

# North American Clean Energy

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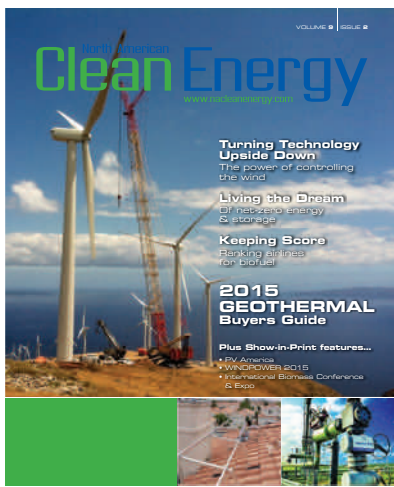


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# contents

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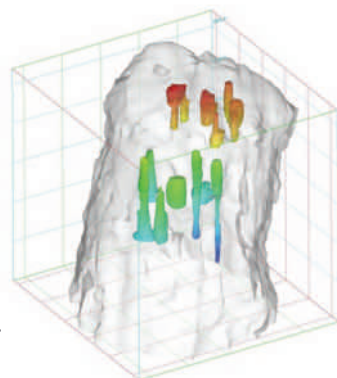
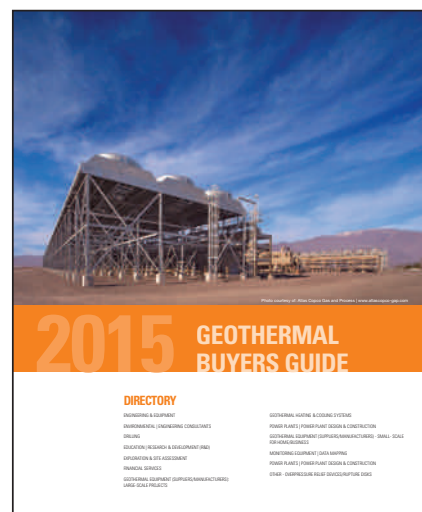
**On our cover...**

IEA Renewable Energy provided engineering, procurement, and construction of the civil and electrical system Balance-of-Plant (BOP) for First Wind's KWP II, 21 MW site on Maui, Hawaii. The KWP II Wind facility has the capacity to power approximately 6,000 homes annually.

IEA Renewable Energy | www.iea.net

## departments

- 06 News bites
- 08 Top story
- 10 Wind power
- 24 Wind product spotlight: Safety & fall protection equipment
- 26 Solar energy
- 42 Solar product spotlight: Batteries
- 48 Show-in-Print: PV America
- 50 Investing in clean energy
- 52 Show-in-Print: AWEA WINDPOWER Conference & Exhibition 2015
- 63 2015 Geothermal Buyers Guide
- 68 Biopower
- 72 Show-in-Print: International Biomass Conference & Expo
- 74 Energy Storage
- 78 Events calendar & Advertisers list



63



- 8 Impact of the Changing Renewable Energy Landscape: *On the EPC industry*
- 10 The Future of Offshore Wind: *The power of controlling the wind*
- 12 Remote Offshore Sensing Resources: *An alternative to met masts*
- 14 Increasing the Efficiency of Aerial Surveys: *By using tablets for project siting*
- 16 Component Considerations: *Improving wind turbine reliability*
- 18 Taming the Cold: *Turbine blades brave icing conditions*
- 20 Turning Technology Upside Down: *The power of controlling the wind*
- 24 Wind product spotlight: *Safety & fall protection equipment*
- 26 Simple Tips for Smooth Solar Projects: *From permitting to paperwork*
- 28 Choosing a Central Inverter: *Utility-scale solar considerations*
- 30 Smart Inverter Topology: *Bipolar advantages*
- 32 Moving the Goalposts for Organic Photovoltaics: *When will commercialization come?*
- 34 Breaking Communication Barriers: *For effective solar monitoring*
- 36 Living the Dream: *Of net-zero energy & storage*
- 38 Residential Solar Financing: *Addressing soft cost reductions*
- 40 On/Off Grid Solar Power Mini-Inverter
- 42 Solar product spotlight: *Batteries*
- 48 Show in Print: *PV America*
- 50 Solar Asset Management: *A marathon, not a sprint*
- 52 Show in Print: *Windpower 2015*
- 63 Geothermal Buyers Guide
- 68 Paving the Road to a Carbon-negative Future: *Biomass, carbon-capture & the western U.S.*
- 70 Keeping Score: *Ranking airlines for biofuel*
- 72 Show in Print: *International Biomass*
- 74 Powering Microgrid Applications: *With renewable energy & battery storage*
- 76 Geological Storage: *Holding hydrogen for electric vehicles & more*

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Photo by Michelle Moore



**AN OLD FRIEND OF MINE** used to have a magnet on her fridge. It stood out, partly because for years it was the only thing on her fridge (she was a minimalist and even an environmentalist of sorts, sourcing only local produce—via her bicycle—and lighting most rooms with soy candles to save on electricity), but mostly because of what it said: “Silent gratitude isn’t much use to anyone.”\*

Searching for a thank-you card the other day, I came across that same quote, as if serving as a reminder to speak up and pay tribute to those whom I am grateful. And, so, I’d like to take a moment to do just that...

To all of our readers, contributing writers, and advertisers of *North American Clean Energy*—a sincere and heartfelt thank you! We couldn’t do what we do without your continued interest and support.

I’d also like to give thanks to the wonderful team I’ve worked with over the past seven-plus years at the publication. Working in the renewables’ sector has been educational, thought provoking, and meaningful. It’s nice to know the content we produce is related to and in line with creating a more sustainable, environmentally friendly future. There’s an inherent appreciation in doing a job that is, ultimately, for the better.

With that said, it’s time I pass forward the editing torch, so to speak, to someone who can take my position to the next level—and, hopefully, into a more sustainable future. I would like to introduce you to my successor, Jill Walters. Jill and I have become fast friends over the last few weeks, chatting and taking notes on everything from grammar to the progress and potential of renewables. (Did you know that since 2004, the number of countries promoting renewable energy with direct policy support has nearly tripled from 48 to over 140, with that number still on the rise? Of course, the industry has a ways to go before becoming mainstream, but it has grown considerably over the last decade—perhaps, yet another reason to be grateful!)

A special thank you to everyone who has made my time as the editor here so remarkable. I wish Jill, and the NACE team, much success and happiness, and look forward to reading the future issues of *North American Clean Energy*.

\*The origin of this quote is unclear, and it has been credited to various writers, including Gertrude Stein (1874-1946) and Gladys Bronwyn Stern (1890-1973), pioneer authors of their time. As a side note, read more about the last decade of renewable energy by downloading the latest report posted at [www.ren21.net](http://www.ren21.net)



**I WROTE MY FIRST BOOK** in the third grade. It was entitled, “There is a Crocodile in my Bathtub and Other Odd Stories.” The pages were tattered from reading through it, editing it, and trying to make it better. I think it’s in a box somewhere in my basement now, having never made it to a publisher because, in my mind, there was always more work to be done on it.

In college, I wrote for the school newspaper and in my early career, I was responsible for the layout and editing of a 4-page daily newsletter and activity schedule. Later, I worked for the newspaper publisher, Black Press. Those jobs were a better fit for me as there was a deadline, a point in time where I had to put the pencil down, let it go, and walk away from it.

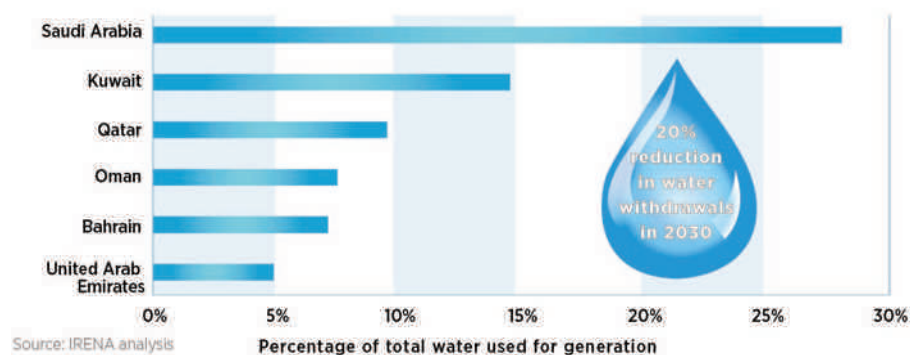
Having said that, I went on to many, non-literary careers and never thought I’d ever get to be an editor, so when the call came and I was asked to join *North American Clean Energy*, I didn’t hesitate.

I know the team here, and many of the contributing writers and advertisers I have already been working with, are going to miss Michelle’s many talents. She has left big shoes to fill and I’m excited about jumping in feet first, and continuing to move this publication into the future.

I look forward to working with you, to sharing the stories of your important work in the field of renewables, and to being a part of this evolving industry.

*Michelle Froese & Jill Walters*

Figure E 3 Potential for reduction in water withdrawals for power generation in GCC region by 2030



### Water-saving potential of renewables

The water-saving potential of renewable energy is among the major findings in a recent report entitled, “Renewable Energy in the Water, Energy, and Food Nexus.” The report provides a detailed analysis of how renewable energy can help address some of the most pressing challenges across the water, energy, and food sectors.

During the power-generation stage, water needs for solar photovoltaics (PV) and wind are negligible compared to conventional thermoelectric generation, where substantial quantities of water are needed for cooling. During this stage, solar or wind power projects could withdraw up to 200 times less water than a coal power plant to produce the same amount of electricity. In a region where water is scarce and expensive, this can lead to substantial cost savings.

In fact, hitting renewable energy targets in the Gulf Cooperation Council (GCC) region alone would cut energy-related water use by nearly one-quarter. In addition, the report also shows that renewable energy-based desalination technologies could play an increasing role in providing clean drinking water for people around the world.

“Until now, detailed knowledge on the role of renewable energy at the intersection of energy, food, and water has been limited,” said IRENA Director-General Adnan Z. Amin. “But this first-of-its-kind report shows that in addition to enhancing energy security, improving air quality, reducing carbon emissions, and creating jobs, greater deployment of existing renewable energy technology can also bolster water and food security.”

**The International Renewable Energy Agency (IRENA) | [www.irena.org](http://www.irena.org)**



### Renewables’ tech exchange

Wiki-Cleantech is an online resource offering free, collaborative knowledge related to renewable energy. The platform is designed to gather all scientific and technology energy information in one easily searchable place. It includes technical papers and presentations on wind, solar, biomass, and other clean energy technologies, contributed by the industry and research communities.

“Wiki-Cleantech was founded with the realization that a large part of the technical knowledge produced by renewable energy engineers and researchers was almost exclusively presented and shared at conferences, and were usually trapped in PDF’s or sold on by the scientific journals,” explained Wiki-Cleantech founder Jonathan Collings. “We believe that this information should be free and easy to share.”

**Wiki-Cleantech | <http://wiki-cleantech.com>**



### Did you know?

Geothermal power plants are currently a leading provider of permanent, onsite employment in California and in the western United States. As part of its annual industry assessment rollout, the Geothermal Energy Association (GEA) released preliminary data showing that there were 3,150 permanent, onsite employees at their power plants, or 1.17 permanent jobs per megawatt of geothermal power installed. That's 19 times the reported onsite employment of wind power projects, and five times the reported onsite employment for solar energy projects.

**Geothermal Energy Association (GEA)**  
www.geo-energy.org

### Gaining a grip on gearboxes

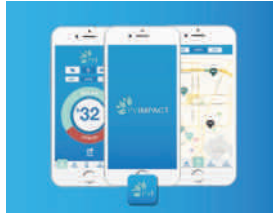
As the central component of the drive system, the gearbox has always been a critical interface in wind turbines, constituting 13% of the overall value of the typical onshore wind turbine.

However, with approximately 175,000 geared turbines in operation in 86 countries worldwide, there are around 1,200 incidents of gearbox failure reported each year—that's one failure per 145 turbines per year—commonly ranging between \$200,000 and \$300,000 in insurance claims, in some unique cases exceeding \$500,000. It's, therefore, crucial that asset managers take proactive, preventative steps to ensure related financial and operational risks are managed appropriately.

Renewable energy underwriter GCube Underwriting Limited has published an in-depth report, entitled "Grinding Gearboxes," which analyzes gearbox failure by addressing root causes, financial impacts, and proactive steps to mitigate the frequency and severity of downtime. The report forms part of a series, seeking not only to quantify the inherent risk and financial impact of gearbox failure, but also to promote knowledge sharing to minimize impacts.

Learn more by visiting  
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### New solar tool for smart homes

The dawn of the smart home is upon us with various products connecting homes to information networks. To fully and efficiently take advantage of these energy networks, the US Department of Energy recently awarded Pick My Solar a grant to develop a universal tool for all solar homes to connect to the information grid. The result: an app called PVimpact.

This new mobile app's dynamic capabilities will not only benefit homeowners, but also solar installers, manufacturers, and utilities by analyzing a home's energy usage in real time. The technology behind PVimpact aggregates three principal pieces of data: a homeowner's electricity use; a solar system's production; and the contractual details of that solar system. Currently, none of these data points are collected together.

This summer the technology will be rolling out for free to all Pick My Solar customers, and then expanding to the rest of the US residential solar market in early fall.

**Pick My Solar** | www.pickmysolar.com

### Wind Trends Bulletin Released

The quarterly Wind Trends Bulletin provides wind plant owners, investors and operators with a high-level analysis of wind resource performance influenced by climatic fluctuations. This aids in identifying potential issues with wind plant underperformance.

Highlights of Q4 2014 Bulletin Include: Winds were above normal across the northern and western United States, much of South America, northern Africa, the Arabian Peninsula, China, Russia, and portions of India and East Asia. Winds were below normal across southern and central portions of the United States, much of Europe, East and West Africa, Indochina, and nearly all of Australia.

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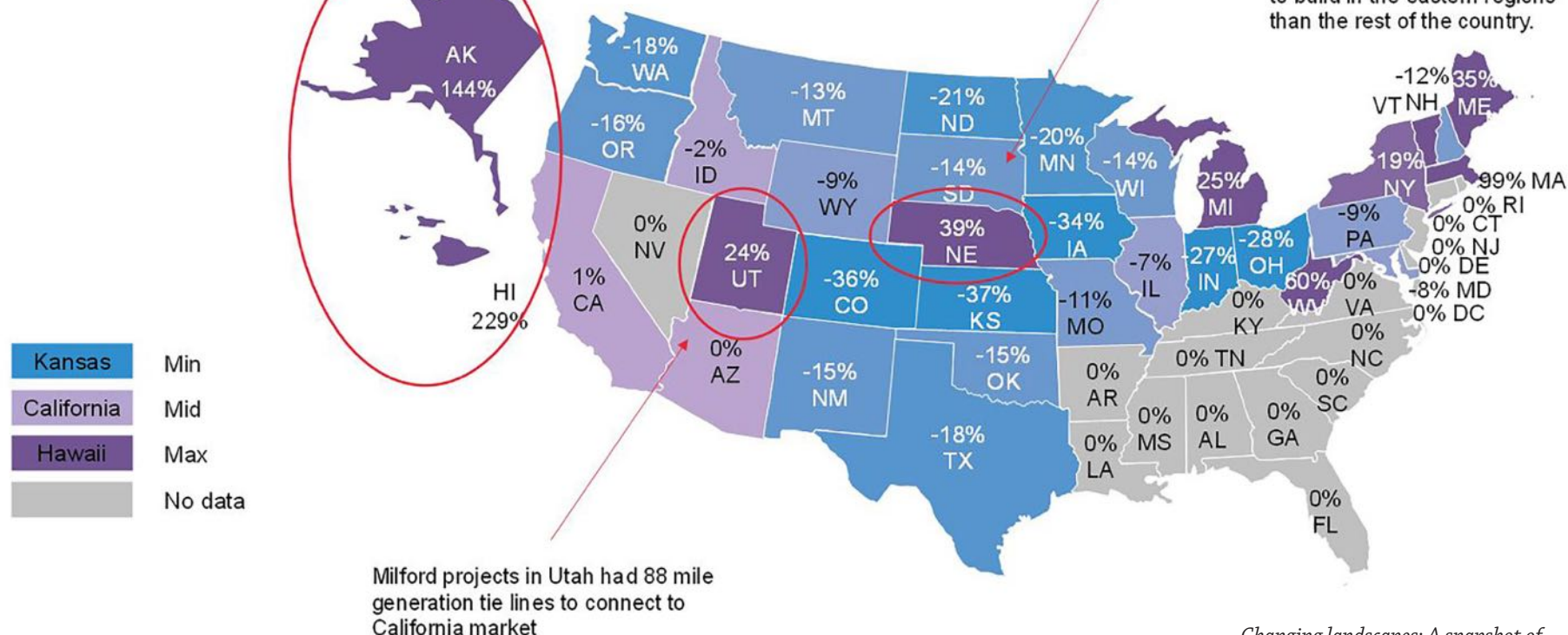
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Milford projects in Utah had 88 mile generation tie lines to connect to California market

Changing landscapes: A snapshot of wind energy across the United States (Source: Bloomberg New Energy Finance, US Treasury)

# Impact of the Changing Renewable Energy Landscape On the EPC industry

By Tim Kemper

The renewable energy industry in the United States is continuing its trend of significant growth and is expected to double capacity by 2021. This changing landscape will, inevitably, have an impact on the engineering, procurement, and construction (EPC) market that's responsible for designing and implementing the related project infrastructure. As a result, the firms that provide services for solar and wind energy development will be forced to adapt to the economic realities of a growing market and a changing industry.

The good news is that the short-term outlook for EPCs appears to be positive. Developers are pushing the industry forward as they continue to rush the completion of projects before the production tax credits (PTC) expire and the investment tax credits (ITC) step out and fade.

However, as the renewable industry continues to develop, it's clear that the EPC sector will need to adapt quickly, diversify, and offer additional critical elements to a project (say, from permitting to financing) that aren't typically associated with engineering.

From profit margins and employment concerns to risk and the value of experience, here's what issues may evolve over the next couple years in the renewable energy EPC world.

## Profit margins

In terms of profit margins, the outlook varies depending on the location and structure. Overall, most EPCs have seen declining margins since 2010. In fact, many are experiencing relative margins thinning, as they are being asked to assume more risk without seeing an increase in margins to reflect such a requirement.

Fortunately, a continued downward trend for margins is not inevitable. EPC services could be in especially high demand this year as developers rush to meet a soft deadline for the PTCs.

## Employment

Over the next two years, the significant increase in renewable energy production will keep engineers, construction companies, and project managers quite busy. Further accelerating EPC demand and margins will be the expansion of the domestic oil and gas industry. To meet this accelerated demand, recruitment will be key.

Renewable energy companies are increasingly concerned that there won't be enough qualified engineers to keep up with the broader industry demand. Statistics show that engineering majors among college graduates have actually declined 40% in the past two decades. Further exacerbating the problem is significant competition from the oil and gas industry, as companies look to hire educated trades professionals in those fields as well.

## Risk

Ironically, during the height of this boom period, EPCs will need to plan ahead for the drop-off in wind and solar subsidies over the next couple of years. This could lead to a scarcity of large, utility-scale projects, as well as shrinking profit margins. The largest and most successful of firms will prepare by seeking new opportunities for growth, or else they will completely change their business model to avoid disappointing returns.



The question for many EPCs will be whether they are willing to take on more risk with diversification of renewable power projects. This field has, traditionally, been divided according to technology, but that's beginning to change.

#### Diversification

Some EPC firms that have historically focused on wind energy are broadening their reach and gaining traction in the solar industry, which offers a more stable policy environment. Firms that can focus on smaller, utility-scale solar projects (1 MW to 10 MW), in states with robust incentives, will likely find higher margins compared to those gained from large-scale wind power projects.

But those large wind EPCs that have been in the market a long time should have a hefty pipeline of deals that should remain active and busy. Other companies will have likely looked into diversifying into newer technologies, such as hybrid projects involving renewables and gas, microgrids, and energy storage projects.

#### Vertical integration

The increasing trend seen in the solar industry of late has been a movement toward vertical integration, with the capability of companies to handle anything from project development to financing. As the solar energy market matures, there's a good chance increasing consolidation and vertical integration will occur, with more acquisitions.

This move has inhibited some large EPCs from fully moving into the solar market. Herein, higher margins may exist than many companies have come to expect in the wind power market. To keep up, EPC firms must have strong credit and financial stability.

#### Experience

Renewable energy costs have been falling as the increased scale and maturity of the US solar and wind energy industries are (for the most part) driving project costs down. Engineering, procurement, and construction costs have also been falling, as firms that provide these services are becoming more efficient.

EPCs with significant experience as general contractors have now also developed deep expertise in US renewable energy, providing their clients with knowledge of financing obstacles, development trends, and technology advancements. They are also becoming involved in a broad range of areas, such as permitting and securing the point of interconnection. Some EPC firms are even providing their clients with financing or alternative payment methods to help get projects completed.

As the renewable industry continues to develop and grow, it's clear that the EPC sector will become a more critical element of the financing of projects.

Nevertheless, EPCs are going to be facing a challenging dual-threat on the one hand, dealing with a short-term boom and recruiting talent while, at the same time, preparing for a future where margins will become thinner, and diversification, innovation and efficiency will be paramount.

For renewable energy-focused EPC firms to thrive in the coming years, they will need to adapt quickly to keep pace with this rapidly changing industry.



*Tim Kemper is the co-national director of CohnReznick Renewable Energy Industry Practice.*

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# The Future of Offshore Wind

## Design standards & certification considerations

By James Nichols

Over the last 20 years, the European offshore wind industry has worked to bring companies together from the onshore wind market and the offshore oil and gas sector. The intent has been to make connections, forming a melting pot of ideas in the quest for cheaper, cleaner, and more predictable energy.

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As the proportion of offshore wind development increases, so does the pressure to reduce dependence on Feed-in Tariffs (FIT), to attract more private investment, and to contribute to a more stable, sustainable electrical grid. This has resulted in some conflicting pressures to reduce costs and risks, with one side seeking new innovations, while the other remains set on more familiar, traditional technologies.

Although the United States is still in its infancy in terms of offshore wind power projects, the developments overseas are worth noting and learning from. Aside from in Germany and Denmark, there are no legal requirements to perform certification of offshore wind farms in Europe. However, for countries such as France and the UK, it's virtually unknown for an offshore wind farm to be constructed without engagement with a certification body.

Certification can mitigate risk, not only assuring investors that new technology is being deployed in a responsible manner, but also ensuring any performance claims are not without merit. The challenge for certification is to remain one step ahead of the industry, developing research to underpin new rules and guidelines, while ensuring the safety and reliability of newer, more efficient installations. In this arena, new methods of deployment of novel and cost-effective technology are continually sought, tested, and validated.

With awareness in the offshore wind market that

prices must decrease significantly in the coming years for continued growth and success, now seems the ideal time for certification and standards to fully develop. It's important to ensure product safety and quality, while harnessing the confidence level required to attract new and ongoing wind energy investments.

### Why a multi-disciplinary approach is best

It's very rare that one engineer, or even one company, can have the required depth of knowledge in every field it crosses paths within the offshore industry—whether that be in aerodynamics, control, structural dynamics, hydrodynamics, geotechnics, fabrication, or finance. There is much benefit for experts in each of these fields to collaborate and share knowledge, not only for productive projects, but also for safety reasons and best practices.

With maintenance and inspection accounting for approximately one-third of offshore wind lifetime costs, vessels and access methods also play key roles in developing any offshore project. It's essential, therefore, that developments are carried out in a manner that strengthen safety standards for workers, increasing the chances of successful rescue in the event that something does go wrong offshore.

At the same time, innovation is required to decrease the cost of supplying energy and to drive uptake of long-term, renewable power solutions. Herein, it's important to be aware that developments

in one area can significantly impact another. For instance, new foundation designs for turbines can either reduce or increase the price of installation and/or maintenance. An understanding of such issues early on in a project (and in a holistic way) is a necessary step to arrive at an optimal, long-term solution and design.

