheet. There are no columns for electricity or water, but there is a column for road maintenance. Some costs fluctuate so much it is hard to keep track accurately. Vehicle

maintenance is one cost that can change very quickly. We have to guess at that. While we know that our expenses will change (some up, some down), we thought it would be useful to have enough data to give us a clue in reckoning a baseline.

We have not carried debt along our road of life, and have paid for everything with cash. Many years ago when Bob-O applied for a credit card, he received a polite letter saying, "I'm sorry, Mr. Schultze, but not everyone is meant to have a Visa card." It was only after we had signed the mortgage on our house—and entered into the biggest debt we'd ever had—that we started to get offers for credit cards in the mail. I still don't understand that.

Our mortgage was for 13.8 years, but we paid it off in six. Bob-O made a spreadsheet of our house payments and interest charges. By adding any extra money we had to each month's payment, which was applied to the principle, we were able to shave years off the tail end of the payment schedule. Boy, did that feel good.

We tackled the high-dollar improvements on our homestead while we were still earning wages. Double-pane windows, extra insulation, cement-fiberboard siding, replacing the deck, and building a shop were all important projects that took a bite out of our savings. We have never lived an extravagant lifestyle, so saving our money was not too difficult. We live too far from town to eat out or take in expensive entertainment often.

When we go to town, we have a list. We start at the farthest store on the list and work homeward. A lot of times, because of business, only one of us could go to town. I would

make Bob-O write out the hardware list so I could just hand it to the store help. Since we got cell phones and Bob-O installed a cell-signal booster at our house, I can take a picture of a part and text him, "Is this it?" I love technology.

## On The Side

We've toyed with the idea of post-retirement jobs. I will, of course, keep writing this column. Bob-O will continue to support his previous clients and friends with their RE systems. But after a visiting houseguest had "smoothed and fluffed my aura," we conceived the idea for a new business: a drive-through smudge and fluff (DTS&F). A smudge, a bundle of dried sage bound with string, is burned to "cleanse" something or someone with the smoke. The idea behind the DTS&F was that before a road trip, you could get your car smudged and your aura fluffed at the same time. Goofy? Sure! But so were pet rocks, and they sold like hotcakes.

As with any business, it is all about location. We happen to live fairly close to Mt. Shasta in northern California. The mountain is considered the center of the universe to some. Others believe it is a focal point for angels, spirit-guides, spaceships, and the home of the survivors of ancient Lemuria, which is believed by some to have sunk under the Pacific Ocean a little more than 12,000 years ago. If a DTS&F were

going to succeed anywhere, it would be here. Los Angeles is too far south.

## Full-Time Food Prep

That's a joke among us—we already have full-time jobs here at the old homestead. A lot of our "prepping" has been honing our self-sufficiency skills to help us in our retirement. Learning how to grow and preserve a large part of our food is an important part of our retirement plan. Our gardens, orchard, and vineyard grow larger every year. Last year, our "grand dried bean experiment" proved we could grow enough dried beans to last us two years. Drying, canning, fermenting, and having a root cellar has added our homegrown food to our self-sufficiency. We are truly excited this year because both of us will be gardening all season long.

And that's where we want to be—with a list of projects that have been on hold because both of us need to be present. We've also been looking forward to long walks and other pursuits. Now, what day is today?

## Access

Kathleen Jarschke-Schultze (kathleen.jarschke-schultze@homepower.com) is driving her electric garden vehicle at her off-grid retirement home in northernmost California.



Stevens Point, WI  
June 16-18, 2014

# Small Wind Conference 2014

*a gathering of the small wind industry*

[www.smallwindconference.com](http://www.smallwindconference.com)

## Attend the 10th Annual Small Wind Conference

Register now at [www.smallwindconference.com](http://www.smallwindconference.com)

Photo courtesy of Roy Raabach, Windline Inc.