Maintaining open communication lines with experts in each field is often the key to bridging new information with past experience. Truly reducing costs in the offshore wind industry requires input from organizations with a high-level overview of the different disciplines. Incentives are also helpful for project success. For example, a supplier may feel they need to produce the lowest cost solution for their piece of the project to win a bid, but the effects of that decision may lead to less favorable return-on-investment (ROI) over time.

It's simple: Developers with the proper tools and access to the right information can make better decisions regarding every element of their wind project.

#### Why different designs are needed

Although offshore wind farms make use of high wind speed sites with low turbulence, the variability in metocean conditions and seabed profiles, coupled with different grid connections and distance to shore, makes for a high degree of variation between different projects.

The current range of sites developed makes for a small fraction of the depth and range covered by the oil and gas industry. Nonetheless, the efficiency required and significance of wind turbine loading has led to many shared designs across these sectors. In fact, many of the designs used in floating oil and gas structures have been borrowed or adopted for offshore wind projects, along with some novel ideas. Even across a single site, savings in steel from using several existing structures often outweighs the cost of developing and manufacturing new and different structures.

Floating offshore foundations offer a plethora of new concepts to explore, but eventually a more standardized design will be likely because of the reduced dependence on water depth and seabed conditions. For floating support structures, these are primarily a concern for the mooring system, which might be a small fraction of the hull cost. Therefore, it may be possible to design floating support structures to certain classes of wave environments, so as to better enable mass production.

Despite future efforts for standardization, the industry can still expect to see substantial differences in designs depending on location. What's appropriate for a North Sea wind site might be completely different than what's best in Mediterranean waters. And, to some extent, the drive for larger offshore wind developments has resulted in higher variability and more bespoke designs for offshore support structures. After all, the larger turbine capacity means fewer turbines for a given power plant size, thereby reducing the impact of savings due to standardization in designs.

Until the industry reaches more maturity, the coming years will likely see a variety of floating platform designs deployed, along with suction bucket concepts and larger-than-ever monopiles. Each will have a particular suitability according to water depth, turbine type, and seabed conditions. It will take some time for the offshore wind industry to develop and decide which design is most economical for a given site.

#### Final thoughts

With high levels of uncertainty in regulatory support from governments and low levels of capital available for investment, it's a challenging time to develop new technology. The fall in oil price adds to these challenges, but can also lead to opportunities.

For those willing to invest to guard against future price rises, the cost of manufacturing, transportation, and installation should be lower now than they have been in years. The time could be right for an explosion of offshore wind innovation and development, which could shape the energy landscape for the next generation (and, hopefully, on a global scale), while delivering the cost reductions the offshore industry needs to flourish.

A development of standards and guidelines can play a key role in responsible innovation. Prudent investors need assurance from experienced engineering organizations that costly errors in production or safety won't be made, and often that must come through independent review and analysis.



*James Nichols is the Renewable Energy team leader at Lloyd's Register Energy.*

**Lloyd's Register Energy** | [www.lr.org/energy](http://www.lr.org/energy)

# Unfortunately, Mother Nature has a Mean Streak. Fortunately, you have Sika.

Face it, Mother Nature doesn't always play nice with wind turbines. High winds, hail, lightning, snow, ice, and even birds can damage blades, reducing their capacity to perform. When that happens, you need fast, reliable repair products and services that can get your turbines back on line. That's why the world's leading wind turbine producers consistently turn to Sika. Our expertise and experience in the wind energy industry are second to none with a full range of repair products that consistently meet the industry's toughest specifications. You can't stop Mother Nature when she gets mean, but fortunately you have Sika to get turbines turning again. For more information, visit [www.sikausa.com](http://www.sikausa.com) or call 248.577.0020.



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# Remote Offshore Sensing Resources

## An alternative to met masts

By Mark Pitter &amp; Alex Woodward

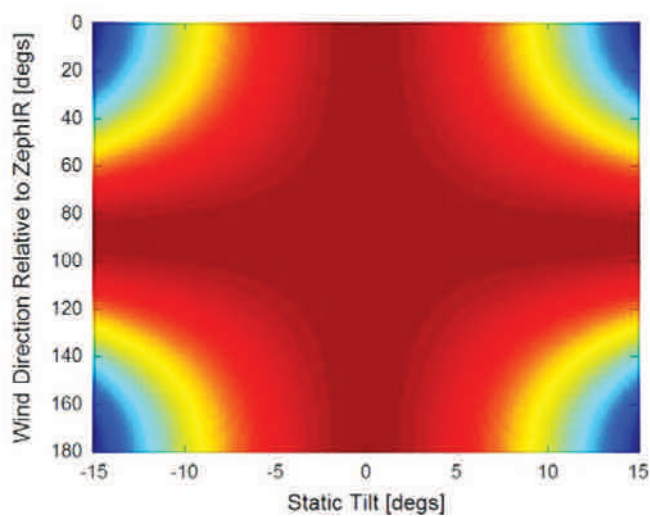


Figure 1.

**REMOTE SENSING ON FLOATING OFFSHORE PLATFORMS**, such as buoys, barges and ships, provides a cost-effective alternative to expensive foundation-mounted offshore wind monitoring towers for wind resource assessment. It's unlikely that foundation-mounted offshore meteorological masts will ever be viable in water depths of over 100 feet; however, floating platforms (depending on their design) can be deployed in almost any water depth.

As floating wind turbines in deep, offshore waters start to come online in the North American wind market, issues related to the collection high-quality, bankable, hub height wind data becomes ever more relevant.

### Weighing the costs

The use of a remote sensor presents significant opportunities for up-front cost savings in any anemometry campaign, especially when compared to traditional, more expensive met mast methodology. However, these devices are subjected to motion. If not fully understood, this could increase the uncertainty connected to the measurement, making the solution unviable. It could also negatively offset any potential capital expenditure (CAPEX) savings caused by measurement uncertainty, impacting the lifetime of the wind farm.

Buoys are primarily the device type chosen for mounting remote sensors in floating offshore applications. They typically exhibit translational (surge, sway, and heave) and rotational motions (pitch, roll, and yaw), and all of these motions have the potential to adversely affect the measurement of the wind vector.

### Defining the devices

There are currently two types of finance-grade (DNV GL Stage 3) wind lidars on the market: Continuous Wave (CW) and Pulsed. They are both termed Doppler lidar—that is, they sense the Doppler shift of the received light and use this to calculate the wind parameters.

CW lidars are deployed on 85% of buoy manufacturers floating lidar systems today, and measure the wind speed at user-defined heights in a sequential fashion. All of the available laser energy is focused at the user-defined measurement height, leading to a high carrier-to-noise ratio (CNR). Consequently, very high line-of-sight velocity data rates of 50 Hertz (Hz) occur. This leads to 50 line-of-sight wind data points being acquired during a one second scan at each height.

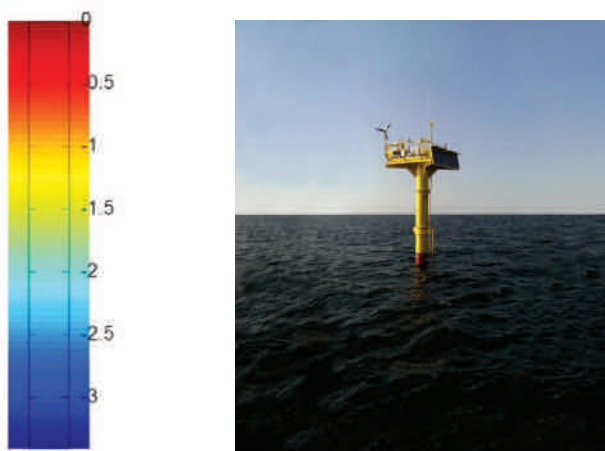


Figure 2.

The nature of buoy motion is such that very little movement occurs over the 20 milliseconds (ms) required for each line-of-sight measurement. And, even over the one second required to measure at each height, motion is limited.

This core technical specification of CW lidar delivers results as shown in Figure 1. The worst-case scenario for the buoy-mounted CW lidar tested: experiencing period pitching or rolling of 10° or less, which is an under-read of around 0.75%. Nonetheless, platforms such as spar and tension leg buoys don't exhibit enough motion to bias the wind speed measurements to any appreciable amount, as they're typically limited to periodic motion of less than 5°—leading to a bias of less than 0.25% (when the results are averaged around the wind rose).

Although it's possible to stabilize a lidar to some extent by using a mechanical gimbal, this has never been found to be necessary for buoy-mounted CW lidar deployments.

### Final thoughts

In conclusion, it can be seen from simulations and offshore trials that the 10-minute averaged wind speed recorded by CW lidar is very resilient to the presence of the type of motion experienced by a range of buoy designs—even when no mechanical stabilization or software compensation is applied.

Yaw is easily compensated for by using a compass to determine the actual CW lidar bearing at the time of the measurement. Translation motions tend to average to zero over 10-minutes, and do not degrade the results.

Floating CW lidar, therefore, has the real opportunity to replace meteorological met masts and fixed platforms, as well as existing infrastructure deployed with remote sensors. And, they can do so for a fraction of the current cost delivering the lowest cost of energy possible as a wind measurement resource.

*A full technical paper detailing all studies and trials to date, entitled "Performance stability of ZephIR in high motion environments," is available by request (research@zephirlidar.com).*

*Mark Pitter is a scientist and offshore applications leader and Alex Woodward is the head of product development, both at ZephIR Lidar.*

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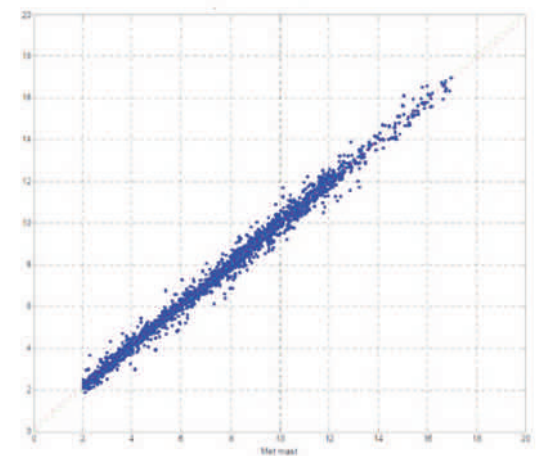


Figure 3.

**Figure 1.** CW lidar wind measurement stability in relation to static tilt and wind direction (Examples of available floating lidar devices by manufacturers to measure wind parameters offshore, include: Babcock's FORECAST (as shown in Figure 2); SeaRoc's SeaZephIR; Fugro's SeaWatch; EOLUS; FloatMast; and Fraunhofer's Wind Lidar Buoy).

**Figure 2.** Babcock's FORECAST floating wind lidar, driven by Continuous Wave lidar ZephIR 300. As one example, the Babcock FORECAST is a low-motion spar buoy, which reduces motion to a level where compensation (other than yaw for wind direction) is unnecessary to achieve excellent accuracy and precision. (In a recent offshore trial at Gwynt Y Môr, in the Irish Sea off the north coast of Wales, UK, regression parameters of  $R^2 = 0.990$  and a gradient of 1.006 were achieved at a measurement height of 90 m, compared to the mast at Gwynt Y Môr as shown in Figure 3.)

**Figure 3.** Herein, the lidar and mast were separated by 260 m. At the time of publishing, system availability has been 100% and data availability has been greater than 99% at all measurement heights.

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	1.5S				m w b	m w b			
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# Increasing the Efficiency of Aerial Surveys

## By using tablets for project siting

By Matt Alexander

**AERIAL SURVEYS ARE A METHOD** of collecting valuable geomatics or site data for a project, which can be effective, but also expensive and time-consuming. These surveys can also, potentially, impact the wildlife on location and can be technologically difficult to navigate and document the data with ease.

Nonetheless, aerial surveys are often conducted prior to and post-construction, particularly for renewable energy projects—either to comply with regulations or to minimize asset loss. Fortunately, evolving technology is creating new opportunities to address these needs that increase aerial survey efficiency, thereby, saving developers, investors, and agencies time and money.

### Traditional methodology

To successfully complete an aerial survey, biologists have three general requirements, including the ability to:

1. View the location of interest inside the survey boundaries;
2. Record the global positioning system (GPS) points; and
3. Record the flight path to track progress and achieve agency reporting requirements.

To meet these requirements, biologists often utilize traditional methodology, which tend to include the use of a handheld GPS unit with a pre-loaded map. This demonstrates the survey boundaries, and includes an electronic data form, which documents the location and information on nearby nests, vegetation, etc., in the GPS. Additionally, biologists use paper datasheets and even printed maps (aerials or quads) as a backup for navigation and documentation.

Use of a handheld GPS unit provides some benefits, including the ability to record data points within a three-meter accuracy, along with the ability to electronically capture GPS coordinates and transition these points to a GIS database without manually transcribing them. However, there are also several pitfalls associated with this technology.

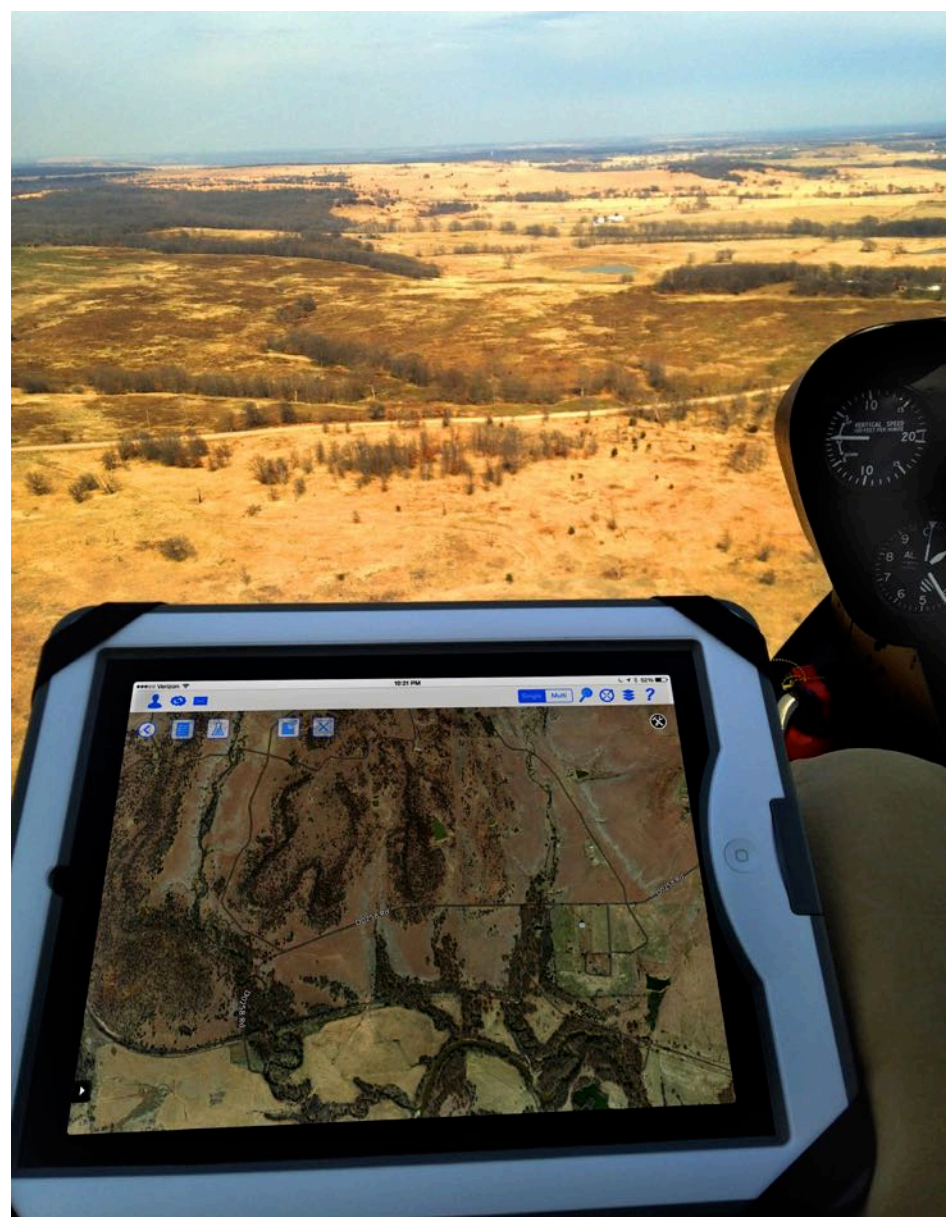
For one, these handheld devices are not specifically designed to track the user or record GPS data while flying and, therefore, they rarely communicate with satellites fast enough to adequately track the helicopters location. This commonly results in technical glitches with the device during the survey, which can often lead to the need for additional flight hours. Secondly, it's difficult for biologists to track their location on the small screen of the GPS device, particularly when the survey area is extensive. Lastly, utilizing a satellite image of a large project area can bog down the memory of the GPS unit, causing the unit to crash.

### New technology

Recent technological advancements in the form of tablets with mobile GIS software, paired with external GPS receivers that are designed for flight applications, are providing new opportunities for aerial surveyors. These tablets can substantially increase efficiency and accuracy of site surveys, while simultaneously reducing the potential impacts to wildlife.

When paired with a GPS receiver, a tablet increases survey efficiency, thereby reducing the total flight hours. As renting a helicopter and a pilot can cost upwards of \$1,600 per hour, the cost of a tablet device and software is easily outweighed in this case by the cost in time saved during a survey. These efficiencies are achieved through several benefits during the survey, including: the use of an affordable external GPS receiver that communicates up to ten times faster with satellites; a reduction in glitches during the survey; elimination of the need for cellular service to find one's current location; and more accurate tracking of the flight path. Moreover, a table with software has been shown to provide greater accuracy, saving on post-survey data documentation.

This increase in efficiency and ease of use are made possible by a number of reasons, including: an ability for a surveyor to more easily record data points electronically; to view the entire survey area over satellite imagery (and quickly zoom in and out to specific



*Conducting an aerial site survey at a potential wind farm with the help of a tablet, paired with external GPS receivers*

locations with a touchscreen); and to upload all of the data quickly at the end of the day, without transcribing additional data from paper maps. Some GPS receivers will also allow users to automatically export a KMZ file that shows the flight path in Google Earth.

Although many tablets have the capability of performing these functions, compare specifications, such as:

- Design durability (and availability of a waterproof case);
- Battery life;
- Mobile GIS apps;
- Compatibility with external GPS receivers; and
- Longevity in the market.

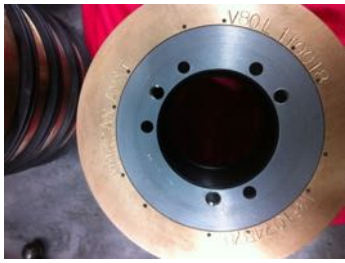
### Conclusion

To date, in a number of case studies and projects where the tablet solution has been employed, aerial survey hours have been cut by 20% to 30%, based on a comparison of flight hours using traditional technology. These cost savings were a direct result of easier navigation, quick GPS coordinate recording, better mapping of the flight path, and the external GPS receiver's ability to maintain position information without glitches.

In these projects, the tablet solution has been extensively used for field and aerial surveys, including: routing surveys; threatened and endangered species surveys; aerial raptor nest surveys; eagle point count surveys; noxious weed monitoring; habitat mapping; and wetland delineations. The potential for this technology will only continue to expand, providing additional opportunities for developers and agencies to save time and money in the future.

*Matt Alexander is a senior biologist and mobile technology specialist with Ecology & Environment, Inc., an environmental consulting firm. He has 18 years of experience designing, leading, and conducting field surveys across North America—working on wind, solar, transmission, and other energy projects.*

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Quality engineered components, such as slip rings, can dramatically reduce turbine downtime and related maintenance costs

# Component Considerations

## Improving wind turbine reliability

By Russell J. Tallyen

**GIVEN THAT MAINTENANCE FOR WIND TURBINES** involves the replacement of costly parts, along with time-consuming and dangerous ascents of turbines up to 100 meters tall, there's a constant focus within the industry on improving reliability. After all, the more durable, dependable, and efficient the components in a turbine are, the less likely repairs or unplanned upkeep will be required.

Although it's impossible to predict all of the necessary maintenance that might be needed in any component throughout its expected lifetime, taking a few extra steps when building and maintaining turbines can substantially reduce the risk of unscheduled downtime—not to mention the associated costs of lost power generation.

### Understanding the system

The system of power generation within a wind turbine is fairly simple. Wind turns the blades of a turbine, which in turn rotates a slow-moving crankshaft. The motion of this shaft is, then, amplified by a gearbox before it's applied to a rapidly spinning generator. This generator produces the power, which is applied to the slip ring, and drawn off by carbon brushes in a brush holder (mounted near the slip ring). The resulting power is taken to the grid.

Operating time is key to effective power generation by wind turbines. Since wind is not constant, turbine operators strive to keep turbines spinning more than 98% of the time during adequate wind events. For this to be possible, all of the components of the turbine must be working properly.

When something fails or simply doesn't work up to par, however, time becomes a major factor. Not only can turbine downtime cost in terms of power losses, but there's also the maintenance time to consider—and the danger involved in repairing or replacing components at height. When these considerations are factored in, it becomes clear that long component service life is critical to effective turbine performance and power generation.

### • Choosing a reliable gearbox

Gearboxes are the components that fail most often within wind turbine power generation systems. Choosing the most appropriate and reliable gearbox for a turbine is, therefore, a significant key to reducing downtime. Because of this, performing adequate scheduled maintenance on the box—such as ensuring proper lubrication for the environmental conditions of the turbine—is an important step that's not to be missed when it comes to ensuring reliability.

Wind turbines are often placed in some of the harshest conditions on the planet. Offshore wind farms, for example, must contend with the high salinity of sea air. Then, there's the wind farms in desert conditions, which must contend with dry air that contains abrasive sand, as well as high temperatures and low wind speeds. Proper maintenance is especially important in these cases, as harsh environmental conditions wear down turbine components much faster than laboratory service conditions might indicate, especially if not properly maintained.

### Carbon brush considerations

Selecting the correct brush grade might seem like a minor consideration, however, it's an important step in turbine upkeep. The brush grade required depends on the service conditions of each turbine. Each grade contains a different material composition and impregnation, which is designed to optimize service life.

Brushes are primarily made from graphite, though the percentage of graphite can vary; some grades include copper, for instance, or other metals as abrasive or cleaning materials in service conditions where brush film build-up is likely. Similarly, impregnations, or chemical compounds that are introduced into the graphite during production, help to optimize brush film, protecting the turbine components.

Monitoring environmental conditions, such as humidity, temperature, and salinity—via consultations with an application engineer, can help turbine operators find the ideal brush grade for each turbine installation.

### • Selecting the correct brush grade

The carbon brushes, resting on the slip ring in a nacelle, might not seem all that significant. Carbon brushes are the least expensive component in a turbine system, and one of the easiest to replace. However, they are responsible for creating a brush film on the ring, and they must be replaced the most frequently.

A suitable carbon brush can last up to three years, helping to extend the service life of other components, such as the slip ring. But, any unsuitable brushes can lead to drastically increased costs and unnecessary downtime. When an unsuitable grade of brush for a turbine's operating conditions is used, or worn



brushes are left for too long, they can create additional wear on the slip ring. They can cause the slip ring to degrade or lose roundness and force early replacement.

The film conditions in each turbine vary based on service conditions and brush grades. Excessively heavy films inhibit transfer of current, while films that are too thin lead to slip ring damage. An ideal brush film allows the slip ring to continue spinning smoothly, without being damaged by the brushes—and, while effectively transferring power to the grid.

#### • Ensuring roundness

Another critical step in improving the reliability of wind turbines is checking the roundness of slip rings while they are in service. A range of instruments for diagnosis of the most common problems in rotating machines and slip rings are available to do just that. A profiler, for instance, can help wind turbine operators combat the detrimental effects of slip rings that have lost their roundness.

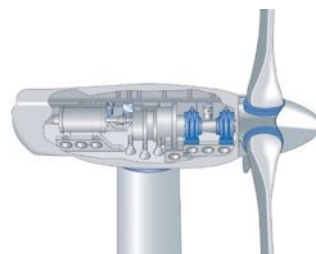
Non-round slip rings place additional stress on carbon brushes, wearing them out faster than in normal conditions and causing early failure. Slip rings that aren't round can also cause carbon brushes to spark due to a poor electrical connection. If this is the case, power is not being drawn from the slip ring as efficiently as possible, and overall power generation decreases as the result.

With this information and proactive research, operators can often reduce the overall maintenance necessary for their wind turbines, thereby decreasing downtime. They can also reduce the number of dangerous and time-consuming trips up and down the turbines for unplanned repairs or component replacements. With the goal of increased power generation and project cost reductions, selecting the right components, including carbon brushes and slip rings, for the job also goes a long way in long-term turbine performance.

*Russell J. Tallyen is the design and application engineer for Morgan Advanced Materials Electrical Carbon.*

*The Electrical Carbon Business of Morgan Advanced Materials designs and manufactures a broad range of high performance solutions for rotary transfer systems, linear transfer systems and electrical carbon systems.*

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# Taming the Cold

## Turbine blades brave icing conditions

By Matthew Wadham-Gagnon, Caroline Farley & Bruno Boucher



**Image 1.**



**Image 3.**



**Image 2.**

**Image 1.** Ice accretion on the leading edge of a turbine blade at the TechnoCentre éolien (TCE) test site in Rivière-au-Renard

**Image 2.** Ice shedding from a blade during a de-icing trial using a prototype electro-thermal retrofit system at the TCE test site

**Image 3.** Snowcat and a 4WD pick-up truck on tracks

**Figure 1.** Preliminary ice map of Quebec, produced by VTT in collaboration with TCE

**Figure 2.** Greatest causes of production loss (Source: “Wind Energy Update’s Turbine Optimization, Maintenance & Repair Canada Survey”)

**WITHIN THE NORTH AMERICAN WIND ENERGY INDUSTRY**, the challenges associated with climates characterized by low temperatures and icing conditions are widely acknowledged. As of the end of 2012, two-thirds of the 11.5 gigawatts (GW) of wind energy capacity installed globally in moderate to severe icing climates were located in Canada and the United States, compared to one third in Europe (according to the BTM World Market Update).

Furthermore, it is forecasted that 5.9 GW of North America’s added capacity by 2017 will be sited in moderate to severe icing climates.

### Ice assessment

The presence of ice on a wind turbine blade, if significant enough, will affect its aerodynamics, which leads to lower energy yield (see Image 1). According to Lacroix (2012), an average of 7.5% of annual production was lost in Quebec in 2011 due to icing climate. The Quebec wind industry is, currently, deploying considerable effort to overcome various technological challenges related to wind plant operation in winter conditions.

In light of the most recent call for tenders in Quebec for a 450 MW wind power farm, many industry players agree that the upcoming contracts with Hydro-Québec will hinge on proper ice assessment. As a result, the industry is keen on having reliable icing maps and validated correlations between meteorological icing, instrumental icing, and production losses.

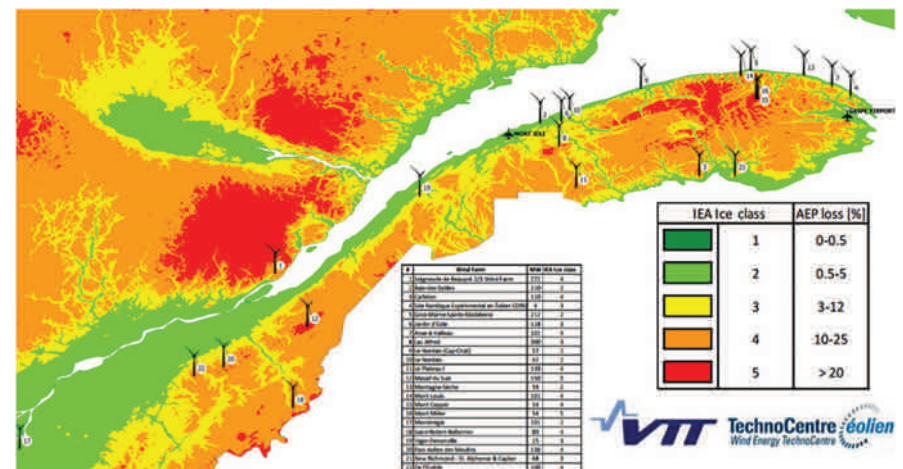
In 2014, Finland’s national research institute, VTT\*, established a preliminary ice map of Quebec (see Figure 1). This ice map has already proven highly useful in pinpointing areas where icing can be a significant issue for wind farms in the region. However, to improve the overall reliability of such information, further long-term climatological and wind farm data are required.

### Ice protection systems

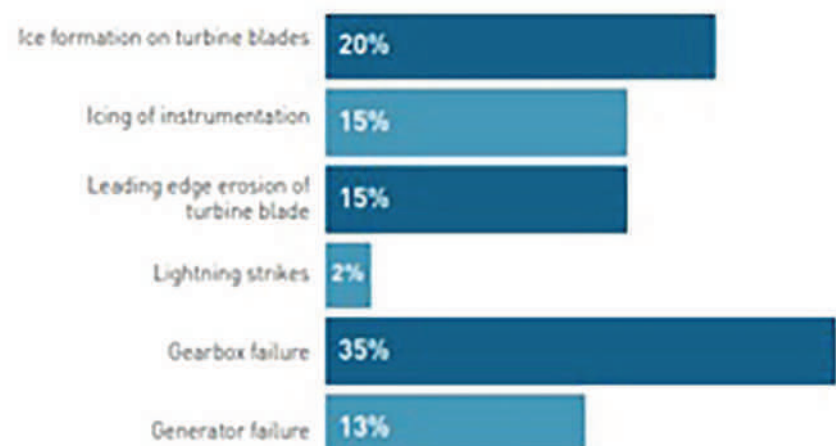
The wind industry has also identified a need for ice protection systems (IPS). Regardless of whether or not icing-related production losses have been estimated correctly during the assessment phase, IPS might be worth including. In fact, anytime icing occurs at a wind energy site, a potential business case can be made for the installation of IPS.

The idea behind an IPS is to recover all or part of the energy potentially lost due to icing by preventing ice accretion on the blades, or by shedding the ice from the blades (see Image 2).

IPS’ closest to technological maturity include hot-air and electro-thermal de-icing systems. Anti-ice coatings, though highly appealing due to their potential low-cost and low-maintenance requirements, still must prove their effectiveness and durability in the field. Retrofit options are much more limited for wind turbines in operation that aren’t already equipped with a built-in IPS. However, some independent service providers are proposing de-icing solutions using helicopters, rope access, or even robots.



**Figure 1.**



**Figure 2.**

The general consensus is that these systems still lack a proven track record and would benefit from standardized performance validation. Many developers would like to see performance warranties similar to those offered with a standard turbine.

## Winter O&M

Operations and maintenance (O&M) during winter presents challenges and opportunities. In a survey conducted in 2014 by Wind Energy Update, over 100 respondents involved in the Canadian wind sector revealed that icing was the most significant cause of production loss, at par with gearbox issues (see Figure 2).

Energy yields are higher in the winter and, as a result, downtime is more costly during colder months. Furthermore, access time and costs are likely to be greater. Based on a case study, Boucher (2013) estimated that O&M activities can be 30% more expensive in the winter when considering increased energy yield, increased access costs, and increased technician time.

Signal trending or condition health monitoring can help predict failures, thereby reducing the costs of maintenance, particularly if the maintenance activities must be carried out during the winter.

To access their assets in winter, wind farm operators mainly rely on one of three methods:

1. Maintaining access roads (at a cost of between \$1,000/km and \$5,000/km);
2. Employing vehicles specially adapted to drive in snow; or
3. Performing a minimum maintenance of the roads to allow for the use of four-wheel drive (4WD) pick-up trucks or ATVs on tracks.

Various factors, such as the amount of snow accumulation on site, as well as the layout of the wind turbines and access roads influence operators' decisions in this regard.

A recent survey\*\* of 11 wind farm operators throughout Canada revealed that the latter most often use vehicles adapted for winter conditions. Of those who don't maintain access roads: 92% use snowcats (at an approximate cost of \$200,000); 69% use snowmobiles (at a cost of \$10,000 to \$16,000); and 62% use 4WD pick-up trucks on tracks (at a cost of \$15,000 to \$25,000).

It should be noted that 85% of operators surveyed use more than one type of vehicle, and those who use 4WD pick-ups on tracks also have snowcats. None of the surveyed operators exclusively use snowmobiles.

The challenges brought upon by cold climates have raised the bar for OEMs, operators, and ISPs who have answered with innovation and resourcefulness. As a result, the wind industry is becoming stronger and more competitive than ever.

\* Note: The VTT worked in collaboration with the TechnoCentre éolien (TCE) on this ice map as a joint partnership

\*\* Survey conducted by the TechnoCentre éolien

The TechnoCentre éolien (TCE) is a center of expertise that supports the development of the wind industry through research, technology

transfer, and technical assistance for businesses. The TCE's primary areas of activity relate to wind energy in cold climates and complex terrain, adaptation of technologies, and integration of supply chains.

**TechnoCentre éolien (TCE)**

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### The Siemens G2 platform

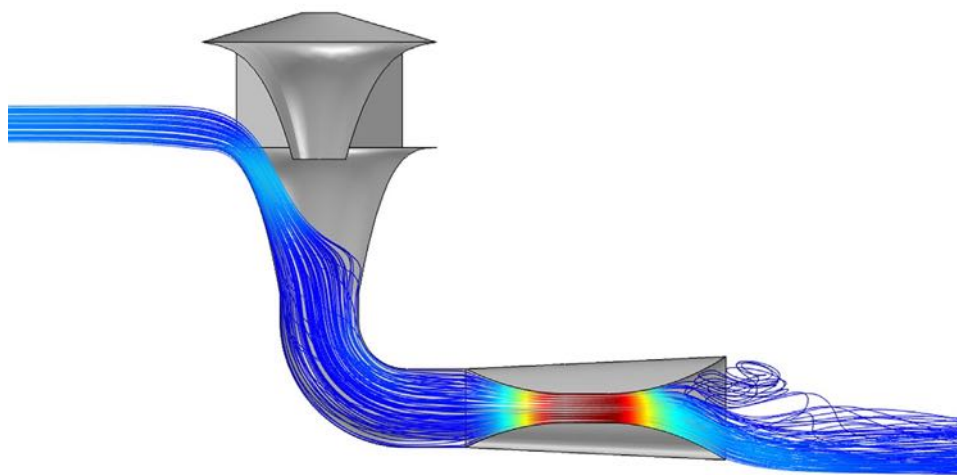
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**Image 1.** (Far Left) Ducted turbine design concept for a rural community (by Vendula Andrs)

**Image 2.** (Left) CFD model showing how wind speed increases

# Turning Technology Upside Down

## The power of controlling the wind

By Steve Faber

**REVOLUTIONARY FOR ITS TIME**, agriculturists in the 1900s implemented age-old windmill technology for pumping water and running mills. In the 1940s, the first megawatt turbine was built with 75-foot blades, weighing in at 240 tons. It wasn't until the late 1970s, however, with the fossil fuel crises that wind turbines began to find their way across the globe.

In the last two decades, manufacturers have incrementally improved the technology behind these turbines. In particular, conventional, horizontal-axis wind turbines have been fine-tuned to gain more and more energy output. These improvements have resulted in turbines with larger blades, adjustable pitch, and taller towers that require more land.

As the size and height of turbines and towers increase—nowadays, often reaching beyond 490 feet—the cost of wind-generated power continues to exceed the cost of power generated by hydropower plants, coal, and natural gas.

### Comparing cost & output

Measuring output (or capacity factor) is an important factor influencing the financial viability of a power plant. Capacity factor is defined as the percentage of the year a turbine generates its nameplate power. This capacity factor of wind turbines ranges from 25% to 40%.

These large systems require a minimum of nine miles-per-hour (mph) winds (i.e. cut-in speed) to begin turning, and 25 mph to produce nameplate power. In addition to low-capacity factors (less than 40%), wind turbines are often subject to excessive downtime due to repair, failure, and service maintenance. Due to the size of today's towers, these costs are comparatively high in expense and in time. Often repairs can take two to three weeks to complete, which adds up in terms of lost power.

Another major factor influencing the cost and output of a turbine is the lack of control over the source of energy—in this case, wind. However, technology has come a long way and rather than controlling the source of the energy, engineers have attempted to control the equipment. Massive yaw systems have been implemented in modern-day turbines,

turning the turbines in the direction of the wind to better capture it. But, these systems do contribute to added costs, failure rates, and turbine downtime.

As the speed of the wind cannot be controlled any more than the direction, the result has been enlarging blade sizes and tower heights, so as to gain access to smoother wind speeds. Two factors control the electric power generated by horizontal-axis wind turbines: free-stream wind speed and blade radius. Because of these two parameters, along with the fact that wind cannot be controlled, the tower height and blade sizes have grown extensively.

Manufacturing, logistics, installation, and maintenance challenges and cost effects at these heights are forcing blade sizes to reach their limits. Furthermore, pitch control systems have been added to help reduce wind loads when wind speeds are higher than 25 mph. However, even a pitch control can no longer be an effective adjustment at high wind speeds, and turbines simply shut down at wind speeds of about 55 mph.

### Controlling the wind

So, what if it was possible to control wind speed and direction? This is one of the questions that led researchers on a new path to try just that. In recent years, a new concept in wind power application was developed that outperforms traditional wind turbines of the same diameter and aerodynamic characteristics, while under the same wind conditions. The technology has been shown to deliver higher outputs, at a reduced cost.

The concept is simple: eliminate tower-mounted turbines, with their large rotational blades, and replace them with smaller, faster blades. This concept advances wind power generation the same way jet engines replaced or advanced prop airplanes. Jet engines simply traded speed with prop size. The concept of capturing and accelerating wind does the same to the large wind turbines of today. Plus, the new technology offers an added benefit of being safely installed inside a tube structure at ground level. Safety, in terms of heights and fall protection, is no longer an issue.

To break it down, this technology includes capturing wind at the top of a funnel structure, which tapers downward like a hopper, funneling wind in a series of pipes that also accelerate and squeeze it (much like a hydro dam accelerates water). A Venturi chamber works on increasing the dynamic pressure, ultimately, increasing the velocity of a wind. With wind accelerated and funneled to ground level, it can safely be converted to electrical energy by turbine-generators securely covered on the ground.

This concept controls the wind, as speed and direction are managed inside the Venturi. The turbine also only receives wind in one direction and, therefore, doesn't require a costly yaw system. As wind speeds can be controlled and maintained at optimum levels, herein, no blade pitch control is required. Wind speed is harnessed and maintained at the speed that results in the maximum power output. This technology operates very much like cruise control in passenger cars. In this case, the turbine runs on cruise control.

### Concept challenges

With all new technologies come skeptics with opposing views, so education is key. In the past, ducted turbines haven't made significant headway in the wind industry. Despite mainly positive performances, questions arose related to their technical implementation and financial viability. Ducted turbines have to be placed at a certain height, for instance, which can increase their technical complexity and add to their costs. Another technical issue involves the implementation of a mechanism design, which allows for self-alignment of large-scale ducted turbines in the direction of the wind.



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However, the “upside-down” concept of bringing wind down to the turbine eliminates the need for self-alignment with the wind because its intake is omni-directional, and all of the rotating parts are on the ground. This simplifies operations and maintenance, not to mention safety.

A significant challenge to a new technology is the time and capital required to mature the product line, and optimize performance at reasonable costs. Ultimately, a willingness to change and to test and try new, potentially better technology, is necessary for growth in any industry—and, especially, for the ongoing success of the wind market.

#### The future of wind

Beyond an ability to now control the wind, this new application for generating wind power allows for much smaller blades, resulting in enormous savings in millions of tons of materials, as well as in manufacturing, transportation, and construction costs.

Moreover, controlling wind direction and speed by accelerating or decelerating when necessary, allows for more efficient production of electrical energy. Accelerating wind allows for potential installs in low wind regions, where wind power is simply not viable with traditional towers. Installation of multiple turbines inside the Venturi section of the system also means improvements in availability (i.e. capacity factor), and reduced generating costs per kilowatt-hour (kWh). The latter allows for little or no downtime, even when maintaining one of the turbines.

Ultimately, this system eliminates the main failure points with traditional wind turbine systems: the yaw control mechanism, and the blade pitch control system. Both equate to costly repairs and long downtime. It also doesn't pose a risk to birds or bats, output flicker or noise, and it won't cause radar interference.

Funneling and accelerating the wind to the turbines also provides for a safe installation in low wind areas that are close to communities, with the potential to connect and expand microgrids. In contrast to traditional turbines that are installed where the wind is strongest, this concept allows for a system to be installed where the need is strongest—so, closer to cities, communities, or industrial plants. The technology could be integrated into buildings, landmarks, or retrofitted to existing structures, vastly changing the way power is produced.

All it took was an ability to look at technology from a different angle. It seems that turning wind power upside down could be the start of transforming renewable energy into the base-load power source that coal has been since the early 1900s.

SheerWind | [www.sheerwind.com](http://www.sheerwind.com)




#### Double-cut shears

Kett Tool's KD-400 Double-Cut Shears help manufacturers and contractors conserve materials and cut costs. The shears deliver precision cuts in C.R. mild steel, stainless steel, aluminum, plastic, and Formica without warping or bending the original material or the finished piece. The Double-Cut Shears' dual-blades transfer any distortion produced in cutting to a small 7/32" waste strip, leaving behind material edges that aren't hardened or burred to allow maximum use of sheet material. The blades' swiping action also seals edges of coated metals.

Kett's KD-400 shears use a five-amp, variable speed electric motor to produce straight or contoured cuts in C.R. mild steel (up to 18 gauge), most grades of stainless, aluminum (up to 0.80"), and 3/32" thick plastics and Formica—all at speeds up to 300 inches per minute. The lightweight, maneuverable shears easily follow a scribed line, capable of cutting a radius as small as six inches. All shear heads are precision made in the US, featuring A2 tool steel blades for prolonged durability.

Kett Tool | [www.kett-tool.com](http://www.kett-tool.com)

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### Three-phase power supply

WAGO expands its growing portfolio of power supplies with three new three-phase variants (787-738; 787-740; and 787-742). These new additions offer a wide input range of 325 V to 800 V, with an output range of 22 VDC to 28 VDC, in a compact, robust metal housing for quick and easy DIN-rail mounting. EPSITRON three-phase ECO Power Supplies come with integrated actuating levers, featuring CAGE CLAMP connection technology to ensure fast and tool-free connection integrity. The units have an expanded temperature range of -25° C to +70° C (-13° F to 158° F), making them suitable for a wide range of applications, including for wind and solar power. The new three-phase ECO power supplies can also be connected in parallel for added flexibility and customization.

WAGO | [www.wago.us](http://www.wago.us)



### PET-based, structural core material

3A Composites introduces AIREX T10, the first product derivative based on the technology AIREX GEN2 for product process. A recycled and recyclable material, AIREX T10 features a homogenous cell structure and highly enhanced mechanical characteristics when compared to AIREX T92. The new, direct extrusion process targets current volume applications for sandwich technologies, such as in the wind energy industry, and allows for consistent material properties and quality control. Due to the lean and highly automated production process, AIREX T10 will offer considerable total cost savings for the end application.

3A Composites | [www.3acomposites.com](http://www.3acomposites.com)



### Current switches

NK Technologies introduces ASXP-LS Current Switches, a combination current transformer and signal conditioner that are specifically designed for monitoring large loads, making them ideal for the wind industry. The ASXP-LS Current Switches feature electromechanical relay output, external power source, simple field set-point adjustment, and easy installation. The mechanical relay contact provides a trouble-free, durable alarm or interlock, improving safety and overall system reliability. At the same time, the selectable "fail safe" operation provides protection for critical loads.

ASXP-LS Current Switches are used to monitor large machines for over- or under-load conditions, detect open discharge lines, and sense clogged filters. They can also monitor generators to shed non-critical loads when demand reaches a set level. With four models available (with trip points between 200 amps and 1600 amps), they are designed to meet UL, CUL, and CE requirements.

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



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# Safety & Fall Protection Equipment

According to the National Safety Council, falls are one of the leading causes of deaths in the workplace. Perhaps more than any other type of workers out there, those who erect and maintain wind turbines are exposed to some of the most serious, and potentially fatal, fall hazards. With many turbines reaching heights of well over 100 feet tall, wind farms are only growing upwards in many cases, and exposure to high winds can make work at high elevations even more hazardous. Here we highlight some of the latest in safety and fall protection equipment—a must for the growing industry.

SEE AD ON PAGE 79



## Snap-on Industrial

**Product:** Tools @ Height Engineered Tool Drop Prevention System

**Application:** Any elevated work environment

**Key Features:**

- Uniquely engineered attachment points on tools that maintain or enhance functionality;
- Small parts/tool pouches for easy reach-in retrieval with a self-closing feature; and
- Third-party rated lift bags with secure closures and multiple D-ring attachment points included inside.

[www1.snapon.com/industrial](http://www1.snapon.com/industrial)



## Tech Safety Lines, Inc.

**Products:** StepWise Fall Arrest Lanyard

**Application:** Fall Protection Equipment

**Key Features:**

- Two shock packs;
- Built-in webbed ladder in each leg;
- Ladder is attached to the lanyard, not the harness, providing a foothold from which to stand and relieve all pressure from the harness.

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



## Diversified Fall Protection

**Product:** LAD-SAF Safety System (manufactured by Capital Safety)

**Application:** Ladder fall protection system for work at heights

**Key Features:**

- Accommodates most ladder rung configurations;
- OSHA Compliant system that meets or exceeds all applicable industry standards;
- Provides hands-free operation, while limiting free falls to a maximum of 24 inches; and
- A unique Lad-Saf sleeve can easily attach or remove anywhere along the cable as the double-action locking mechanism automatically follows as one climbs or descends.

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

## Dakota Riggers & Tool Supply, Inc.

**Product:** DBI Sala Exofit NEX Global Wind Harness

**Application:** Tower safety

**Key Features:**

- Connects to a fall protection system via the back D-ring (side D-rings are used for ladder safety);
- The Dri-Lex lining provides breathability, helping to wick moisture away from the body;
- An ergonomic design features sewn-in shoulder, leg, and hip padding, along with first-of-its-kind torso strap adjusters and a radio and Lad-saf sleeve holder;
- An easy buckle connection allows for effortless, one-handed fastening; and
- A trauma safety system is included.

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

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## Capital Safety

**Product:** Rollgliss R550 Rescue and Descent Device

**Application:** Rescue and descent for work at heights

**Key Features:**

- Emergency rescue and evacuation from a wide variety of elevated work areas;
- Fully automatic controlled descent;
- Built-in rescue lifting wheel; and
- Compact and lightweight design.

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



## Hi-Line Utility Supply Co

**Product:** Lightweight Rope Access Harness

**Application:** Suspension / Tower / Wind

**Key Features:**

- Lightweight at only 6.5 lbs (2.95 kg);
- Ergonomically designed back pad with lumbar pad;
- Aluminum dee rings positioned in four locations to reduce weight, and shoulder pads to prevent neck irritation; and
- multiple gear loops on the back insures needed equipment is always within reach.

[www.hi-line.com](http://www.hi-line.com)



## Honeywell/Miller Fall Protection

**Product:** Miller Swivel Anchors

**Application:** Permanent and portable structure mount options for steel and concrete

**Key Features:**

- Freedom of movement;
- Versatile application use;
- Multiple anchorage options;
- Corrosion resistance;
- Removable and reusable; and
- 310 lb (141 kg) worker capacity.

[www.millerfallprotection](http://www.millerfallprotection)



## Power Climber Wind

**Product:** IBEX 1000P Climb Assist

**Application:** Intelligent climb assist for wind turbine technicians

**Key Features:**

- EasyClimb Controller puts control at climber's fingertips;
- Designed to retrofit in any wind turbine tower, providing personalized performance with increased safety and better productivity;
- Patented, closed-loop control offers adaptive ride performance, and the multiple assist settings allow users to Up and Down set independently; and
- Truly portable control box, which is 8.5 pounds, durable, and weatherproof.