# The 25th Annual Energy Fair

clean energy & sustainable living

## DON'T MISS THE ENERGY FAIR

- Over 200 workshops
- Over 200 renewable energy and sustainable living exhibitors
- 18,000 energy and sustainable living enthusiasts
- Lively music, delicious food, solar-brewed beer



MIDWEST RENEWABLE ENERGY ASSOCIATION  
**ENERGY FAIR**  
CELEBRATING  
**25**  
YEARS

**JUNE 20-22, 2014**

**CUSTER, WI**  
**MIDWESTRENEW.ORG**

ABB (Power-One) .....	7	Hydrocap .....	78	Rolls Battery Engineering .....	IBC
AEE Solar .....	11	Hydroscreen.....	79	Small Wind Conference 2014 .....	81
altE Store.....	IFC	Independent Power Systems .....	79	Solar Data Systems .....	12
Alternative Power & Machine .....	78	IOTA Engineering.....	65	Solar Pathfinder.....	69
Apex Solar .....	18	Iron Edison Battery Company .....	30	SolarTech International.....	75
Appalachian Energy Center.....	79	Log-Alert .....	74	Solectria Renewables .....	29
Array Technologies .....	19	Magnum Energy.....	8/9	Solmetric .....	75
ART TEC .....	79	MidNite Solar .....	2	SolWest Fair .....	78
Backwoods Solar .....	25	MK Battery .....	23	Southwest Solar .....	79
Battery Life Saver .....	75	Mounting Systems.....	58	Splash Monitoring .....	43
Bogart Engineering .....	27	Northern Arizona Wind & Sun.....	32	Steca Elektronik .....	75
Butler Sun Solutions.....	69	OutBack Power Technologies.....	15	Stiebel Eltron.....	3
Canadian Energy .....	31	Pika Energy .....	BC	Sun Frost.....	74
Crown Battery.....	69	Power Spout .....	43	SunDanzer.....	65
Energy Systems & Design.....	69	Quick Mount PV.....	13	SunXtender .....	33
Fronius.....	83	RAE Storage Battery .....	79	The Energy Fair.....	82
GRID Alternatives .....	59	Real Goods Solar.....	59	Trojan Battery .....	1
Harris Hydro.....	65	RightHand Engineering.....	79	U.S. Battery .....	17
HuP Solar-One .....	42	Rogue Power Technologies .....	79		

/ Perfect Welding / Solar Energy / Perfect Charging

## WELCOME TO THE FUTURE OF RESIDENTIAL SOLAR. MEET THE FRONIUS GALVO.



SHIFTING THE LIMITS



/ SnapINverter hinge mounting system.



/ Arc Fault Circuit Interruption included.



/ Wi-Fi®\* Enabled. Smart Grid Ready.



### FRONIUS GALVO: SINGLE-PHASE STRING INVERTER

/ Fronius introduces the brand new Fronius Galvo! The Fronius Galvo is the first and only Wi-Fi\* enabled, super lightweight residential inverter that disrupts the residential solar market by providing a list of features never before seen in the solar industry. With the revolutionary Fronius SnapINverter hinge mounting system, which allows for a single person installation in record time, it is no wonder that installers are demanding the Fronius Galvo more than any other string inverter currently available. [www.fronius-usa.com](http://www.fronius-usa.com).

**POWER RANGE  
FROM 1.5 to 3.1 kW**

# Assessing Wind

## Determining Your Wind Resource

**Y**ou want a wind system, and have researched turbine, tower, and installation companies. But one critical question remains: Will it generate the energy (kWh) that you need? To answer, you need to know the average wind speed at the tower height required for your site.

Arriving at a wind speed number is not easy, and getting it wrong can have serious ramifications, since a wind turbine's output is related to the cube of the wind speed. For example, an 8 mph wind will yield only half the energy that a 10 mph wind will. You need a good idea of how much "fuel" you might have.

A wind site assessor will be able to best estimate the average wind speed at your site. Expect to pay \$200 to \$600 for a boots-on-the-ground visit followed by an in-depth report. While this might seem like a lot of money, consider the risk of putting up a \$30,000 to \$80,000 wind system without full knowledge of the resource. Even those who decided against a wind system concur that a site assessment is money well spent.

Online site assessments for comparable prices are available, but they are less reliable than a personal on-site visit. Some manufacturers offer online wind estimates based on your address, but with a financial stake in your decision to purchase, most of these "assessments" are too optimistic.