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



## Gravitec Systems, Inc.

**Product:** G4 Rescue & Evacuation System

**Application:** Versatile in accommodating evacuation, lowering, lifting, and suspended or assisted rescue or evacuation

**Key Features:**

- Contains 350 feet of 11 mm rescue rope, triple-locking aluminum carabiners, an upgraded, progress-capture pulley (with locking cam feature), and a self-contained accessory bag;
- The G4 is applicable to most industries, including wind power, and can be customized for specialized work environments;
- A security seal provides assurance that the G4 is fully intact and ready to use; and
- Waterproof, step-by-step laminated reference cards and a manual attaches to the users harness for quick guidance.

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



## Rescue Technology

**Product:** RT Tower Rescue System II

**Application:** Tower rescue

**Key Features:**

- Specially designed pack and rescue system allows one-hand-rigging, rescue, and lowering of climber;
- Transfer system allows rescuer to move the climber onto the rescue system;
- Adjustable Rigging Sling easily secures transfer and lowering system to the tower;
- Load is lowered using Anthron Double Stop Descender; and
- Full kit contains: Personal CSR/Line Transfer Kit, 3/8" (10mm) rope, Double Stop Descender, Tower Rigging Sling and Carabiner, and a T2 Rescue Pack.

[www.rescuetech1.com](http://www.rescuetech1.com)



**Far Left.** Installers at work on a solar rooftop project in Las Vegas  
**Left.** Solar “S” profile tiles being installed at a 30-degree angle

# Simple Tips for Smooth Solar Projects

## From permitting to paperwork

By Jake Owsley

**A LOT GOES INTO A SOLAR POWER PROJECT** before construction ever begins. From a project developer or contractor’s perspective, it can look a little like this:

- Bid on the job;
- Awarded the contract;
- Developed a site plan (for a solar rooftop project, this involves inspecting the roof and/or tiles involved);
- Filed and/or ensured proper permitting is in place;
- Researched, purchased, and engineered the best PV modules and most ideal mounting system for the project;
- Hired the team of onsite installers and engineers; and
- Set the date for construction to begin.

Preparation is well underway, and it’s time to get those solar modules up on the roof to start producing power. Installing solar panels on an existing residence should be a relatively straight-forward process, but it can be filled with a lot of preparatory steps and frustration from the get-go. Among the most important in the early stages: permitting.

### Getting permit-ready

Being well-versed and educated in the local regulations for solar rooftop installations, while following some simple steps in the pulling permits process, is vital to a successful project experience—not to mention, a company’s bottom line. Time is money, after all, and there’s no sense pushing a project forward that isn’t fully approved or permit-ready.

Here are some of those simple, yet critically important, steps to take to get the required permissions to start and finish a solar rooftop project with the least amount of delays.

#### 1. Contact the local energy company

There are a few questions that are essential to ask first prior to installing a PV system to ensure success and to ensure a satisfied customer. The local energy provider should be able to provide the answers.

For example:

- Is it okay to tie into the local power grid?
- Does this particular residence qualify for a net, or a dual meter?
- Are there any monthly fees associated with a new meter?
- Is net metering allowed?
- Are there any other issues or concerns to consider in the region related to power and installing a solar system?

#### 2. Research the building codes

Once all of the energy-related questions have been answered, the next essential question should relate to the local building codes and design criteria requirements in the region. It’s imperative to maintain due diligence and fully ensure research is done here.

Avoid making assumptions about requirements based on previous jobs or word of mouth. As no national PV solar installation code has been adopted, cities and counties have their own unique policies, which can differ widely even within a few miles.

The jurisdiction for a job on one side of the street or on one block in a neighborhood could require that a solar system meet certain designed criteria that are completely different than another. These can include factors, such as the snow loads, wind speeds, and structural weights. In fact, in some areas, a structural analysis of the existing building may be required to ensure it can withstand the additional weight of a PV array.

In extreme cases, information on all data sheets and products being utilized (from the inverters to the racking system) are necessary. A site plan of the entire property is almost always required, and the building department will keep this plan on file—so, don’t ignore any details. The site plan should include the locations of the modules, inverters, PV sub panel, house main, and label size.

#### 3. Organize the required paperwork

Most city and county building departments will list paperwork requirements online, however, it’s often worth calling and speaking directly with an inspector before beginning construction on a solar project. This can help speed the permitting process, ensuring the correct forms are submitted and signed.

As back-up support, it’s also worth having a reliable racking manufacturer partner in the area who’s experienced and willing to lend a hand. A reputable dealer should willingly provide support and help answer any questions.

Simple paperwork delays have caused many jobs to go in the red, leading to unnecessary project delays. Yet, it’s the easiest thing to avoid.

#### 4. Know the inspection process


While on the phone with a building inspector, be sure ask if there’s a single or a two-step inspection process and how to set-up the appointment. A two-step process includes an inspection of the grounding and racking system before the solar panels can be installed and tied into the grid. This is, then, followed by a final inspection of the project once it’s complete. In other cases, a one-time inspection might be all that’s necessary once the solar system is fully complete.

From the permit to the final inspection, ensuring the requirements for a successful solar project takes knowledge and patience. But it is time well spent if the project can be installed without faults or delays.



Jake Owsley is a PV solutions specialist at TRA Snow and Sun, Inc. of American Fork, Utah. He has worked with solar implementers and designed custom PV arrays from as far east as Williamsburg, New York, to as far west as Los Angeles, California.

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# Choosing a Central Inverter

## Utility-scale solar considerations

By Louis Lambruschi

**Image 1.****Image 2.****Image 3.****Image 4.**

**WITH THE EVER-GROWING NUMBER OF CHOICES** of central inverters in the solar energy industry, it's important to recognize there are differences between the players—some more subtle than others. What may seem like an attractive initial purchase price, for instance, can prove false economy when analyzing an inverter's long-term performance and features.

Typically designed for utility-scale solar fields, a central inverter can operate at higher voltage levels and handle up to two megawatts (MW) of power. All inverters perform the basic function of converting direct current (DC) to alternating current (AC), but some provide additional benefits by virtue of their hardware and their ability to be programmed.

### Design details

Most central inverters are engineered for direct, outdoor mounting. The ideal scenario is to truck in the unit, mount it to a pad, and connect it to a transformer; though sometimes it's skid-mounted with a transformer. Either way, the inverter will often be subject to extreme weather and environmental conditions over its lifetime.

Some designs include forced-air ventilation, using filters and hoods to clean the air before it's used to cool internal components. This can result in a lower initial cost, but ongoing maintenance is the trade-off. Air-breathing units will have filters to change periodically. Plus, water/glycol systems come with their own requirements.

Compressor-based air conditioning allows for the more sensitive electronics to be sealed from the environment, but it carries a relatively high rate of power consumption. Another inverter option comprises of a sealed design, using refrigerant in an evaporative cooling (two-phase) configuration. This option provides for a high degree of internal cleanliness, as usually only the low-maintenance condenser assembly is exposed to the elements. Without a compressor, the evaporative cooling system tends to use less energy to run, employing a small, low-flow rate pump.

Yet another factor to consider is the efficiency of the cooling system. When evaluating an outdoor inverter package, consider what percentage of the inverter's throughput will be consumed by blowers, air-conditioners, or pumps.

### Maintenance considerations

When it comes to maintenance issues, users tend to agree that less is more. Any aspect of maintenance that can be eliminated, or at least automated, is desirable. All major central inverter components should be easily accessible from the outside, rather than requiring technician entry into the enclosure. This not only simplifies the maintenance process, but also makes it safer for the technician.

It's also important to enquire about the level of personal protective equipment (PPE) requirements for individuals who will be working on it. Although infrared (IR) camera viewing ports can be useful for onsite troubleshooting, internal temperature monitors that are strategically mounted inside where the critical electrical connections are made, can save time and money. These monitors are always on the alert for anomalies, which can be transmitted through the inverter's diagnostic system and remotely reported to an operator.

Servicing a solar inverter is another topic to research before committing to a specific design. Obviously, an inverter should be designed with field service in mind (and "return

**Image 1.** A typical two-megawatt (MW), 1000-volt, outdoor-rated central inverter

**Image 2.** Networked busbar temperature sensors allow remote monitoring of critical connections

**Image 3.** Inverter rack showing liquid-cooled, field-replaceable phase power modules

**Image 4.** Replaceable inverter phase power module

to the factory" a non-option). Since service will be performed outdoors in unpredictable weather conditions, the process should be quick and relatively easy.

Even though many inverters make the claim of having a modular design, it's worth considering just how modular they are. If a module requires heavy equipment to change, along with removal of extensive wiring harnesses, it might not lend itself to a very quick change after all.

Evaluate the mean time to replace (MTTR) for all critical components, including IGBT modules, inductors, capacitors, and fuses. Also, consider what level of support is required to replace parts. Ideally, they should be installable by site maintenance personnel without requiring a service call to the manufacturer. All of these points should weigh into a central inverter decision, as they factor into the total cost of ownership (TCO).

### Conclusion

As mentioned, the basic function of any solar inverter is to convert DC from the solar panels to AC for connection to the grid. "Smarter" inverters will do this, but can offer additional benefits related to grid quality, such as fault tolerance and grid support.

Firmware and programmability in smart inverters can allow for flexibility of control and operating autonomy. If they contain the algorithms for real and reactive power management, they can also eliminate or reduce the responsibility of external site management by the utility. Be sure to consider the inverter's tolerance to grid disturbances, as well as its course of action when a disturbance occurs. At minimum, it should include low-voltage ride-through (LVRT), high-voltage ride-through (HVRT), frequency ride-through (FRT), and should be able to provide volt-amp reactive (VAR) support during these events.

One last item to bear in mind is the level of long-term support from the manufacturer. A central inverter is a big investment, and with a life expectancy measured in decades future support is critical. With the playing field consisting of manufacturers with a wide range of longevity and experience, it's worth checking into a company's background, financial stability, and capabilities. Consider the depth of engineering support, local sales offices, or authorized distributors, and the experience of field service teams.

*Louis Lambruschi is the marketing services and E-business manager for the Energy Grid Tie Division of Parker Hannifin Corporation.*

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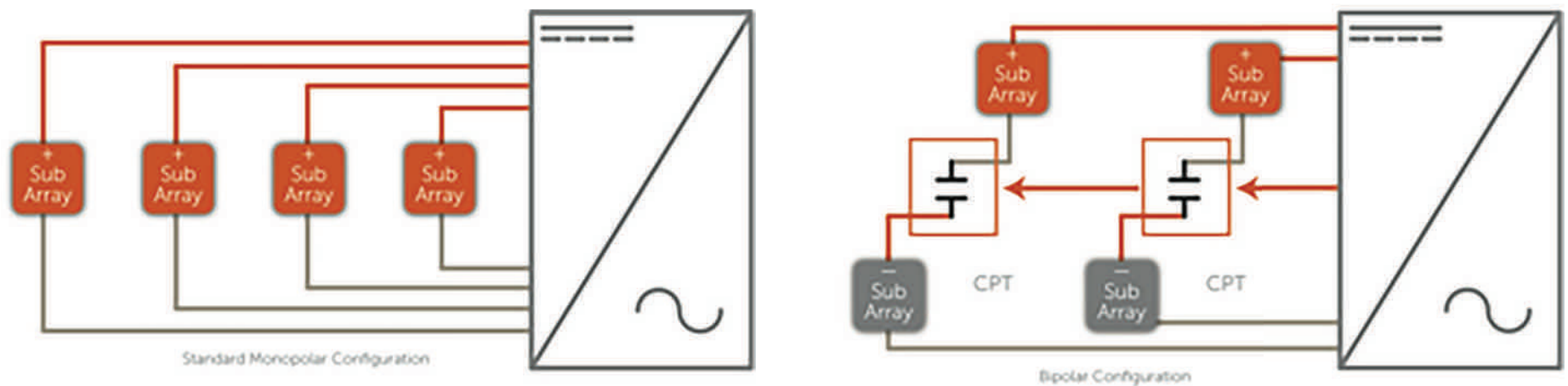
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**Figure 1.** Bipolar  $\pm 1000$  VDC enables reduced home run requirements

# Smart Inverter Topology

## Bipolar advantages

By Jeff Harrell

**IN ANY PV SYSTEM**, the inverter is in a unique position to provide technology that unlocks compelling performance enhancements and savings. This isn't only based on the overall topology, but also the coordinated and intelligent component functionality. The bipolar  $\pm 1000$  volts of direct-current (VDC) inverter enables a unique topology with advanced DC-side innovations, making utility-scale solar simpler, more affordable, and more intelligent.

### New Topology from Existing Technology

Monopolar 1000 VDC is a current industry standard topology for utility-scale solar projects. However, discussion and technology has already begun to shift from 1000 VDC to 1500 VDC designs. Though 1500 VDC promises a number of potential benefits, bipolar  $\pm 1000$  VDC technology can deliver all of the same advantages, while remaining within the current equipment set with familiar implementation. Plus, this technology is available now, with no waiting required for new development, qualification, or standards evolution.

The advantages that bipolar  $\pm 1000$  VDC offers over monopolar systems are reduced balance-of-system (BoS) costs on the DC and AC side, and on the overall project installation. Two primary factors enable this savings: bipolar  $\pm 1000$  VDC topology dramatically reduces DC home-run wiring requirements, and it enables larger block sizes, which reduces AC wire requirements and construction costs, among other benefits.

### Crafting cuts

The bipolar  $\pm 1000$  VDC topology enables pairing of 1000 VDC equipment with in-field, combiner-level PV ties (CPTs) to reduce the DC home-run wire length by up to 50%. As shown in Figure 1, in standard, negatively grounded monopolar configurations, all sub-arrays are positive, ranging from 0 VDC to 1000 VDC.

Each sub-array requires its own, dedicated set of home-run circuits. However, the bipolar technology, ranging from 0 VDC to 1000 VDC and 0 VDC to -1000 VDC, allows the connection of neutrals in the field via a combiner level PV tie, connecting two separate arrays during operation. This reduces overall, DC home-run wiring length by half.

Shorter DC wire length reduces the voltage drop across these circuits by the same factor, resulting in lower DC line loss and increasing energy harvest. Engineers can also size the DC conductors to the required ampacity for the circuit, rather than over-sizing the conductor to compensate for voltage drops. Typically, this allows the designer to utilize smaller conductor gauges than in comparable monopolar applications, reducing wiring costs even further.

With the reduced DC wire length and gauge, typical utility project savings are approximately \$10,000 per megawatt, with typical single-axis tracker designs. Even greater savings can be achieved in more elongated layouts due to site constraints.

### Maximizing size

With the optimized DC system topology, designers may increase the generating array block size, maximizing energy yield per installation dollar. With the conventional monopolar approach on larger block sizes, DC conductor sizes would increase to accommodate for voltage drop, becoming prohibitively expensive. In contrast, the bipolar  $\pm 1000$  VDC topology allows for block sizes that are unattainable with standard technology.

By enabling larger block sizes, the enhanced DC side reduces the AC equipment costs, installation costs, and maintenance requirements. Construction costs, including trenching,

foundations, and crane picks, are also reduced. Furthermore, fewer medium-voltage transformers are required, given less array blocks overall, thereby optimizing equipment costs.

### Enabling innovations

The inverter is fundamental to the bipolar  $\pm 1000$  VDC topology, providing technology that enables compelling performance enhancements and system savings. However, the integral, contactor-based recombining capabilities of the bipolar  $\pm 1000$  VDC inverter go even further, offering intelligent performance that enhances energy harvest, increases system insight and control, and minimizes additional DC costs.

Typically, an additional and external DC recombiner is used to collect current from all of the PV sub-arrays in a plant to meet NEC 2011 requirements, and to utilize circuit breaker or fuse-based protection. This design results in paralleled circuits when the inverter is off, and the same protection levels are utilized for forward and reverse current-fault conditions.

The bipolar  $\pm 1000$  VDC inverter's unique design enables intelligent protection of the DC system in the event of a fault. A current-sensing device controls a contactor on each input, which opens based on separate thresholds for forward and reverse current, enabling the inverter to intelligently isolate sub-arrays in the event of a fault condition.

Given that the  $\pm 1000$  VDC is a floating array during operation, it eliminates ground-fault blind spots, enabling more reliable ground-fault detection and troubleshooting at site commissioning and during operation. Moreover, when the inverter isn't in operation, this approach eliminates paralleled circuits due to individual contactors on each input. Lastly, this approach allows the operator to safely isolate a faulted sub-array and allows the inverter to continue power production with the unaffected sub-arrays.

Integrated sensing doesn't only provide fault protection and isolation; it also eliminates the need for supplemental DC sub-array monitoring, typically an expensive upgrade. Unique system insight is available with the inverter's existing sensing capabilities, allowing enhanced plant monitoring and diagnostics. The integrated NEC 2011 compliant recombiner also eliminates the significant expense of adding a separate external recombiner. In addition, the inverter's contactors require less maintenance than conventional fuses and breakers.

### Addressing needs

The solar industry is unique in that innovation is spurred by an imperative need to drive clean energy alternatives to price parity with more traditional forms of power production. The urgency of this need has motivated rapid technological evolution, as well as uniquely innovative advancements. The innovations of the bipolar  $\pm 1000$  VDC inverter offer a step forward in the continuing evolution of solar technology, addressing multiple needs and integrating capabilities into a single, central component, significantly reducing overall project costs.

*Jeff Harrell is the product manager, Central Inverters with AE Solar Energy, Inc.*

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## Remote monitoring & asset management

Schneider Electric Solar Business announces the launch of Conext Insight, a remote monitoring and asset management platform for distributed PV plants. The Conext Insight web portal gives users detailed insight into the performance of a distributed PV plant from any Internet connected device—anytime, anywhere.

Conext Insight provides smart insight to installers by facilitating remote diagnostics of PV plant issues, which can minimize their truck rolls in response to service calls. Installers can leverage Conext Insight to remain connected with their customers, while offering value-added services. At the same time, Conext Insight also provides PV plant owners with powerful insight. The web portal gives them access to their plant's performance data to ensure the desired ROI is realized.

**Schneider Electric**

<http://solar.schneider-electric.com>



## PV rapid shutdown solution

Along with the increase of solar PV systems is an increased concern for the safety for those who come into contact with the high-voltage portions of these systems. This concern is not only for installers and owners, but also for firefighters and first responders to a scene that includes a PV system. Now with UL Certification, GIGAVAC's P115 MiniTACTOR uses patented technology to provide a small, lightweight, and cost-effective solution to DC power switching.

At less than four ounces, and measuring about 3" x 1" x 2", the GIGAVAC P115 can easily be installed in any orientation on a panel in a matter of seconds. An integrated safety cover provides added protection for power and coil connections. The sealed chamber for contacts and coil assures clean switching in any environment. Safe make and break power switching can be achieved at any voltage up to 1200 VDC.

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## Temperature profiling

In conditions of low wind and high solar load, naturally aspirated, multi-plate sensor shields cause even the best temperature sensors to overheat inside—leading to incorrect readings from 1° C up to 10° C (2° F to 18° F). Apogee Instruments new TS-100 Fan-Aspirated Solar Radiation Shield solves this problem by providing constant internal aspiration using a tiny IP56 80mA fan. Built from industrial-strength Gelyol plastic, the unique Coandă inlet and inner Venturi contour design optimize air-flow over the included precision thermistor. This consistently yields accuracies of 0.1° C (0.18° F), exceeding the current recommended IEC standard for air temperature measurement.

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# Moving the Goalposts for Organic Photovoltaics

## When Will Commercialization Come?

**ORGANIC PHOTOVOLTAICS (OPV)** has continued to draw the focus of much research as an alternative solar technology, because of the allure of its core attributes: it's lightweight, flexible, inexpensive, highly tunable, and potentially disposable. Yet, OPV researchers have spent the better part of a decade struggling to translate these competitive promises into something that could be commercially successful.

Expectations for OPV stalled in 2012 largely due to the demise of Konarka, which was arguably the company closest to a real-world product and they had plans for large-scale factory output. In the end, they were recognized for attracting hundreds of millions of dollars from investors with very little to show for it.

Surveying the OPV landscape today, we still see a sector striving to translate early lab-scale results into real-world products. However, there are some encouraging signs that the technology is moving closer to commercial readiness.

### Technology marches forward

Industry leaders have partnered together and strategically committed to OPV's eventual success.

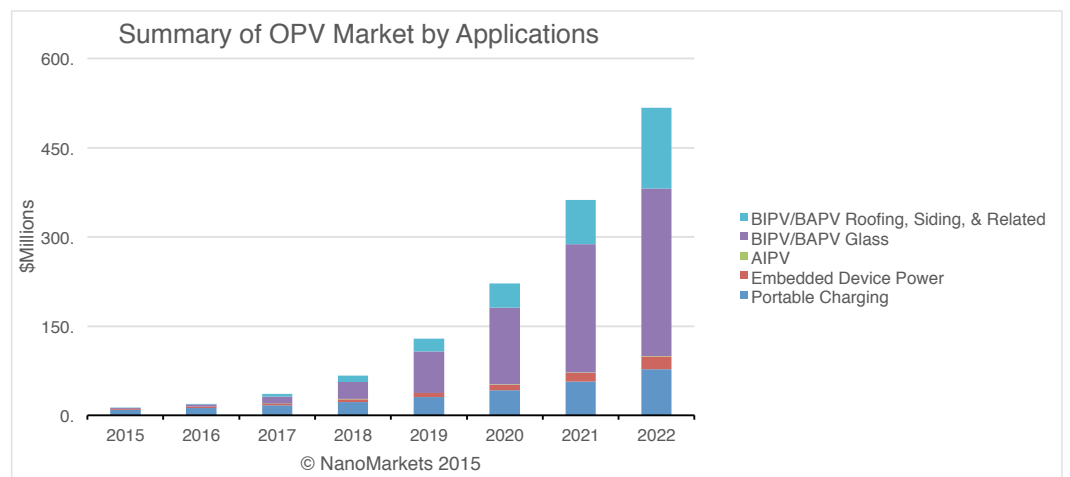
Such supporters point to progress being made in a number of areas:

- Conversion efficiency has risen to 11%-12% for both polymers and small-molecule OPV, and 5%-7% percent now on pilot production lines.
- Suppliers claim a 10 year lifespan could be achieved within a year or two, which would be enough to start targeting some building-integrated photovoltaics (BIPV) applications.
- Much of those efficiency and lifetime gains are to be credited to improvements in both cell architecture, including tandem and triple-junctions, and new materials such as transparent electrodes and non-fullerene acceptors.
- Work continues on improving various aspects of actual OPV manufacturing processes, including: large-area monolithic panels and thicker junctions, printing multiple layer stacks, and inkjet printing processes. Heliatek has had a pilot line since 2012, but CSEM Brazil claims an even bigger OPV R2R pilot line running since September 2014.
- Several recent field test installations, most notably by Heliatek and Mitsubishi Chemical, are showing OPV in several BIPV contexts: glass facade, concrete, and attached to a polymer inflatable building shell.

### Managing expectations

While acknowledging that OPV technology is progressing, and key suppliers certainly seem convinced that market readiness is imminent, there's still quite a lot of improvement needed, particularly in lifetimes. Bridging performance achievements made in a lab into an actual full scale production line are several years away from happening for OPV. Heliatek's proposed factory by 2019 will require an additional €70 million in fresh investments, assuming both technology improvements and investor interest persist.

OPV also has some serious competition in its intended target markets. Other solar PV technologies can make similar promises about flexibility, transparency, and low-light performance, and are arguably further along the commercialization path. They do, however, need to address



stability and lifetime concerns:

- Dye-sensitized (DSC) visibly has pulled ahead in multiple ways: efficiency levels, pilot projects, and key partnerships especially in BIPV glass.
- Thin-film copper-indium-gallium-(di)selenide (CIGS) offers potentially significant higher efficiencies, and already has a roofing shingle product in the market.
- The newest solar wonder material, Perovskite, has dazzled researchers with the potential for remarkably high conversion efficiencies combined with cost-effective wet-chemistry processing. This technology, which could be called "next-generation DSC," is far from production-readiness, but the heavy interest among researchers should result in relatively fast performance improvements.

### OPV end-markets

The targeted end-markets for OPV haven't changed: off-grid charging applications, grid-connected building-integrated (BIPV), and building-applied (BAPV) systems. Additionally, energy harvesting cells and portable solar chargers can accommodate much low-power conversion efficiencies than what is needed for solar panels, because there is an acceptable trade-off for other features such as flexibility. Moreover, a few years of lifetime is often sufficient to last as long as whatever they're attached to, be it a pack or table awning.

For BIPV, efficiency requirements may not be quite as lax, but there are similar trade-offs among other factors such as low weight, flexibility, and an ability to be integrated into a building's design. Early field trials suggest that enough OPV spread around building areas could actually outperform c-Si panels in long-term energy production. Longer lifetimes are a high priority; early expectations are 10 years, but it is recognized that 20+ years is required to really open up the market.

Most suppliers today remain adamant that the BIPV market can provide the necessary volumes required to generate real revenues and profits for OPV. Higher field performance will happen soon enough and reward users who have patience. However, others prefer to focus on solar charging where applications, if not profit margins, seem broadest, and choose to revisit BIPV once efficiencies and lifetimes improve.

To fulfill OPV's promise of high-volume, low-cost production processes, there needs to be enough volumes to achieve economies of scale. It seems clear this will have to come from BIPV markets, assuming anticipated further performance improvements are realized in actual production. Off-grid solar charging applications present potentially large markets (consider developing regions of the world and the billion people without power today) and have less stringent performance requirements that allow for inroads sooner. Overall, this seems too fragmented and lower-value to be a path for sustainable revenues.

### When Will OPV Be Ready?

In the end there remains, the one overriding question for OPV: when will the persistent enthusiasm translate into market delivery and profitability? Even today's OPV industry supporters privately ask, with varying degrees of concern, how many more years will pass before OPV is not just "production-ready" but is actually a competitive product, generating substantial revenues and profits in target markets?

In viewing the state of the supply chain and of the two major target end-markets, it may be at least 5 years before OPV is a viable, sustainable product, and even longer to establish a strong foothold in BIPV. Projections show OPV ultimately exceeding \$100 million within the next five years, and topping \$500 million by 2022. However encouraged by ongoing progress, the warnings about market entrance still ring true: OPV can't afford to slip much further behind when competition seems to pull ahead.

*Jim Montgomery is senior market research and content editor for NanoMarkets.*

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### Silicon-carbide semiconductors

The new SCT20N120 silicon-carbide power MOSFET from STMicroelectronics brings advanced efficiency and reliability to a broader range of energy-conscious applications, including for solar or wind power generation, as well as for inverters for electric/hybrid vehicles and smart-grid equipment.

The 1200V SCT20N120 extends the ST semiconductor family with an on-resistance (RDS(ON)) better than 290mΩ, all the way to the 200° C (392° F) maximum operating junction temperature. Switching performance is also consistent over temperature, thanks to highly stable turn-off energy (Eoff) and gate charge (Qg). The resulting low conduction and switching losses, combined with ultra-low leakage current, simplify thermal management and maximize reliability.

**STMicroelectronics**

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### Dual-MPPT inverters

Completing their innovative SnapINverter line-up, Fronius USA announced the availability of the Fronius Primo and the Fronius Symo to the US residential and commercial markets. Fronius Primo, for the residential sector, features power classes that range from 3.8 kW to 8.2 kW. And, Fronius Symo is available in three-phase applications, from 10 kW to 24 kW.

Both SnapINverters offer a wide voltage window, as well as NEC 2011 and 2014 compliance solutions. Lightweight and transformerless, the inverters feature a hinged mounting system, and both come standard with Fronius' field-proven, Arc-Fault Circuit Interruption.

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### Environmental boot

Anderson Power Products (APP) offers a new addition to the SB Environmental Boot Series. Ideal for a wide range of indoor and outdoor applications, the SB Environmental Boots' soft shell provides water, dirt, chemical, and UV protection to SB 50 and SB 120 connectors. Designed for inline and surface mount applications, the IP64-rated boot shields connectors from water and dirt in the mated and unmated condition. Mounting is achieved with the use of wire tie or band clamp. The boots feature markings for easy trimming to accommodate the proper AWG or mm<sup>2</sup> wire size.

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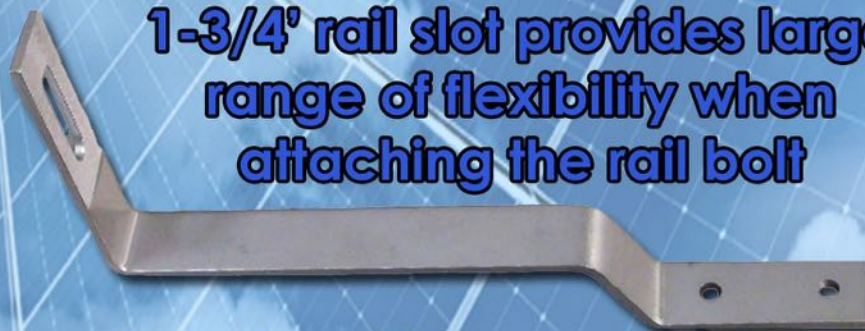
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The new UC-8112-LX platform from Moxa is designed for embedded data acquisition applications

# Breaking Communication Barriers For effective solar monitoring

By Daniel Liu

**PERFORMANCE MONITORING** has long been an important topic of solar energy build-up. Designing a monitoring system, however, can be challenging. Until recently, it involved integrating recording equipment from other industries that didn't necessarily relate to the issues faced by renewable energy projects.

Most monitoring system providers, for instance, use traditional remote terminal units (RTUs) or dataloggers for I/O data acquisition. These dataloggers and RTUs are, typically, designed for specific applications (such as for the water/wastewater or the power industries) where they have their own standards.

Most of the industry-specific RTUs and dataloggers support special protocols, including DNP 3.0, Modbus, and other automation-based Fieldbus protocols. Generally, these products come with those protocols out of the box, which make them easy to be used in that particular market.

However, when it comes to solar monitoring, there are many solar energy equipment manufacturers. And, every single one of them might use different protocols to talk to their logger devices. This makes it extremely difficult for solar monitoring engineers

because the dataloggers and RTUs won't support an open programming environment to build drivers. This is important and required to properly communicate with equipment, such as the solar inverters or the weather-base stations.

As a result, system engineers have to rely on the datalogger and RTU providers to build a driver, which can be unstable and expensive.

### The new monitoring solution

As an alternate solution to drivers, an increasing number of solar energy monitoring builders are starting to opt for ARM-based computing platforms for their dataloggers and RTUs. ARM-based platforms are based on a reduced instruction set of computing architecture. They are not only cheaper, but also more flexible.

For instance, ARM-based computing platforms:

- Typically come with open-source Linux OS, renowned for its bountiful-free coding resources on the Linux communities that make it extremely easy to code and develop user applications;
- Tend to be more cost effective when compared to traditional dataloggers and RTU;
- More easily expand network interfaces, especially Wi-Fi and cellular; and
- Offer more central processing unit (CPU) power compared to the RTUs and dataloggers.

When choosing an ARM-based platform for solar monitoring, there are a few key points that deserve special attention. Ideally, these devices should come with:

- An expansion slot that's available for different wireless interfaces (most of the wireless cards now use Mini PCIe as the standard interface);
- The most up-to-date Linux OS, ideally Debian ARM because of its openness and ease of use;
- An industrial rating. Note: many ARM-based CPU boards are readily available in the market at a low price, but aren't industrial-rated—which can result in shorter product life cycles that aren't likely to survive the high and low fluctuating temperatures of solar applications;
- Ready-to-use protocol sample codes to



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- build the device drivers around;
- An ability to use the sample codes for WAN communication back to the central servers—a good platform should make it easy for a programmer to build their software applications, without having to worry about what protocol stacks they have to build by themselves (this will also speed up the time needed to install the product in a live environment); and
- Easy-to-expand I/Os, especially digital and analog ones.

#### A case study

Over the past few years, numerous solar energy monitoring solution providers have migrated from close-ended datalogger and RTU solutions to an open, ARM-based computing platform. It's not tough to see why in the following example.

In this situation, the solar energy monitoring system builder used a ready-to-run datalogger that had I/Os. The biggest problem that arose related to the inflexibility of the protocols the datalogger supported. So, every time this company's customers had new equipment that used a different protocol, the integrators had to contact the datalogger manufacturer, requesting that a new driver be built for them—wasting time and money.

It's also worth noting that most dataloggers don't have options for cellular expansion for long-distance communication. This is an issue for remote solar power projects, resulting in an extra expense whenever a cellular router must be added to the mix.

However, after migrating to an ARM-based computer, this company has the ability to simply insert a cellular card for 3G and 4G communication. The ARM-based computer, in this case, was also equipped with Debian 7 Linux, which supports on-device compiling. This allows the user to build device drivers all by themselves without contacting a datalogger manufacturer.

Ultimately, the ARM-based solution has cut their spending on custom driver development fees by over half, and has reduced their overall hardware spending by more than 30%.

Project monitoring has come a long way in the solar industry. New technology can ensure renewable projects—and, especially those built in remote locations—don't have additional and unnecessary expenses when it comes to performance.

*Daniel Liu is the Business Development manager for Moxa Americas, Inc.*

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#### AC breaker panels

SolarBOS' new AC Breaker Panels have been specifically designed for PV systems, making it easy for system integrators to combine the AC outputs of multiple string inverters. The NEMA-4 enclosure allows for vertical and horizontal installation, and the breaker spacing reduces breaker temperatures to minimize nuisance tripping on rooftop installations. Sized for 2 to 16 input circuits, with a main bus sized for 250 or 400 amps, the AC Breaker Panels provide 480 VAC three-phase output, and are rated for 14 kAIC (higher kAIC ratings are available upon request). They have an optional main breaker up to 400 amps and come with optional revenue-grade monitoring. Available in NEMA-4 powder coated steel or NEMA-4X fiberglass enclosure, the AC Breaker Panels are ETL listed to UL 508A.

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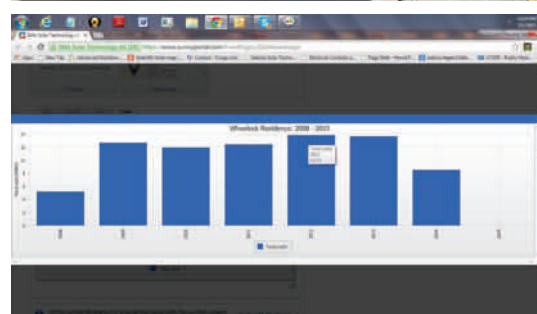
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**Image 1.** (Far left) The Wheelock residence receives power from 36 mono-crystalline solar panels on three passive solar trackers

**Image 2.** (Left) With the addition of energy storage—from 16, six-volt, lead-acid batteries—power outages are a thing of the past



**Figure 1.** Wheelock's annual power production, with the addition of early wakeup trackers

## Living the Dream Of net-zero energy & storage

By Mark Snyder

**MILLIONS OF PEOPLE AND COMPANIES** dream of never paying another electric bill. But for most, the possibility of actually going net-zero remains unattainable, either because they don't think it's affordable or even possible.

Among the crowd of dreamers was Mr. Wheelock, whose 1800 square-foot home was built in the 1980s. Poorly insulated, the house had sky-high air-conditioning costs and electric heating bills to match. Even in a dream, it was unlikely the house could attain anything close to a net-zero goal, where the total amount of energy used by the structure annually equals the amount of renewable energy created onsite.

Beliefs aside, Wheelock was nothing if not determined. After paying ongoing high utility costs, there is one thing of which he became certain: "I don't want another electric bill—ever."

### The road to net zero

Not one to back down from a challenge, Wheelock's quest began with a comprehensive energy analysis that revealed where power was going and where it was being wasted. This approach helped assess and reduce the house's power electricity demands before any major energy changes or additional power sources were considered.

At first, older appliances were switched to Energy Star models, for example, and window awnings were added to block-out the summer heat. Eventually, Wheelock installed a solar water heater and solar attic vents, which have helped to keep the home cooler in the summer. The biggest gains, however, came from upgrading the home's inefficient air-conditioning system.

Adding blown-in insulation boosted the attic's R-value from R-19 to over R-50, reducing heat losses and stabilizing the indoor temperature. Next, daytime heating was installed to supplement the electric heating. Finally, a compressor-less air-conditioning alternative reduced Wheelock's air-conditioning needs by nearly 90%. These systems slashed total electrical demand without sacrificing comfort.

Diurnal (nighttime) temperature swings are key to this system. During the summer, midday temperatures in the area hit 100° F (37.8° C). But they plummet to the 60s (far below 20° C) at night. These temperature swings are common in coastal and mountain areas from California up to Washington, as well as in Arizona, Nevada, Colorado, and New Mexico.

This simple ventilation/cooling system pressurizes the house to push in cool nighttime air and drive out hot air from the house. Because the house drops to the lowest outside temperature of the night, the building itself becomes a cooling system. During the daytime, the house stays cooler because the attic's solar vents, insulation, and cold air from the night before prevent any heat buildup.

As a result, the system doesn't have to cool incoming air with power-hungry compressors—it only brings in pre-cooled air—eliminating 90% of air-conditioning needs by using just 700 to 840 watts of power.

At this stage of the efficiency upgrades, Wheelock's overall electric usage was down almost 50%. But, he wasn't done. To reduce the amount of heating done by the house's electric heat strips, daytime hot-air heating was also installed for the winter months. The system delivers enough warm air on sunny days to heat the whole home.

Moreover, the compressor-less cooler system is capable of reversing the direction of its airflow to also work during the colder months. Even on winter days, the air is often warmer during the day and colder at night. Although technically a cooling device, the system can pull in the warmer daytime air from the outside, warming the house to 70° F to 75° F (21° C to 24° C), and reducing nighttime heating needs.

The PV system gets its power from 36 mono-crystalline solar panels on three passive solar trackers. And, the grid-tied system sells back additional power.

After this first project, the Wheelock residence was net-zero for 2009, 2010, and 2011. But, after adding a welding studio to his home (he's an artist who does metal scroll work in wrought iron), Wheelock was about to lose this status and have electric bills again, unless he generated more power.

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### Studio gains

With Wheelock's decision to start welding at home, the home's power needed a jump. Instead of throwing money at the challenge and simply adding more solar panels to his roof, Wheelock decided to install three ground-mounted, passive trackers. Though mostly passive, these trackers have the ability to "flip over" before the sun comes up to boost power output.

In addition, a thermal device ensures the trackers wake early, so the modules can catch the first sunlight in the morning. This device provides another 1,100 kilowatt-hours (kWh) per year, which is roughly a 10% gain. And, most importantly, that's enough to bring the home back to its net-zero status.

By combining ground-mounted trackers with an early wakeup device, this system is over 54% more efficient than ground or roof-mounted panels. The panels generate an average of 40 kWh per day.

### Power outages

What once were mere dreams had become a net-zero reality for Wheelock, until 2012. That year, utilities in San Diego began shutting off electricity to the backcountry during especially high winds, leaving thousands of people (including Wheelock) without power during windy weather.

Wheelock had power most of the time, but he never knew when his grid-connected power would be turned off. And without a backup system to store energy, solar system owners are dependent on daylight or the utility for their power. At times, these power outages can last days, and those affected can't so much as pump water from their wells, never mind air-condition their homes or operate their businesses.

In 2014, Wheelock decided to become self-sufficient by installing a battery backup system to his home. Flooded, lead-acid batteries were chosen for their durability, cycle life, and ability to handle large temperature variations. In total, 16, six-volt, lead-acid batteries were used for Wheelock's storage system. These batteries are rated at 390 Ah (@20-hour rate), and are specifically designed for renewable applications, such as for use with solar power.

After installation, Wheelock received training on how to maintain the batteries in conjunction with the solar panels, for longer life and better performance. So far, Wheelock has been through three power outages, but he has yet to lose power in his home. Everything has continued to operate normally because of the battery backup system.

Wheelock's home provides a shining example of energy efficiency, solar power, and storage, proving that net zero is

a possibility without sacrificing modern comforts. And, despite running a welding studio, Mr. Wheelock has even beat his net-zero dream. Last year, he produced a \$200 surplus of power.

*Mark Snyder is the owner of Mark Snyder Electric, a renewable energy system installer and factory-certified inverter repair service for renewable energy and mobile systems.*

**Mark Snyder Electric** | [www.marksnyderelectric.com](http://www.marksnyderelectric.com)

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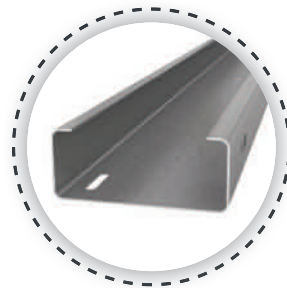
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## Residential Solar Financing Addressing soft cost reductions

By Stephane Dufrenne

In 2014, growth in the solar industry was driven largely by the residential sector: over 200,000 residential solar photovoltaic (PV) systems were installed throughout the year. That's more than four times the number of residential installations in 2011.

As of the outset of 2015, the Solar Energy Industries Association (SEIA) predicts the demand for residential solar power will only increase based on data from recent years. Falling prices and new financing models have further driven demand by making solar energy more accessible to homeowners and more cost-efficient for downstream businesses, such as for installers.

For homeowners, the benefits of installing a solar PV system include security against volatile electric utility bills and a reduced environmental impact. System costs have dropped in recent years, most notably with an 80% decrease in hardware costs since 2008. However, only 36% of the total cost to install rooftop solar comes from hardware.

"Soft costs" make up the remaining 64%, and until the overall system price is decreased, high upfront costs will continue to be the number one barrier preventing homeowners from installing residential solar systems. Demand for residential solar energy may be high, but the market cannot realize its full potential until financing models successfully enable reduction of both upfront system costs and soft costs.

### New financing models

The first financing models on the market offered by third parties, such as developers and banks, primarily focused on upfront cost reduction. Although these third-party leases and power purchase agreements (PPAs) did, in fact, dramatically reduce upfront costs, they

fell short for homeowners over the long-term, limiting the rate at which installers could afford to acquire new residential customers.

In a typical lease or PPA, the rebates and federal tax credits are monetized for the financing institution. For homeowners, this diminishes the return-on-investment (ROI) over the long-term. Installers, who typically purchase equipment prior to installation, are left holding the check, assuming high overhead costs without immediate financial returns. Additionally, lease terms are often rigid, proving difficult and costly to handle should a homeowner decide to move before the term of a lease is completed.

Over the past year, some states have experienced a gradual decline in third-party financing. In part, this decline has resulted from further decreased hardware costs. But, more notably, solar loans have become more prevalent and easier for homeowners to obtain and have begun to displace leases and PPAs. The shift to loans makes sense: why rent when you could buy?

Instead of paying rent on a leased system indefinitely, a loan enables

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homeowners to make payments toward ownership of, and build equity in, their solar PV systems. Loans typically provide low and fixed interest rates, greater flexibility, and added value to a home—and, in some cases, up to \$15,000, even in the event of sale before the loan is paid off.

Some residential solar loan programs are further geared to maximize homeowner ROI through use of reliable hardware and partnerships with qualified installers, both of which ensure the system achieves peak performance over time.

In these types of programs—where an installer-manufacturer and/or installer-loan provider relationship exists—further cost savings can be achieved because the installer is able to purchase hardware directly from the manufacturer, or even install hardware purchased directly by the homeowner.

This eliminates the installer overhead costs, which would otherwise be rolled into the homeowner's bill. These types of programs that consolidate costs and streamline installation, as well as operations and maintenance (O&M), are necessary to help drive down the overall cost of residential solar energy and help the market realize its full potential.



*Stephane Dufrenne is the president of Upsolar America, Inc. and the CTO of Upsolar Global. He supervises all technical functions for Upsolar, including quality systems, customer support, certifications, R&D center management, new product development and system application development.*

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## Solar panels

Vasari Energy Inc. announces the expansion of its product line to offer a 12-volt solar panel selection in its E-12 Series, which is an ideal solution for off-grid battery charging for a wide-range of applications. Meeting rigorous quality control at the highest international standards, the standard sturdy frame passes a mechanical load test of 5400 Pa—providing far more strength for heavier snows and higher wind pressure than the standard 2400 Pa rating.

The 12-volt solar modules in the E-12 Series also feature an aesthetic appearance, along with highly efficient, innovative PV technology. The modules are constructed with a strong aluminum frame, high transmissivity, low-iron tempered glass, and UV-resistant silicon. The unique design can be set up at 45-degree angles without screws, and features drainage holes that prevent freezing. The E-12 Series further provides a high-quality connector box, so it's easy for service providers to integrate into a range of applications.

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Figure 1.

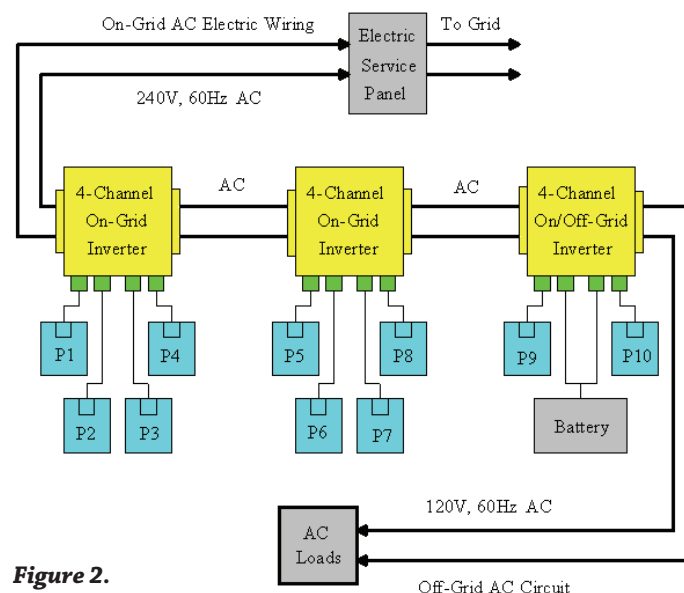


Figure 2.

# On/Off-Grid Solar Power Mini-Inverter

By Dr. George S. Cheng

Climate change in our world is becoming more catastrophic. Power grid brownouts and shutdowns are more frequent and severe, resulting in loss of production and personal hardship. Solar power backup systems are getting more popular but solar power is wasted when the grid is on. This is because the off-grid power inverters used in backup systems are designed to power AC loads, which cannot send power to the grid.

On the other hand, homeowners with on-grid solar systems often wonder why their systems are unable to generate power during a power outage when the sun is shining and they need the power the most. The reason is simply because grid-interactive or on-grid solar inverters in the system are required to shutdown immediately when the grid is down. In fact, it is a key testing item in the UL1741 certification process. When the grid is down and if an inverter is still sending power to the grid, it can cause fire and even fatal accidents to repair workers.

So, the dilemma is that on-grid inverters are designed to deliver power to the grid and cannot run as off-grid inverters to power AC loads, and therefore cannot be used for solar power backup systems. Off-grid inverters cannot send power to the grid so the solar en-

ergy is wasted when grid is on. Can we combine both on-grid and off-grid functions in one inverter?

## A New On/Off-Grid Power Mini-Inverter

Figure 1 shows a 4-channel on/off-grid power inverter that inverts the DC power from four DC sources, such as photovoltaic solar panels or batteries, to AC power and supplies the AC power either through its on-grid AC output port, or off-grid AC output port. Each inverter has four input channels that can connect directly to four 250W-320W solar panels and produce 1150W AC peak power. Each input channel has its own control and MPPT to eliminate partial shading problems and maximize power production.

In North America and some other parts of the world, split-phase AC standard is used. In the U.S., the line-to-line (L1 to L2) output voltage is 240V, and the Line-to-Neutral (L1 to N, or L2 to N) is 120V. Thus, the on/off-grid power inverter for the U.S. market must supply 240V AC to the grid from its on-grid AC output port, or 120V AC to the AC loads from its off-grid AC output port. As shown in Figure 1, the on/off-grid power inverter has two AC output ports and wires on the top, where the left is the on-grid AC output and the right is the off-grid AC output.