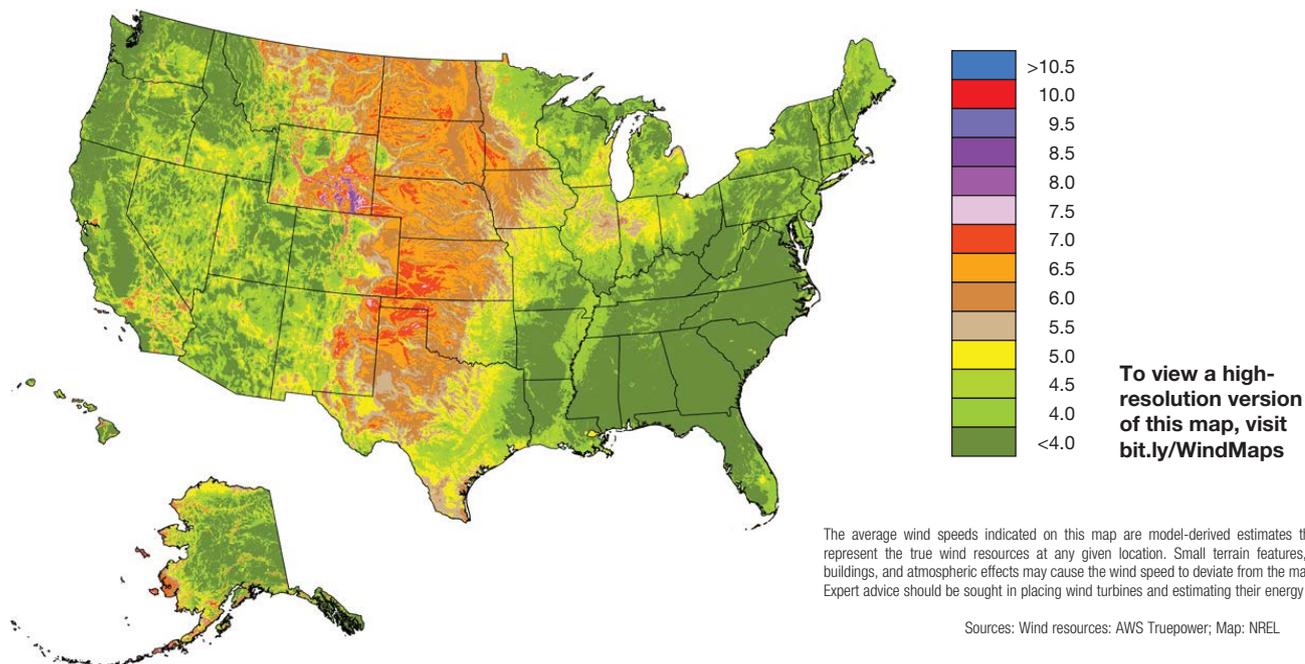
Before you hire an assessor, there is a do-it-yourself method to get a ballpark wind speed. This will help you determine if you should even consider a wind system, or if hiring an assessor is justifiable. First, consult the up-to-date wind resource maps at Wind Powering America ([bit.ly/WindMaps](http://bit.ly/WindMaps)). Click on your state and view a model of the average wind resource for your "area."