## How It Works

During normal operating conditions when the grid is on, the inverter works like a regular on-grid power inverter that meets all UL1741 and IEEE1547 standards including: over or under voltage shutdown, over or under frequency shutdown, and anti-islanding. When the grid is down, the inverter will shutdown within a fraction of a second. After waiting for a few seconds, the inverter sends a test signal to the connected off-grid AC circuit to check: (1) if there is AC present in the off-grid circuit; and (2) if there is an AC load in the off-grid circuit. If there is no AC present and an AC load is detected, it will start generating AC to power the load. Now, the inverter works in its off-grid mode.

During the off-grid mode, the inverter is constantly detecting if the grid is back on. After grid power is detected, the inverter will wait for a few minutes to assure the grid is stable. It will then stop generating power to the off-grid circuit. After a 5-minute mandatory wait based on UL1741 standard, the inverter starts generating AC power to be sent to the grid. Now, the inverter works in its on-grid mode.



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## A Grid-Flexible Solar Power System

For ease of installation, multiple on-grid and on/off-grid power inverters of the same family can daisy-chain using the attached AC wires and connectors. The inverters can be mounted on solar racks on the roof where each solar panel connects to an input channel of the inverter with MC-4 connectors. Since there is no high-voltage DC, the system is safe and easy to install.

Figure 2 illustrates a 3.6KW grid-flexible solar power system that includes two 4-channel on-grid solar inverters and one 4-channel on/off-grid solar inverter. All three inverters can be installed on the roof daisy-chained. Notice that the on-grid AC output wire of the on/off-grid inverter is daisy-chained with an on-grid inverter. This way, only one on-grid AC wire is needed to run from the roof down and connect to L1 and L2 of a 20A branch circuit of the electric service panel. The off-grid AC output wire from the on/off-grid inverter can go through a junction box and run inside the house to support a 1.2KW off-grid AC circuit to power AC loads such as lights, fans, TV, computers, phone-chargers, and a small refrigerator when the grid is down.

For areas where power outages are frequent, the on/off-grid inverter can be installed inside the garage. Two input channels of the inverter can connect to two solar panels on the roof using a 4-conductor DC wire. The other 2 input channels can connect to a 36V battery set. This way, the system can produce 600W AC power in the evening when the grid is down. This is a scalable design so a bigger system can be easily installed with more solar panels, inverters, and batteries.

## Conclusion

The on/off-grid solar power Mini-Inverter can work in either the on-grid or off-grid mode, and switch back and forth between the two modes automatically depending on the grid condition. This means that the same solar power system can generate power to the grid and can also be a power backup system when the grid is down. The on/off-grid solar power inverter can significantly improve the usefulness of solar power systems and make them more competitive compared with fossil fuel and other types of renewable energy, resulting in better return-on-investment (ROI) and faster adoption of solar energy in the global market.

*Dr. George S. Cheng is the chief technical officer of CyboEnergy, Inc.*

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# Batteries

A reliable battery is a key component to any efficient and sustainable solar energy system. Here are some of the more popular choices in the industry today...



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## SEE AD ON PAGE 45



## MK Battery

**Product:** 8GGC2 – DEKA Solar Gel Battery

**Description:** DEKA Solar GEL batteries, marketed by MK Battery, are a premiere, deep-cycling choice for renewable energy applications. They're designed for use in even the harshest environments, and are deployed on all seven continents.

**Capacity (Ah @ 20hr rate):** 180 Ah @ C20

**Voltage:** 6 volts

**Cycle Life:** 2000 Cycles at 50% Depth-of-Discharge

**Dimensions:** 10.25" x 7.13" x 10.88"

**Weight:** 68.4 lbs (31 kg)

### Key Features:

- Individual Plate Formation (IPF) technology utilized for cell consistency;
- Valves are UL recognized and 100% tested for quality;
- Recombinant construction with gelled electrolyte eliminates dangerous spills; and
- Includes 250 QC checks, from raw materials through to the finished product.

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



## GNB, Division of Exide Technologies

**Product:** Absolyte GP

**Description:** The Absolyte GP product line is a premium, valve-regulated, lead acid (VRLA), stationary battery for PV and energy storage projects. Made in the USA, Absolyte GP combines long duration and deep discharge performance in a modular, steel tray design for easy installation.

**Capacity (Ah @ 20hr rate):** 120 Ah to 5460 Ah

**Voltage:** 2 V

**Cycle Life:** 1200 Cycles at 80% Depth-of-Discharge; 5000 Cycles @ 20% Depth-of-Discharge  
**Dimensions:** Modular tray design provides for a variety of configurations

**Weight:** 30 lbs to 275 lbs (13.6 kg to 125 kg) / cell

### Key Features:

- **Non-spillable:** No water addition maintenance is required;
- **Weather-resistant:** Tolerant of freezing temperatures;
- **Code compliant:** The modular tray design meets seismic codes, while eliminating the need for a separate rack; and
- **Scalable:** There are 34 models, which scale to meet small, medium, and large power requirements.

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

SEE AD ON PAGE 46



### Discover Energy Corp.

**Product:** 12VRE-3000TF

**Description:** Discover Tubular Flooded RE Series Batteries provide superior deep-cycling performance and reliability for demanding commercial, industrial, and residential renewable energy applications.

**Capacity** (Ah @ 20hr rate): 215 Ah

**Voltage:** 12 volts

**Cycle Life:** 2500 Cycles at 50% Depth-of-Discharge

**Dimensions:** 19.7" x 7.4" x 16.2"

**Weight:** 142 lbs (65 kg)

#### Key Features:

- Tubular Flooded RE Batteries utilize Advanced Tubular Plate Technology to deliver long service life with low-maintenance requirements;
- Tubular positive plates and proprietary alloy compositions for long life;
- International Electrical Commission (IEC61427) compliant for battery performance and life in PV applications; and
- Low-maintenance designs with sight gauges ease electrolyte level maintenance

[www.discover-energy.com](http://www.discover-energy.com)



### Storage Battery Systems, LCC (SBS Battery)

**Product:** STT Series – STT2V600 / 6 OPzS 2-600

**Description:** The STT / OPzS series are 20-year, lead-selenium, flooded tubular plate batteries, manufactured in accordance with OPzS DIN40736 standards.

**Capacity** (Ah @ 8hr rate): 660 Ah

**Voltage:** 2 volts

**Cycle Life:** 1200+ Cycles at 80% Depth-of-Discharge

**Dimensions:** 5.71" x 8.11" x 27.6"

**Weight:** 100 lbs (45 kg)

#### Key Features:

- Offers a 20-year design life;
- The watering intervals are between one to three years;
- Has a leak-proof post seal; and
- Can withstand high-temperature applications better than lead-calcium batteries.

[www.sbsbattery.com/stt-opzs](http://www.sbsbattery.com/stt-opzs)

[www.sbsbattery.com/stt2v600.html](http://www.sbsbattery.com/stt2v600.html)



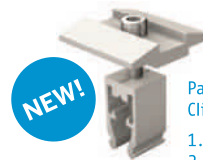
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SEE AD ON PAGE 47



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### Rolls Battery Engineering

**Product:** Rolls S-550

**Description:** Maintaining the versatile and popular L16 battery size, the newly redesigned, Rolls S-550 6-Volt model offers customers increased capacity and long-term, dependable power storage options—backed by an industry-leading warranty.

**Capacity** (Ah @ 20hr rate): 428 Ah

**Voltage:** 6 volts

**Cycle Life:** 1280 @ 50% Depth-of-Discharge; 2000 @ 80% Depth-of-Discharge

**Dimensions:** 12-1/2" x 7-1/8" x 16-3/4"

**Weight:** 123 lbs (55.80 kg)

#### Key Features:

- Redesigned L16 case size for added durability, easy transportation and installation;
- A 7%+ Increase capacity over previous 6-Volt model (S-530); and
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### Fullriver Battery Company

**Product:** DC400-6 (Group Size: L16)

**Description:** The DC400-6 is a high-capacity, 6-Volt AGM battery, ideal for high-demand solar backup applications. This maintenance-free battery is an excellent solution to remotely located systems.

**Capacity** (Ah @ 20hr rate): 415 Ah

**Voltage:** 6 volts

**Cycle Life:** 1250 Cycles at 50% Depth-of-Discharge; and 2300 Cycles at 25% Depth-of-Discharge

**Dimensions:** 11-5/8" x 7" x 16-11/16"

**Weight:** 123.5 lbs (56 kg)

#### Key Features:

- The sealed construction requires no watering, and eliminates terminal and cable corrosion;
- Includes thick grids and a high-density paste for long life;
- AGM electrolyte retention provides superior performance in low temperatures, and is reliable and safe in hot climates; and
- Non-hazardous, non-spillable, as well as non-gassing.

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



### Concorde Battery Corporation

**Product:** Sun Xtender Batteries (PVX-12150HT)

**Description:** Sun Xtender Deep Cycle AGM sealed lead acid batteries are built to meet energy demands of homes, businesses, or industrial sites. Sun Xtender is engineered for optimum delivery, as it's needed.

**Capacity:** (Ah @ at 24hr rate) 1215 Ah

**Voltage:** 2 Volts

**Dimensions:** 11.6" x 6.95 x 15.7"

**Weight:** 124 lbs (56.2 kg)

#### Key Features:

- Manufactured by Concorde Battery Corporation, the original equipment supplier to aircraft manufacturers and military operators worldwide;
- Sun Xtender Batteries incorporate PolyGuard, a proprietary microporous separator around the positive plates for protection from shorts, extending battery life;
- Large, intercell connections maximize charge and discharge performance; and
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## OutBack Power

**Product:** EnergyCell GH

**Description:** OutBack's EnergyCell Valve Regulated Lead Acid (VRLA) 200GH batteries are designed to support critical power applications in grid/hybrid systems where renewable sources normally augment grid power, but the power-conversion system switches to off-grid operation during emergencies or outages.

**Capacity** (Ah @ 20hr rate): 191 Ah

**Voltage:** 12 volts

**Cycle Life:** 725 Cycles at 50% Depth-of-Discharge

**Dimensions:** 11.1" x 22.1" x 4.9"

**Weight:** 116 lbs (53 kg)

**Key Features:**

- Valve regulated lead acid battery;
- Front terminal access for ease of installation and design;
- 18-month shelf life at 25° C (77° F); and
- EnerSys SBS EON technology allows for higher energy density.

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



## Trojan Battery Co., LLC

**Product:** Reliant AGM with C-Max Technology (L16-AGM)

**Description:** Reliant AGM with C-Max Technology is the industry's first true, deep-cycle, absorbed, glass-mat (AGM) battery made in the USA. It provides maximum sustained performance and increased total energy output to meet demanding deep-cycling requirements for a variety of applications, including for inverters and renewable energy.

**Capacity** (Ah @ 25hr rate): 817 Ah

**Voltage:** 6 V

**Cycle Life:** N/A

**Dimensions:** 11.66" x 6.94" x 16.31"

**Weight:** 115.3 lbs (52.3 kg)

**Key Features:**

- Proprietary Paste Formula: the paste features elements designed to address the unique needs of deep-cycle applications to maximize sustained performance and increase total energy;
- Unique Separator Composition: A thick design ensures high compression for a effective contact between the glass-mat and plates, which protects against stratification for extended battery life;
- Plastic Polymer Case Design: A distinct plastic polymer case formula with reinforced case end walls increases durability and provides higher battery cell compression to ensure reliable performance;
- Maximum Flame Arrestors: Features one flame arrestor for each cell for maximum safety; and
- Extensive Testing: Includes compliance and verification to IEC, SAE, and BCI Industry standards, ensuring the reliability and consistency.

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

# Deka Solar Saves The Day

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

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SEE AD ON PAGE 39



### Crown Battery Manufacturing Company

**Product:** 2CRP3690 Power Module

**Description:** The 2-Volt 2CRP3690 Power Module combines massive ampere-hour capacity availability to renewable energy system users. The battery delivers application flexibility, while providing a better solution for temperature management and electrical isolation.

**Capacity** (Ah @ 20hr rate): 2550 Ah

**Voltage:** 2 volts

**Cycle Life:** 1500 Cycles @ 100% Depth-of-Discharge; 4300 Cycles @ 30% Depth-of-Discharge

**Dimensions:** 12.81" x 6.56" x 33.38"

**Weight:** 313 lbs (141.9 kg)

**Key Features:**

- Rugged internal construction with heavy-duty plate, cast-on strap, and terminal-post components, which deliver strong performance and durability;
- Posi-Wrap Plate Protection ensures active material retention, protecting from internal short-circuits to deliver proven ROI for customers;
- Low-maintenance design features reduced frequency of preventative maintenance to lower service costs and total cost of ownership; and
- High-capacity 2-Volt Power Module design includes fixed handles and the flexibility to be installed with or without battery racks.

[www.crownbattery.com/applications/renewable-energy-systems](http://www.crownbattery.com/applications/renewable-energy-systems)



### NECES

**Product:** ALM 12V35

**Description:** The ALM 12V35 is a high-performance and long lasting battery for tough, critical applications. It is an ideal replacement for lead-acid batteries where users seek a light-weight storage solution that can provide high-energy capacity even under high discharge rate and deep cycling.

**Capacity** (Ah @ 20hr rate): 35Ah

**Voltage:** 12 volts

**Cycle Life:** >8000 Cycles at one-hour rate at 100% Depth-of-Discharge

**Dimensions:** 7.75" x 5.2" x 7.1"

**Weight:** 13.8 lbs (6.3 kg)

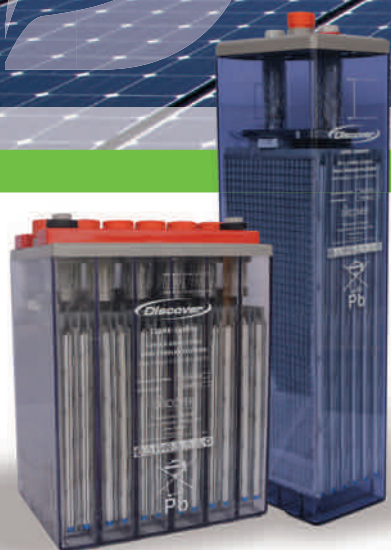
**Key Features:**

- Integrated EverSafe battery technology. Protection at the cell, battery, and system level;
- Safe, proven, high-performance Nanophosphate LiFePO4 chemistry;
- Fast, simple charging. Compatible with most lead acid chargers;
- Intelligent CAN or SMBus communications options for access to battery status and usage tracking; and
- IEC 62133, UL 1973 Recognized

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

## Redefining RE Systems

The superior design elements of Discover Energy Advanced Tubular Plate batteries deliver proven reliability in renewable energy applications and remote, high temperature or unstable power network installations.



[www.discover-energy.com](http://www.discover-energy.com)

Design features include, tubular grids and multi-tube gauntlets that encapsulate the positive plate active material resulting in cyclic stability, longer life and higher capacity than flat plate batteries.

- Up to **20% more electrical capacity** than flat plate batteries of comparable size and weight using the same electrolyte volume and specific gravities.
- Up to **30% longer service life** than flat plate batteries due to less positive plate shedding and reduced short circuits.
- Up to **50% savings in total cost of ownership** over high quality flat plate battery options.



**DISCOVER**  
ENERGY CORP.

SEE AD ON PAGE 43



### U.S. Battery

**Product:** US RE L-16XC

**Description:** Design optimized for maximum performance and life in stationary (non-vehicular) applications, including solar power and renewable energy installations, the OSP battery design and insulating DEFENDER "moss shields" increases life expectancy and performance.

**Capacity** (Ah @ 20hr rate): 401 Ah

**Voltage:** 6 volts

**Cycle Life:** 675 Cycles at 80% Depth-of-Discharge, and 1150 Cycles at 50% Depth-of-Discharge

**Dimensions:** 11-7/8" x 7-1/8" x 16-3/4"

**Weight:** 114 lbs (51.7 kg)

### Key Features:

- OSP outside positive plate;
- Higher peak capacity and increased initial capacity; and
- Lower acquisition and per-cycle cost than lithium ion, nickel metal hydride, or other rechargeable battery systems.

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



### NorthStar Battery

**Product:** NSB 170 Blue+ Battery

**Description:** The NSB Blue and Blue+ Battery range are designed for high performance and long life in demanding cyclic applications. The proven performance of Blue Star Technology has been enhanced to deliver more power, higher cycling, and a faster recharge.

**Capacity** (Ah @ 20hr rate): 181 Ah

**Voltage:** 12 volts

**Cycle Life:** 3000 cycles at 20% Depth-of-Discharge

**Dimensions:** 12.6" x 4.9" x 22.0"

**Weight:** 135 pounds (61 kg)

### Key Features:

- Partial state of charge (PSOC) cycling technology;
- Operating temperature range -40° C to +65° C;
- High potential fuel savings when used with hybrid genset applications;
- High modulus Polyphenylene Oxide (PPO) plastic materials used, which are designed to withstand extended elevated operating temperatures; and
- Flame-retardant (UL 94 VO) with a LOI of at least 28%.

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



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## PV America

March 9th to 10th, 2015

The Westin Boston Waterfront—Boston, Massachusetts

With a regional focus, PV America brings together manufacturers and service providers, with professionals interested in solar power technologies, research, and innovation. This annual event offers a focused expo, quality networking, and timely educational content and training related to what's driving the PV industry forward today and into the future.

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

show in print

Features just some of the companies and technologies attendees will see at this year's show.



### Financial services

The Rodman & Rodman, CPA "Green Team" provides solar energy companies with expert counsel and services in solar energy tax accounting and business strategy. They can provide companies with a sustainable financial roadmap through: expert partnership/corporate structuring for optimal tax benefit; grant qualification assistance and auditing; ongoing advisory services for federal, state, and local tax incentives; and specialized strategic financial planning and management for solar energy companies. Rodman & Rodman offers a personalized, cost-effective approach to business and accounting, allowing solar companies to benefit from their counsel at every stage of the business lifecycle.

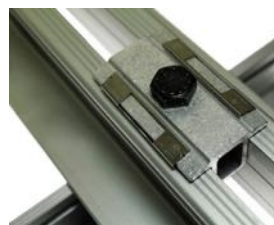
**Rodman & Rodman** | [www.rodmancpa.com](http://www.rodmancpa.com)



### Combiner solutions

SolarBOS' Rapid Shutdown solutions include low-cost, space-saving units for residential and commercial solar systems utilizing string inverters. As required by NEC 690.12, the combiners and pass-through disconnecting units with integrated load-break contactors provide rapid shutdown functionality, when placing the inverter within 10 feet of the array is not feasible. SolarBOS' Arc Fault Circuit Interruption (AFCI) Contactor Combiners analyze string currents and overall system noise to accurately detect and interrupt series arcs, eliminating false alarms and nuisance tripping. AFCI is the first combiner of its kind in the solar industry to be ET listed to UL-1741.

**SolarBOS** | [www.solarbos.com](http://www.solarbos.com)



### Bonding solutions

WILEY, a division of Burndy, supplies a complete selection of integrated mid-clamp bonding solutions that are specifically engineered to exceed the demanding needs of the solar PV industry. This line of WEEB mid-clamp washers easily snap or slide onto the mid-clamp for quick installation. The 304 stainless steel WEEB mid-clamp washers also provide a simple, consistent, and low-cost method to bond PV modules. When the WEEB washer's teeth pierce the anodized coating, the result is excellent conductivity without added installation steps. All WEEB washers are listed to UL 467 for grounding and bonding, and are UL 2703 recognized.

**Burndy** | [www.burndy.com](http://www.burndy.com)



### Racking system

Gamechange Racking's Grid-Lite Roof System features an interlocking grid design, combined with a wind deflector that helps eliminate ballast. Available in 5 and 10-degree tilts, the typical roof loading—including ballast, panel, and racking—is 2.5 to 3.5 psf total. In severe seismic conditions, the system may be installed with or without attachments. With less ballast and minimal components, the Grid-Lite Roof System provides for a fast installation and reduced overall costs and labor. Rigorous ETL/UL 2703 electrical, mechanical, fire, and wind tunnel testing are in progress.

**Gamechange Racking**  
[www.gamechangeracking.com](http://www.gamechangeracking.com)



# ANCORA METALWORKS



## Foundations for Ground Mounted Solar Projects

- Driven Piles
- Grouted Piles
- Helical Piers
- Rock Screws

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



### Tile mounting solutions

The Tile Flashing System from EcoFasten Solar was specifically designed for use on new or existing roofs, and is available in three profile options for flat, "W," and "S" tile roofs. Each flashing system replaces one complete tile, eliminating the need for cutting, drilling, grinding, or replacing tiles. Multiple fastener points in the system's base plate allows for attachment into the rafter, regardless of flashing alignment. The embossed, cone-shape stamped into the underside of the flashing is fitted with an EPDM rubber bushing, creating a watertight seal when paired with a compatible EcoFasten Solar compression bracket. The system attaches to the roof deck with as little as two lag bolts, resulting in a fast, simple installation. An optional second flashing at the roof deck is available for jurisdictions that demand it. Made in the USA using recycled materials, the Tile Flashing System is third-party tested for pullout and shear.

**EcoFasten Solar** | [www.ecofastensolar.com](http://www.ecofastensolar.com)



### Ground-mount solution

Second-generation Power Peak GS Utility-Scale, Ground-Mount System is a cost-effective, utility-scale mounting system that's manufactured from high-strength, galvanized steel. The new design features pre-assembled clamps, field-adjustable components, and bottom access clips to ensure faster build rates. Similar to the Power Peak AL, the Power Peak GS rack easily assembles over pile-driven "H" beams and adjusts to changes in terrain. Wind tunnel tested and code compliant, the Power Peak GS promises long-term reliability.

**DPW Solar** | [www.dpwsolar.com](http://www.dpwsolar.com)





### Foundation systems

Manufacturing a range of foundation systems that include driven posts, grouted posts with or without grout flow holes, helical piers, and rock screws, Ancora Metalworks has delivered foundation posts to projects totaling over 300 MW. Typical post sizes are 3.5" OD, 4.5" OD, and 5.5" OD. Wall thicknesses range from 0.188" to 0.375", to ASTM A500-C specifications. The selection of a foundation system is influenced by many factors, such as the geographic location, soil conditions, racking system, and panel configuration. Every project has different requirements, so Ancora works closely with the structural design engineers to optimize the foundation design and minimize costs. Full cost analysis of foundation systems include the foundation posts, installation speed and process, and connecting the racks to the posts. Foundation posts are hot-dipped galvanized to ASTM A123 after fabrication, and shipped in bundle configurations that minimize the trucking costs.

**Ancora Metalworks**  
www.ancorapiling.com



### O&M and project development

EDF Renewable Services ensures ongoing project profitability for solar power project owners and investors by providing a full range of operation and maintenance (O&M) services and expertise. With over 9,300 MW of renewable energy in North America, EDF Renewable offers: total project operations, balance of plant (BOP); asset administration; warranty inspections, and engineering support and analysis. From their Operations Control Center, the company provides a full suite of standard and advanced services including: 24/7 remote monitoring; project performance evaluation; SCADA support; remote resets, and technician dispatch. Their development affiliate, EDF Renewable Energy, is an expert in all areas of development, including: site selection; procurement; financing; permitting; project planning and construction, and long-term management.

**EDF Renewable Services**  
www.edf-renewable-services.com  
www.edf-re.com



### Dual-axis GPS tracker

AllEarth Renewables engineers and manufactures the AllEarth Solar Tracker, a complete grid-tied, dual-axis solar electric system that uses GPS technology to follow the sun and produces up to 45% more energy than fixed rooftop systems. Made in the US, the ground-mounted solar tracker is designed for residential and commercial-scale installations. Its simple, durable design, and complete system pallet, reduces costly procurement and installation time. It also ships directly to the installer or the jobsite. With a 120-mph wind rating and snow shedding that can withstand harsh, winter climates, the tracker comes with an industry-leading, 10-year warranty.

**AllEarth Renewables** | www.allearthrenewables.com



### Solar structures & carports

Baja Construction offers a complete line of solar support structures as well as design, engineering, supply, and installation services. Providing pre-fabricated, pre-engineered, high-tensile, and light-gauge steel structures, they focus on designing solutions that work for the industry. Their Solar Support Systems are designed to support solar panels with a proprietary attachment. These structures can be used in a variety of solar installations including: solar farms, solar carports, solar/EV charging stations, solar truck bays, and solar RV/boat storage. There are various standard styles to choose from and custom designs are also available.

**Baja Construction Co. Inc.** | www.bajacarports.com

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Did you know nearly 25% of all solar electricity generated in North America flows through a SolarBOS product? Why not put our expertise to work for you? Call us for a quote for your next project.





# Solar Asset Management

## A marathon, not a sprint

By Chad Sachs

Over the last decade, a tremendous growth in solar photovoltaic (PV) installations have been sited across the United States. Currently, there are nearly 20 gigawatts (GW) of solar power deployed in the US, nearly tripling the cumulative deployment of 7.7 GW in 2012. That's certainly an impressive figure, denoting solar energy's sure foothold in today's energy sector.

As solar becomes a mainstream energy resource and an established investment asset class, it's time to turn the focus on the future—and, on ensuring the long-term success of the

industry. As with any significant capital investment, solar power system owners and operators have an obligation to manage significant capital assets efficiently, responsibly, and profitably.

After all, it's clear the projects are getting built. Now, it's imperative to ensure someone is taking care of them properly.

### Performance standards

Whether it's a five-kilowatt (kW) system on a residential rooftop or a 50-megawatt (MW) ground-mounted, utility-scale solar array, the goal for any solar power project should be to ensure certain qualities, including safety, reliability, and durability. Of course, the return on investment (ROI) is also important.

The challenge is that these systems are purposely exposed to the sun and the elements. Wear and tear takes its toll over time, so how can one ensure—or, even, exceed—expectations as a steward of these assets? These systems are power plants, after all, and not simple appliances. They have complex contracts and highly engineered capital structures. This is where solar asset management plays a critical role.

### Asset management

When deploying solar, it's anticipated that projects meet their performance expectations. A great deal of technical and financial expertise goes into a system's design, development, and execution. Careful fulfillment of ongoing requirements, as well as operations and maintenance (O&M) duties, enables projects to live up to these expectations.

Comprehensive solar asset management helps ensure solar projects fulfill their demanding obligations, and involves precise contractual, financial, and technical acumen. Each one of these components is also inextricably intertwined. System owners can't just focus on one aspect at the expense of the other two. Technical optimization doesn't mean much, for instance, unless it's tied to the boundaries set by contracts and incentives, achieving the financial goals of investors and owners.

### Leveraging incentives

Solar system owners are encouraged to leverage all tax and other incentives offered. These incentives introduce a host of complicated financial and contractual structures, and often entail complex, ongoing obligations that need to be managed carefully.

A solar plant may be performing beautifully, but if the project's contracts aren't fulfilled on time or as promised, benefits can be stripped away. For example, many PV system owners have accepted cash

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grants. But, it's critical that each year owners report how their solar plant is performing to the Treasury, who provided the incentive. Failure to do so can result in expensive and unnecessary problems.

Another potential concern is when equipment breaks, and owners need to replace compromised modules or other hardware. Technical solutions can vary, and investors or lenders may have different risk appetites that complicate how quickly a decision can be made to fix a technical solution. Delays created from poor information dissemination, or even poor maintenance of operational logs, can lead to unnecessary tensions with lenders, threatening the long-term performance of a project.

So, how does one properly manage all of the real and potential challenges that occur with developing a solar power project? There are several checks and balances to have in place, including:

- Clear oversight and management of O&M providers;
- An ongoing cost/benefit analysis of predictive maintenance solutions (ideally, done before something fails);
- Cash flow management, which includes a record of all invoices and payments; and
- A schedule or deadlines to plan for and meet (such as when to send a report to Treasury).

To manage these and all of the other issues that might come up with a project, an asset management resource is essential.

#### Outsourcing gains

Solar power projects are robust systems, but they need thoughtful financial, technical, and operational management to achieve and exceed expectations. With a myriad of obligations to fulfill, owners often collapse by focusing on the immediate, day-to-day activities of taking care of the assets.

As a result, they can sometimes lose out on identifying, developing, and closing new projects and new revenue streams, simply because of time management. Outsourcing demanding obligations can make solar project ownership more efficient and cost effective. Outsourcing can also offer benefits in terms of economies of scale and industry proficiency, from those in the field who are managing many hundreds of megawatts of projects across the PV deployment spectrum.

Moreover, finding an in-house asset manager who's mastered all the disciplines necessary can be tricky, as they're essentially a Jack or Jill of all trades: an accomplished accountant, an experienced engineer, and a knowledgeable attorney, all rolled into one. By outsourcing to independent experts, solar power systems

owners can ensure they're leveraging multi-disciplinary expertise and best practices in asset management from across the industry.

As the solar energy industry grows, smart and careful solar asset management is becoming critical to the industry's continued success. Managing solar assets to maximize ROI for the long term is a sure-fire way to encourage future investment and ongoing solar success.

*Chad Sachs is CEO of RadianGEN, a provider of ongoing solar asset management and advisory services, works with solar power system owners to monitor and maintain solar system performance, ensuring system owners maximize ROIs.*



**RadianGEN** | [www.radiangeneration.com](http://www.radiangeneration.com)

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## WINDPOWER 2015

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WINDPOWER is the annual conference and exhibition for the US wind industry, hosted by the American Wind Energy Association (AWEA). It's the nexus between wind power professionals and industry experts, who converge to generate actionable ideas for expanding the wind energy economy through technology and collaboration.

[www.windpowerexpo.org](http://www.windpowerexpo.org)

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Features just some of the companies and technologies attendees will see at this year's show.



### Compression grounding system

BURNDY offers the HYGROUND Irreversible Compression Grounding System. A safe, cost-effective, and time-efficient grounding method, HYGROUND is a complete system consisting of connectors for cross-grid connections, taps, splices, cable-to-ground rod, ground plates, and terminations. HYGROUND promotes sustainability by providing a product that's greener than competitive technologies, which produce heat and emissions. HYGROUND is a clean product, created from very few base materials. It can be recycled and doesn't produce any negative environmental impacts during installation. The BURNDY HYGROUND system meets the most stringent safety and performance requirements, including NEC code, IEEE 837, UL 467, UL 96-81, and NFPA Lighting Protection Code. Its non-hazardous process installation is extremely safe, as it doesn't produce heat or dangerous process chemicals, eliminating the need for protective equipment or clothing. The system meets the toughest industry performance requirements, and is safely installed at a low cost.

**BURNDY** | [www.burndy.com](http://www.burndy.com)

**Booth 5205**



### Full-service wind engineering & manufacturing

Janicki Industries is a privately owned, full-service engineering and manufacturing company. Janicki specializes in manufacturing wind energy parts, patterns, and production tools made of advanced composite materials and metals. They are capable of tackling large-scale projects, utilizing high-precision five-axis mills, curing ovens, autoclave, and large annealing oven. Janicki also has extensive experience using many composite systems, such as: 71° C | 160° F machined syntactic putty; 121° C | 250° F carbon/fiberglass hybrid molds; 177° C | 350° F carbon molds; and 177° C | 350° F invar and steel molds. This 100% in-house capability for the total tooling and parts solution enables a one-stop shop for customers.

**Janicki Industries** | [www.janicki.com](http://www.janicki.com)

**Booth 1925**



### Wind automation & manufacturing

Dokka Fasteners Inc. is a US manufacturer of high-quality, safety critical, large-diameter bolts (M24 - M64), studs (M20 - M52), and threaded rod (M20 - M80), using steel that's melted and rolled. With a cell production concept, Dokka Fasteners use high-end robotics and automation to manufacture their products, including in-house, heat-treat equipment, to ensure product consistency in every lot. With ISO 9001:2008 certification and an A2LA accredited Quality Inspection laboratory, Dokka Fasteners provides quality products to all major wind turbine OEM's and O&M providers in the Americas, as well as to companies involved in the transport and lifting of the turbine components.

**Dokka Fasteners Inc.**  
[www.dokkafasteners.com](http://www.dokkafasteners.com)

**Booth 3227**

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Howard Stevenson, Harvard Business School

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Andy Stoll, Vault Coworking & Collaboration Space



### Port connections

Port Corpus Christi sits on the Texas Gulf Coast, 150 miles north of Mexico. The warm, dry climate of South Texas and the Port's infrastructure provides year-round operations, making it an ideal location for cost-effective, wind energy transportation and productivity. The port has two laydown yards, conveniently located near highway and rail access, which are ideal for heavy lift and project cargo. The port also provides the following: a 45' deep ship channel; dockside rail; three Class 1 rail carriers; a knowledgeable labor force; heavy lift capabilities; open, covered, and dockside storage and fabrication sites; and high-end security and safety operations.

**Port Corpus Christi** | [www.portofcc.com](http://www.portofcc.com)  
**Booth 3815**



### Temporary solar LED lighting

TWR Lighting, Inc. introduces the only FAA Compliant L-810-OL800RS Red Solar LED fixture for temporary lighting during construction. The L-810-OL800RS has set the benchmark for low-intensity solar LED obstruction lighting in an easy-to-install, low-maintenance package. The OL800RS features a top-mounted LED display, with a simple tap-to-activate functionality and an Automatic Light Control (ALC). The ALC automatically adjusts to low levels of sunlight to ensure continuous operation. Optional GPS Synchronization is also available, allowing two or more units to flash in unison.

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### Tools, safety & onsite consultation

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**Snap-on** | [www.snapon.com/industrial](http://www.snapon.com/industrial)  
**Booth 4009**



### Polyamide plug connector

Phoenix Contact introduces the new addition to the Heavycon product line, the HEAVYCON EVO. This black, polyamide, glass-filled plastic connector offers high-reliability and durable construction, even in applications with high impact and vibrations. Heavycon EVO is UV, salt spray, and corrosion-resistant for reliability in outdoor applications, and has a high IP65 and NEMA 4/4x/12 rating. The Heavycon EVO is fully compatible with Phoenix Contact's and other B-series metal rectangular connector products, while the bayonet cable gland system and the patented EVO housing can reduce inventory costs.

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**Booth 4401**

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- ▶ Precision 5-Axis Machining
- ▶ Composite Fabrication
- ▶ Engineering Services

[www.janicki.com](http://www.janicki.com)  
360.856.5143



### Versatile, hydraulic torque wrench

Alltite's multi-patented X Driver is a versatile, hydraulic torque wrench. The square drive boasts a 40° power stroke, making the tool 30% faster per stroke. The low profile links are easy to get into confined areas and around nuts in hard-to-access spaces. With the durability of its solid steel design, it has fewer parts and clean-lined construction. To decrease the chance of failure, it has three o-rings, versus up to nine in other hydraulic torque wrenches. The powerhead locks into both the links and the square drives, making it a convertible and cost-effective tool kit option.

**Alltite** | [www.alltite.com](http://www.alltite.com)  
**Booth 5425**



### Battery gun

HYTORC's Lithium Series Battery Gun adds to HYTORC's current line of bolting equipment with its extended battery life and portability. The 36-volt Battery Gun features an integral metal frame with a color graphical user interface. The two-speed gun has the capability for torque and angle practices. The product line includes numerous output capacities, comprising of 250-, 700-, 1,000-, and 2,000-foot-per-pound models. The Lithium Series dual-speed torque gun provides the speed and convenience of a pneumatic torque gun without the noise, vibration, or load variation. Its aluminum frame makes it lightweight, yet resistant to damage.

**HYTORC** | [www.hytorc.com](http://www.hytorc.com)  
**Booth 4022**



## Pitch & yaw solutions

Bonfiglioli is a designer and manufacturer of complete packages that control energy generation with reliable solutions for pitch and yaw control for a wide range of turbine sizes. Bonfiglioli's 712TW, a yaw drive for 1.5 MW to 2.5 MW turbines, is more compact and features an integrated brake and (optional) inverter, which decreases height and weight compared to its predecessor, the 712T. The 714T and 707T, Bonfiglioli's yaw and pitch drives for 2.5 MW to 3.0 MW turbines, are used by leading turbine manufacturers. The 707T yaw drive operates at a torque of 12 Nm (105 in-lb) and peak static torque of 25 Nm (220 in-lb). The 714T operates at torque of 60,000 Nm (529,800 in-lb), and peak static torque of 150,000 Nm (1.3M in-lb). Bonfiglioli also produces a complete series of inverter drives for wind turbines, including the Integrated Agile inverter, which can be mounted directly to the yaw drive motor.

### Bonfiglioli

[www.bonfiglioliusa.com/wind](http://www.bonfiglioliusa.com/wind)

Booth 5222



## Radar activated lighting

Laufer Wind's Aircraft Detection System (ADS) is a radar-activated obstruction lighting system designed to reduce the impact of FAA-required aviation warning lights on neighboring communities and wildlife. The system keeps lights off at all times, except when aircraft enter into a protected airspace. Laufer Wind's ADS is the first of its kind to be successfully tested by the FAA on a U.S. wind farm.

Laufer Wind | [www.lauferwind.com](http://www.lauferwind.com)

Booth 3006



## Electrical design & commissioning

System 3, Inc. is an electrical contractor providing design, construction, and commissioning services to the wind industry. Having safely constructed transmission lines, substations, and switchyards up to 345 kV, they also provide services for collector systems, MET towers, tower wiring, and communication networks. Available to work with utilities across the country, they have experience integrating projects into every power pool in the US, including community wind or utility-scale facilities.

System 3, Inc. | [www.system3inc.com](http://www.system3inc.com)

Booth 3316

## Condition Monitoring

### More Profit, Greater Production



Condition Monitoring System



### BACHMANN SUPPORTS ALL ASPECTS OF CONDITION MONITORING

- Integration of condition monitoring to existing Bachmann controllers
- Stand-alone condition monitoring
- Remote monitoring and analysis
- End of warranty vibration inspection

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T: +1 (847) 249 30 03 | [office.boston@bachmann.info](mailto:office.boston@bachmann.info) | [www.bachmann.info](http://www.bachmann.info)



### Tower cable

American Wire Group's patented TowerGuard CCA 2kV UL RHH/RHW-2 cable is a low-cost, lightweight, theft-deterrent, and flexible cable. It exhibits the same flexibility and life expectancy of conventional DLO cable, yet weighs and costs approximately 35% less, and has no scrap value. TowerGuard CCA (CopperClad Aluminum) effectively replaces copper DLO from the bottom of the tower to the transformer. It can also be used from the generator to the transformer (withstanding the required turn-twist tests). TowerGuard CCA meets the following specifications: ICEA S-95-658, UL44; ASTM B-566, ASTM B-172, IEEE 383, and IEEE 1202; and has CSA approval.

**American Wire Group**  
www.buyawg.com  
**Booth 2906**



### Blade repair adhesives

Sika offers a full system of product solutions from the base foundation to the tip of the blades, capable of withstanding the toughest climatic conditions. SikaForce-7800 Blue and Red are two-component, high-performance, non-sagging, polyurethane structural adhesives for blade repairs. The products have been developed to offer the same finish speed at two different temperature ranges: Blue = 32°F to 77°F (0°C to 15°C), and Red = 77°F to 104°F (15°C to 40°C). SikaForce-7800 is specifically used for finishing and deep-surface repairs on wind blades, with quick (maximum 30 minutes) sanding time characteristics. SikaForce-7800 Blue and Red are available in standard, cartridge packaging, specifically designed for on-location wind blade repair applications.

**Sika** | www.sikausa.com  
**Booth 5309**



### Cranes & wind transportation

From site analysis to transporting cranes and operating and maintaining equipment on the job, ALL Erection & Crane Rental serves the wind energy industry, nationwide. They operate one of the largest, technologically advanced fleet of cranes, with thousands of crane options—from 8 to 1,000 tons. All Crane also provides in-field technical support to ensure the equipment on the job is performing safely and properly. They help with lift-planning, short and long-term rentals, bare rentals, as well as equipment sales and parts.

**ALL Erection & Crane Rental**  
www.allcrane.com  
**Booth 3605**



### Combined breaker & grounding switch

EMA Electromechanics, LLC's VDH/GSMI combined 34.5 kV outdoor vacuum circuit breaker and high-speed, mechanically interlocked grounding switch is specifically designed for application with wind energy collection units. This patented system for switching and grounding of wind power collection circuits replaces traditional grounding transformers, and can be combined with conventional circuit breakers in each feeder of a wind power substation.

**EMA Electromechanics LLC**  
www.emaelectromechanics.com  
**Booth 3029**

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**HYTORC**<sup>®</sup>  
WIND, LLC



HYTORC Washer™



HYTORC Nut™



HYTORC Z-Washer™

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Over the last 45 years HYTORC has tested and manufactured nearly every type of bolting system imaginable. With the desired goal of achieving even and accurate bolt load in the safest and simplest way possible, all systems had drawbacks. That's why HYTORC developed a series of fasteners designed to improve safety, speed and accuracy with all bolting jobs in mind. To find out which system is the best for your job, contact us at [wind@hytorc.com](mailto:wind@hytorc.com) and **let's move forward together.**

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### O&M and project development

EDF Renewable Services is a North American energy provider, developing and building wind and renewable energy projects. They maximize project profitability and ensure the performance of investments for the long term. EDF Renewable Services is fully equipped to perform a full spectrum of services for any wind project, including: operations & maintenance (O&M), asset administration; procurement; retrofits; BOP; 24/7 remote monitoring; NERC compliance support, and more.

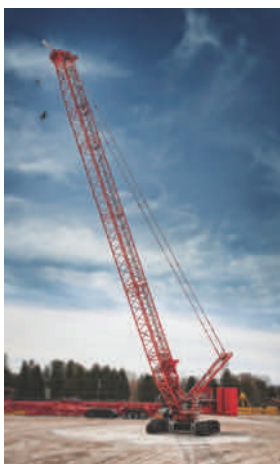
**EDF Renewable Services**  
www.edf-renewable-services.com  
**Booth 4610**



### Developer & operator

BayWa r.e. Wind, LLC is a turn-key developer and operator of renewable energy projects in North America. Headquartered in San Diego, CA, the company has been active in the U.S. since 2001. The company's business model is to develop, construct, own and operate renewable energy projects. It seeks to complete the life-cycle by either divesting of or partnering on the operating assets. The company is actively seeking new renewable energy projects.

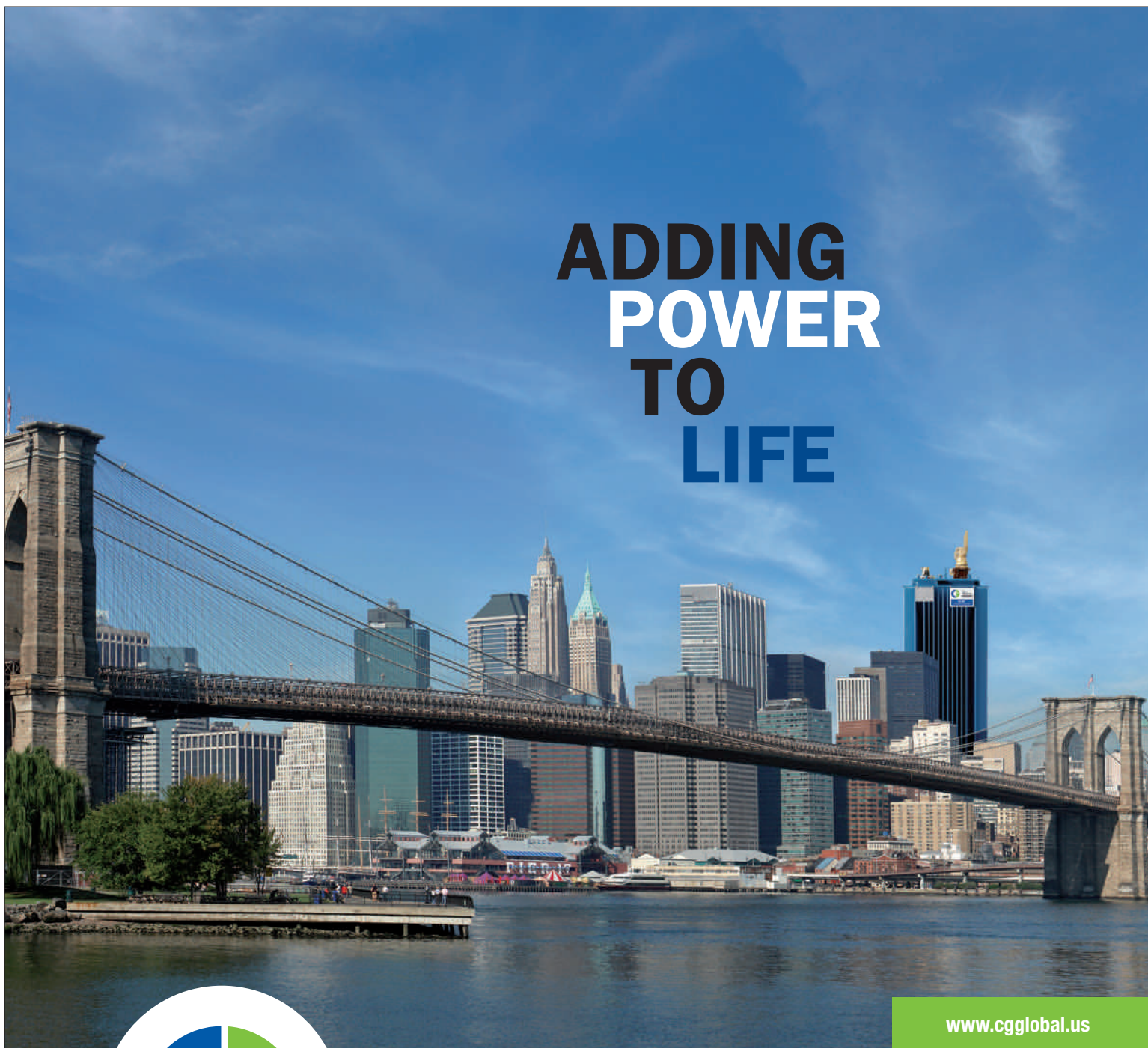
**BayWa r.e. Wind, LLC** | www.baywa-re.us  
**Booth 3409**



### Cranes & wind attachment

Manitowoc builds crawler cranes, tower cranes, mobile cranes, and boom trucks. Engineered to serve the wind industry with limited equipment, the Manitowoc MLC650 has a main boom length of 103.9 meters (341 ft), an available wind attachment option that increases boom length to 110 meters (361 ft), and a base capacity of 650 tons (716 USt). The VPC system allows the crane's counterweight to be positioned automatically, increasing its versatility and lifting capability. The company also provides after-market service through Manitowoc Crane Care, and offers equipment financing solutions through Manitowoc Finance.

**Manitowoc Cranes**  
www.manitowoccranes.com/mlcvpc  
**Booth 3107**



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Visit us at AWEA in Orlando at booth 4721





### Advisory services

DNV GL's services span the entire wind project life cycle. They offer strategic advice and resources to reduce the specific risks associated with eagles, bats, and other endangered species during project development, financing, and operations. DNV GL customizes solutions by combining their services in energy production assessments and asset management with a strong understanding of stakeholder, agency, and permitting requirements to proactively mitigate wildlife risks.

**DNV GL** | [www.dnvgl.com/energy](http://www.dnvgl.com/energy)

**Booth 2609**



### Turbine lighting

Designed with the customer in mind, the Flash Technology Vanguard II is more user-friendly, robust, and easier to install than ever before. Tested by multiple lightning test laboratories, the Vanguard II has a surge-suppression rating of 25 kA. The Vanguard II provides many options for monitoring, whether performed by a company's NOC or by Flash Technology. Now, with Vanguard II, Flash Technology offers an Infrared (IR) version as an option for better visibility to night vision goggles (NVG) and NVIS. The FTS 370i NVG compatible design combines Red (620nm) and IR (850nm) LEDs to ensure the lighting system is visible to pilots in all circumstances. With an integrated design for simple installation, and a radar interface standard, the Flash Technology Vanguard II is a durable, capable, and functional choice for any lighting system needs.