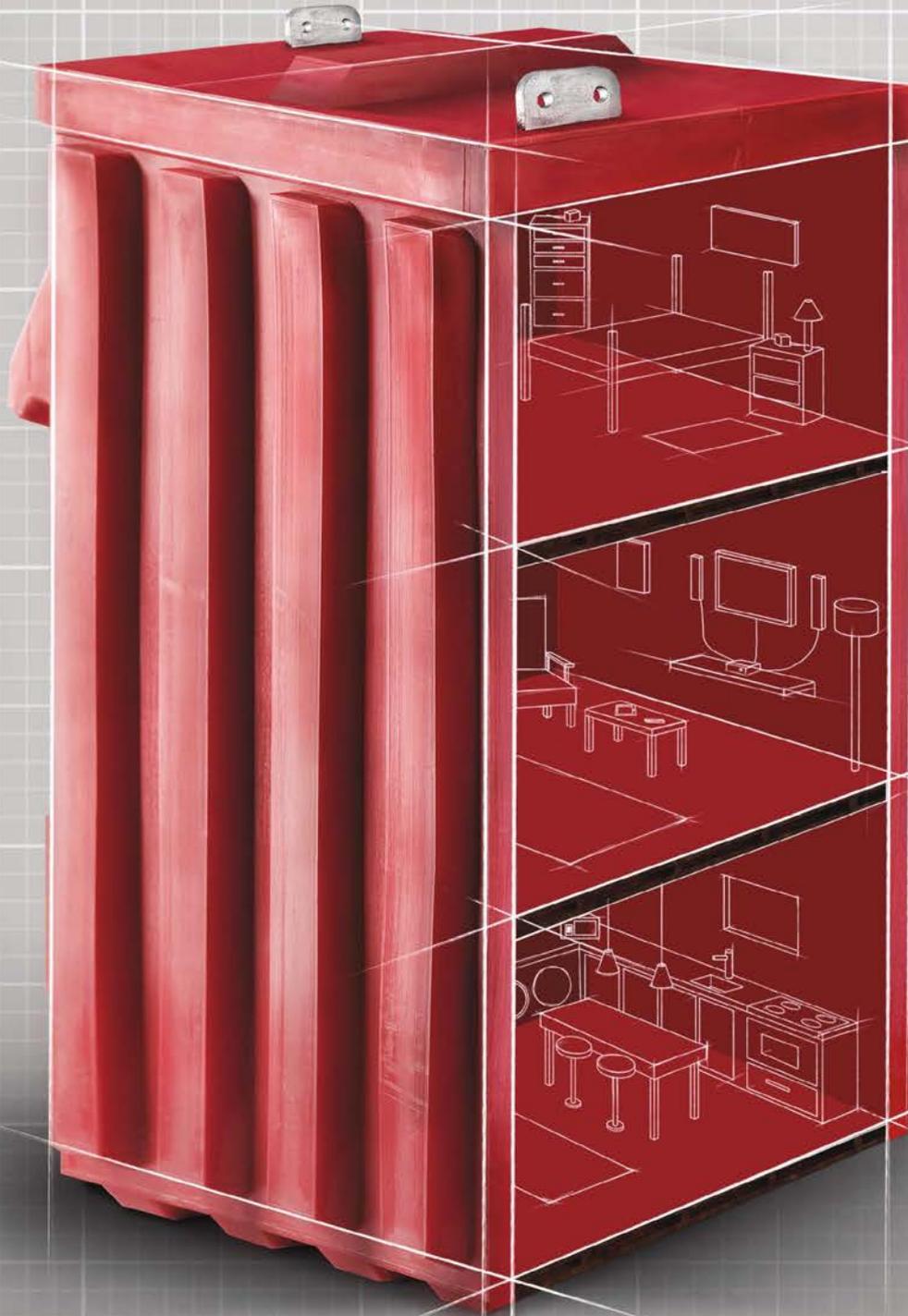
These maps not site-specific, but rather a two- by two-kilometer resolution interpolation. The map cannot give the wind speed at your required tower height (at least 30 feet above anything within 500 feet and the mature tree heights in your area). To fine-tune this number, you'd also need to know your tower site's surface-friction coefficient, turbulence intensity, prevailing wind direction, and displacement height. These are the four critical factors you need to understand to optimize your site's wind speed.

To better understand all of this and why it's relevant, visit [smallwindtraining.org](http://smallwindtraining.org). The "Site Assessor" tab is a resource for site assessor training workshops. There's a lot to read, after which you'll have a good idea of where and how to site your system. Finally, ask nearby wind system owners about their experiences—and what they might do differently.

—Mick Sagrillo

### Average Wind Speed (m/s) at 30 m





There's a lot of life  
in one battery.

*Rolls*  
BATTERY ENGINEERING

THE LONGEST LASTING BATTERY  
FOR YOUR OFF-GRID HOME.  
LEARN MORE AT [ROLLSBATTERY.COM](http://ROLLSBATTERY.COM)

# WIND+SHINE



## Pika Residential Wind Turbines With Solar Hybrid Option

Only the Pika T701 Turbine and Hybrid Microgrid System make it easy and affordable to capture energy from multiple sources, year-round, in almost any weather.



- Nearly silent operation
- Just two moving parts
- Hybrid inverter with plug-and-play PV option
- Grid-tie & battery options
- Built in WiFi for real-time monitoring



Give Us A Call For More Details  
**(207) 887-9105**

35 Bradley Drive, Suite 1 sales@pika-energy.com  
Westbrook, ME 04092 www.pika-energy.com

**See Pika products at:**  
Small Wind Conference, June 16-18  
MREA Energy Fair, June 20-22

Proudly  
Built in  
Maine