**SPX Corporation**

[www.spx.com/en/flash-technology](http://www.spx.com/en/flash-technology)

**Booth 5005**



### Oil filters

C.C. Jensen is a trusted partner for providing clean oil for wind turbines. They manufacture offline oil filter systems, gear flushing filters, and oil contamination monitoring systems. Clean oil is the lifeblood of a wind turbine. With C.C. Jensen's Fine Filters, they will systematically remove particles, oil degradation products, and water from the oil, which means longer life, greater reliability, and significant savings.

**C.C. Jensen, Inc.** | [www.ccjensen.com](http://www.ccjensen.com)

**Booth 2519**



### Wind development region

Iowa is centrally located in the heart of a region that boasts some of the nation's most abundant wind resources, providing a strong economic environment for the wind energy industry. Companies can also benefit from a robust supply chain, with direct access to transmission lines that connect to regional transmission systems.

**Iowa Economic Development Authority**

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

**Booth 4104**

# TWR Lighting, Inc.

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## ALL IN ONE SOLUTION

Preferred & Specified By Most OEMs and Developers  
Orga's new generation of LED FAA obstruction lights for the wind industry



Integrated Photocell/  
GPS/Flasher/Monitoring

FAA/U.S. Fish and Wildlife  
Avian Protection Compliant

Radar System(VWS) Interface  
Compatible with all manufacturers

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Temporary Solar Lighting  
During Construction

Met tower lighting system for  
60-100 meter tower complete  
with solar system



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### Torsion cables

HELWIND WK DLO 2kV is a torsion-rated, double-extruded cable for use in wind turbines and in other industrial applications. Specifications include: 2000V; FT4; VW-1; RHH/RHW-2; ERP insulation; CPE jacket, and flexing temperature -40°C (104°F) to +90°C (+194°F). UL and CSA approved. This cable has been rigorously tested at Helukabel's research facility in Germany. In a 26 ft high tower that replicates the cable loop in a wind turbine, the cable has been tested for more than 16,000 cycles.

**Helukabel** | [www.helukabel.com](http://www.helukabel.com)

**Booth 3415**



### Fire suppression system

Firetrace offers a fully automatic fire suppression system for the wind industry that is able to be fit on new or existing wind turbines. While remaining unaffected by vibration, dust, airflow, and temperature, this system can protect the control panels, capacitor cabinets, braking system, transformer, and other at-risk areas of the turbine, without requiring power or excessive space. Firetrace will conduct a fire assessment, and provide a customized method of protection.

**Firetrace International**  
www.firetrace.com  
**Booth 3922**



### Certification & testing

UL is a global, safety science company. They offer wind energy measurement and testing services, certifications, type approvals, as well as energy analysis and studies. They also provide seminars and consultancy for turbine manufacturers, developers, banks, and more. UL's advanced outdoor wind test facility allows small and large turbine manufacturers, seeking certification to international standards, to erect turbines for extended periods of time. Advancing in the field of renewable energy—from small and large wind turbines to onshore and offshore turbines and components—UL offers combined technical expertise that provides customers a global, one-stop wind energy facilitator.

**UL** | www.ul.com/wind  
**Booth 2904**



### Lubrication systems

BEKAwind offers 3 customizable lubrication systems for wind generators; The Single Line System is easy to install, operate, and maintain. It can be applied to main bearings, blade bearings and yaw bearings. The Progressive System offers a flexible lubrication system for oil and grease up to NLGI Class 2 and can be applied to main bearings, blade bearings, and yaw bearings. This system can be matched with a lubrication pinion for the pitch and yaw drives. BEKAwind Flow; a spray lubrication system, is selected for use with special lubricants with high solids content. This efficient non-contact technology offers a clean alternative for pitch and yaw drives.

**BEKAwind** | www.beka-lube.com  
**Booth 3616**



### Blade coatings solution

ALEXIT BladeRep is an advanced blade coatings solution that maintains turbine blade surfaces for optimal performance and efficiency. For more than a decade, the BladeRep two-component, polyurethane-based system has proved to perform effectively in all conditions - ranging from challenging to harsh. These innovative coatings, GL certified for performance and reliability, meet the requirements of the cosmetic blade maintenance market, as well as the OEM small to medium blade specifications for high-quality, durable products.

**BladeRep (Mankiewicz Coatings)**  
www.bladerep.com  
**Booth 4216**



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**+49 (0) 40 / 75 10 30**



**EPC & BOP services**

Renewable Energy Systems Americas, Inc. (RES Americas) provides development, engineering, construction, and operations services to utility-scale wind, solar, energy storage, and transmission projects across the Americas. With over 7,700 MW in their construction portfolio to date, they offer customized solutions tailored to meet the unique needs of their clients. Their energy storage solutions can help defer distribution upgrades, reduce transmission costs, and store off-peak energy. Currently operating more than 200MW of renewable energy and storage projects, RES Americas has a development pipeline of wind, solar, and energy storage projects across North America.

**Renewable Energy Systems Americas, Inc.**

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

**Booth 2610**



**Electrical & integrated solutions**

CG is a global provider of electrical products and integrated solutions. Their products, solutions, and services range from distribution and power transformers, to medium- and high-voltage switchgears, to SCADA and automation, to complete turnkey substations and lines, as well as EPC solutions. They offer: transformers; switchgears; substations; integrated solutions; automation; and engineering services. CG is a reliable equipment and solution provider to the renewable market, with a track record of on-time delivery and completion, and an installed base of more than 20,000 MW in North America.

**CG** | [www.cgglobal.us](http://www.cgglobal.us)

**Booth 4721**



**Erosion-resistant coatings**

Hontek's sprayable and moldable polyurethane coatings protect against rain, water cavitation, erosion, and impact damages. The Hontek coating system with its repair kit and repair procedures, provides a preventive maintenance concept for field repair. They are ideal for use on the leading edge of a turbine blade. When properly maintained, Hontek-coated blades have the ability to prolong the life of a wind turbine blade and prevent costly erosion damages. Hontek sprayable and moldable resins can be customized to fit specific needs.

**Hontek Corporation**

[www.rain-sand-erosion.com](http://www.rain-sand-erosion.com)

**Booth 3820**

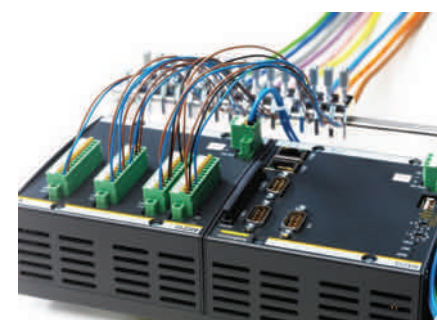


**Integrated solutions**

Tetra Tech provides solutions using an integrated environmental, engineering, and construction approach throughout all phases of energy projects. Tetra Tech is ranked #1 in Wind by Engineering News-Record. They provide support to 20 of the top 25 wind power developers. They have an integrated team of environmental, engineering, and construction professionals who help achieve developmental and operational objectives. With 13,000 employees worldwide, Tetra Tech's depth of resources and geographic coverage ensure international competence and local delivery. Maintaining strong working relationships with regulatory agencies allow them to successfully site and permit energy projects as well as cost-effectively develop, install, and maintain successful wind energy projects that generate an ongoing return on investment.

**Tetra Tech** | [www.tetrattech.com](http://www.tetrattech.com)

**Booth 1821**



**Wind monitoring & automation solutions**

Bachmann offers innovative automation solutions for the onshore and offshore wind energy sector. Their integrated condition monitoring systems (CMS) offer continuous acquisition of turbine conditions by measuring and analyzing meaningful physical variables, including vibration, temperature, lubricants, etc. CMS can provide important information to detect failure hazards early on, so maintenance tasks can be planned in advance. Bachmann also offers wind farm networking, which enables a central control room connection, as well as a wind library/template and retrofit solutions to ensure efficient engineering for wind turbines. Their system solutions are safe, flexible, and modular, helping to save 200 million tons of CO<sub>2</sub> each year.

**Bachmann electronic** | [www.bachmann.info](http://www.bachmann.info)

**Booth 2601**



### Bolt securing systems

The Nord-Lock Group manufactures wedge-locking washers designed to secure bolted joints with tension instead of friction, keeping bolts tight even when subjected to extreme vibration and dynamic loads. Also available are Superbolt multi-jackbolt tensioners (MJTs) designed to eliminate unsafe and time consuming bolting methods. MJTs replace or retrofit existing nuts and bolts, and only require hand/air tools for installation and removal of any size tensioner.

**Nord-Lock, Inc.** | [www.nord-lock.com](http://www.nord-lock.com)  
**Booth 4012**



### Structural bolting

Cooper and Turner provides a wide range of hot and cold formed fasteners for the wind power market for use in tower construction, nacelles, and foundations. They operate their own production sites in the US, Europe, and Asia; manufacturing high-strength bolting up to 4" diameter (M100) in-house, and adhering to local and international standards. They also have licensed coating and lubrication facilities on premises. The certified, in-house testing facilities include tensile testing with 4,000 kN capacity, torque vs tension testing equipment capable of testing bolts up to M80, and grain and structural analysis.

**Cooper and Turner Limited**  
[www.cooperandturner.co.uk](http://www.cooperandturner.co.uk)  
**Booth 3406**



### Blade enhancement system

3M has developed a maximum performing, highly reliable, and quick-to-install aerodynamic enhancement system: 3M Wind Vortex Generators. The blades of large, pitch-regulated wind turbines often have sub-optimal aerodynamic properties at the root, frequently leading to airflow separation and negatively impacting wind turbine efficiency. Each Vortex Generator is tailored to a specific blade type, and is designed to improve blade performance by energizing the flow around the surface. This reduces flow separation and increases the turbine capability. Made of a highly durable thermoplastic with dimensional stability and strength, this product provides superior weathering resistance. Furthermore, Vortex Generators are equipped with 3M Acrylic Foam Tape, which provides excellent durability and holding power in spite of the long-term fatigue and harsh environmental conditions the wind blades are faced with.

**3M Wind Energy** | [www.3m.com/wind](http://www.3m.com/wind)  
**Booth 4004**



### Gear Oil

Kluber Lubrication's Kluebersynth GEM 4-320 N is a synthetic gear oil that is highly tuned for wind turbines. The performance of this oil has been validated with numerous lab tests as well as operation in the field. Synthetic base stock covers a wide range of temperatures with long service life while additives impart high resistance to wear and foam. The formulation reaches the highest levels of protection against corrosion, scuffing, and micro-pitting. Converting to Kluebersynth GEM 4-320 N is easily accomplished by utilizing a proven process coupled with a high-performance cleaner.

**Kluber Lubrication NA LP** | [www.klueber.com](http://www.klueber.com)  
**Booth 4622**



### Wind turbine slip rings

Moog slip rings provide the performance and quality needed in demanding environments. Wind turbines require reliable transmission of power and data signals from the nacelle to the control system for rotary blades. Costly downtime is eliminated by using fiber brushes and robust mechanical components in the slip ring design. Moog developed and patented the fiber brush technology for slip rings. In addition, Moog provides direct replacement pitch control slip rings for numerous wind turbines. Advantages include: maintenance-free operation for 100 million revolutions; minimal wear debris generation; no lubrication required; wide operating temperature, and lower life-cycle cost.

**Moog Inc.** | [www.moog.com/wind](http://www.moog.com/wind)  
**Booth 4204**

## 34.5 kV Vacuum Circuit Breakers & High Speed Grounding Switches for Wind Power Substations



Visit us at WINDPOWER 2015  
**Booth #3029**

### VDH/GSMI® Series

**Combined vacuum circuit breaker and high-speed, mechanically-interlocked grounding switch rated 38 kV, 1200 A, 25 / 31.5 / 40 kA**

A unique and patented circuit breaker specially designed for application in wind energy collection circuits were 34.5 kV radial feeders are used to collect the power output of the individual wind turbines. It totally replaces traditional use of grounding transformers combined with conventional circuit breakers improving TOV mitigation and reducing costs.

### VDH Series

**Vacuum substation circuit breaker up to 38 kV, 3000 A, 40 kA**

This series is particularly used in wind power substations as main breaker, bus-tie breaker and capacitor bank breaker.



**EMA Electromechanics, LLC**  
 16 Industrial Drive, Sweetwater, TX 79556  
 (325) 235-8000 • [contact@emaelectromechanics.com](mailto:contact@emaelectromechanics.com)  
[www.emaelectromechanics.com](http://www.emaelectromechanics.com)



### Power output upgrade

Mersen's experience in the protection of electrical rotating machines enables them to offer unique solutions to protect frequency converters, turbines, controls, and other electrical equipment from the nacelle to the grid connection. The SR13-10 is an upgrade to one of the most common wind turbine generators in North America where the additional work load due to up-rating can sometimes exceed the capabilities of the existing unit. Requesting more power from existing machines requires an understanding of the technical implications and the exacting requirements of such demands. Mersen has responded by providing verifiable and workable solutions supported by intense R&D to the satisfaction of major OEM's and Power Utilities worldwide. Field tests have verified the designs which are based on sound technical expertise and a true working knowledge of the various applications.

**Mersen** | [www.mersen.com](http://www.mersen.com)

**Booth 3401**



### Flexible braid connectors

ILSCO's Flexible Braid electrical connectors for power and grounding applications are UL Listed and CSA Certified. Flex braid consists of high-quality, tin-plated copper braid with seamless copper tube ferrules stamped on the ends. The ferrules have rounded, smooth edges to prevent chaffing of the braid strands. ILSCO's Flexible Braid connectors are ideal for grounding, and in applications where vibration, expansion, and contraction exist, including: generators, turbines, and wind applications.

**ILSCO** | [www.ilSCO.com](http://www.ilSCO.com)

**Booth 5108**



### Inspections, analysis, & technical services

Frontier Pro Services provides technical services to the wind industry, specializing in physical turbine inspections, including the tower sections and blades, but focusing on drivetrain borescope inspections. Their certified inspectors have completed more than 30,000 individual gearbox inspections on more than 41 wind turbine platforms. Frontier Pro Services offers turbine commissioning services, solar and substation expertise, and perform composite blade repairs backed by their patented Dynamic Rotor Balance technology. They also provide wind turbine specific vibration monitoring hardware and integrated vibration analysis software systems, designed by their own vibration analysts, CME engineers, drivetrain experts, and turbine operators. Moreover, Frontier Pro Services provides oil and grease analysis, including wear debris and spectrographic analysis.

**Frontier Pro Services**

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

**Booth 5324**



### Slip ring modules

BGB Technology Inc. manufactures slip ring modules, slip ring assemblies, and Fiber Optic Rotary Joints (FORJ) for use within wind turbines. Applications include generator slip rings and brush holder assemblies, as well as hub and pitch control slip rings and shaft grounding systems. To accommodate the levels of data now required in modern pitch control applications, BGB also offers power and signal data pitch control slip rings with integrated fiber optic rotary joints (FORJ). These slip rings are available with sealed enclosures and heating systems to operate within all climatic conditions.

**BGB Technology Inc.**

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

**Booth 5103**



### Gear oil exchange system

Sage Oil Vac Wind offers the Gear Oil Exchange System (GOEX) in 4 different configurations; skid, open trailer, enclosed trailer, and an offshore unit. The "19394" open-trailer GOEX is equipped with two 390 gallon tanks; one tank for used oil, and the other for new oil. There are two additional 120 gallon tanks that are used to store, flush, and rinse oils. The "19394" is also available with an onboard 3-micron filtration unit and a heat exchange system; one dual reel, and one single reel that contain three 330 ft (100 m) hoses, and a containment pan that can hold up to 110% of onboard oil. Available upgrades include: air or electric driven reels, filtration for rinse and flush oils, remote start, and more.

**Sage Oil Vac** | [www.sageoilvac.com](http://www.sageoilvac.com)

**Booth 3719**

**The Port of the Lone Star State**

**We're a fan of wind.**

With superior logistics for wind components, a 45-foot channel authorized and permitted for 52', direct vessel-to-rail, three Class 1 rail on site, and dockside truck access, we get straight to business. Call your Texas Partner.

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f t in g+ y



Photo courtesy of: Atlas Copco Gas and Process | [www.atlascopco-gap.com](http://www.atlascopco-gap.com)

# 2015 GEOTHERMAL BUYERS GUIDE

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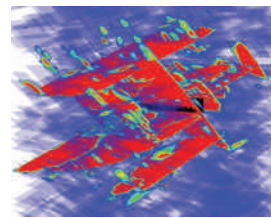
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[www.ene.com](http://www.ene.com)



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

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Webco Industries manufactures LaserLine seam-welded nickel alloy, duplex, and stainless steel coiled tubing, including capillary strings for scale and corrosion inhibition in geothermal wells. Tube sizes range from: 0.250 to 1.5 OD; wall thickness from 0.035 to 0.125; and lengths can be up to 12,000 meters or longer. Product specifications and process requirements can be met by tailoring material grades and customizing to specification, including limiting orbital welds.

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



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

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**Geothermal Institute**

The Geothermal Institute is hosted in the Faculty of Engineering at the University of Auckland. Staff spread across the university carry out geothermal energy related research, education, consulting, and training programs, while the Geothermal Institute coordinates the expertise. It also provides R&D, testing and laboratory services, commercial and consultancy services, education and training, as well as it coordinates the post-graduate geothermal programs.

[www.geothermal.auckland.ac.nz](http://www.geothermal.auckland.ac.nz)

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



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Geologica Geothermal Group provides high-quality, global geothermal resource exploration, development, and assessment services. They also offer environmental consulting services for private and public sector clients. Technical expertise includes: geology; hydrogeology; geochemistry; geophysics; data management; GIS; remote sensing; and project permitting and regulations. Geological Geothermal also provides environmental services, such as reservoir assessment and management, environmental science, as well as geotechnical and civil engineering services.

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



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## GEOTHERMAL EQUIPMENT (suppliers/manufacturers): Large-scale projects



### Emerson Process Management – Rosemount Division

Emerson Process Management specializes in geothermal, main steam line, differential pressure (DP) flow metering. Their hot-tap installation makes insertion and retraction possible without a line shutdown. It can also be adapted for an auto-matic line purge in high sulfur areas. Plus, enhanced electronics can provide wire-less monitoring, including process diagnostics and system health, mass flow out-put with temperature and pressure compensation, totalization, and more. [www.rosemount.com](http://www.rosemount.com)



### Hudson Products Corporation

Hudson Products provides large-scale, air-cooled condensers for use in the power cycle for organic rankine cycle (ORC) designs. Through years of experience and continuous innovation, Hudson Products has become a pioneer in the geothermal industry, developing internationally recognized trademarks, such as Fin-Fan Air-Cooled Heat Exchangers, Hy-Fin Extruded Finned Tubing, and Tuf-Lite II and Tuf-Lite III FRP Axial Flow Fans for air coolers and cooling towers. Hudson Products also offers airflow testing of equipment, vibration analysis, noise analysis, condition monitoring, and project start-up services. [www.hudsonproducts.com](http://www.hudsonproducts.com)



### Nash, a Gardner Denver Product

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A BS&B rupture disk and safety head installed at the inlet of safety relief valve.



S-90™ Rupture Disk  
(activated disk on right)



**BRUSH Turbogenerators Inc.**

BRUSH are an original equipment supplier of steam and gas turbine-driven electrical generator equipment for industrial, utility and process applications. All generators are factory tested, reducing onsite testing and commissioning time. Direct-air TEAAC (air to air) and TEWAC cooling is available in most powers. BRUSH also supplies various design solutions with special features required for geothermal applications. They can provide generator and control installation, as well as commissioning and after-market support services.

[www.brush.eu](http://www.brush.eu)



**L.A. Turbine**

L.A. Turbine delivers turboexpander (TBX) design, manufacturing, and testing of application-specific, highly engineered TBXs used in geothermal power generation and industrial power recovery applications. TBX configurations include expander-compressor, generator, dyno (brake), and expander compressors with active magnetic bearing units. TBXs range from 3 kW to 14 MW, are capable of handling up to 3000 PSIG of pressure, run shaft speeds up to 105,000 RPM, and can endure temperatures between -195° C (-320° F) and 260° C (500° F).

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

**GEOTHERMAL HEATING & COOLING SYSTEMS**



**Bosch Thermotechnology**

Designed specifically for the new construction and the replacement/retrofit markets, the small footprint LV Split System heat pump from Bosch Thermotechnology comes in eight sizes: from 1.5 through to 6 tons. The geothermal heat pump split system comes in two parts that can individually replace and work with existing HVAC system, or both can be used in tandem for a full solution. The LV Split System also permits the condensing section to be placed remotely from the air handler section.

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



**REHau Construction, LLC**

The RAUGEO PEXa ground-loop heat exchange system is a high-efficiency energy source for heating and cooling. PEXa piping offers superior flexibility and abrasion resistance compared to HDPE, while double U-bends reduce bore-hole foot-age by up to 30%. Secure EVERLOC ASTM F2080 compression-sleeve fittings and balancing manifolds complete the system. Single and double U-bends are available in 1" and 1-1/4". CTS are offered in lengths up to 510 feet (155m).

[www.na.rehau.com/raugeo](http://www.na.rehau.com/raugeo)



**Fuji Electric**

Fuji Electric's low-voltage, FRENIC-HVAC, slim-type inverters deliver optimal control and energy savings. The AC drives provide simple and cost-effective solutions for industrial and commercial standalone motor control applications, including for geothermal pumps, fans, and HVAC systems. The FRENIC-HVAC series offers key features, including: a real-time clock; PID controls; torque vector control; removable keypad; fire mode; and filter-clogging prevention functions. Fuji Electric also designs and builds HMI operator panels, motor starters, and instrumentation, such as transmitters, controllers, and meters for the geothermal industry.

[www.americas.fujielectric.com](http://www.americas.fujielectric.com)



**WaterFurnace International, Inc.**

The Envision2 NXW Chiller provides water heating and water cooling for a range of geothermal applications. Available in 10 to 50-ton capacities, the NXW will fit through most doors and features external fork truck lifting points for easy installation. Designed to perform to the highest standards in the industry, the NXW is used for pools, commercial aquariums, radiant floor heating, ice melt, chilled water applications, industrial process water, or to provide precisely heated or cooled water for fan coils or other applications. It's equipped with a new and improved control box, providing clean wiring and easy accessibility. The control box includes an emergency shutdown button and a user interface to aid in set-up and diagnostics. The refrigeration circuit has also been updated with suction and discharge line vibration absorbers and larger, more efficient heat exchangers.

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

**POWER PLANTS | POWER PLANT DESIGN & CONSTRUCTION**



**AMSA Inc.**

AMSA provides organic deposit and corrosion control products for cooling in industrial applications. They offer DTEA II, which is a safe, water-based, phosphonate-free product that provides sulfur control for geothermal cooling towers. DTEA II also minimizes the use of biocides by reducing the accumulation of organic deposits. It comes with an environmentally friendly profile, due to its quick degradation rate prior to release, when used under common cooling tower treatment conditions. Overall, DTEA II reduces operational costs by diminishing corrosion and improving equipment lifetime. It is sold under the BCP 5000 series label for geothermal applications. Proprietary and custom formulations, as well as private labels, are also produced by AMSA.

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



**NAES Corporation**

NAES provides operations and maintenance (O&M) services to facilities engaged in the production of renewable electricity, including for geothermal energy. They offer management for all O&M services, including: development and implementation of customized operation's programs; management of safety and environmental compliance programs; planning and oversight of major maintenance activities; as well as planning and management of infrastructure support services.

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



**Turboden Srl**

Turboden designs, produces, and provides installation and maintenance of organic rankine cycle (ORC) turbogenerators for the combined generation of electric power and heat employing renewable resources and waste heat recovery. ORC technology can be efficiently applied to generate electric power from medium-to-low enthalpy geothermal sources, providing solutions up to 30 MW per single generator, as well as modules scalable for larger plants.

[www.turboden.eu](http://www.turboden.eu)

**GEOTHERMAL EQUIPMENT (suppliers/manufacturers): Small-scale for home/business**



**A-T Controls**

A-T Controls provides solutions for demanding geothermal applications, providing a variety of durable valves for tough environments. The A-T Controls M Series Metal-seat Ball Valve, for example, is designed for use in severe services, such as high-temperature and high-pressure projects. It can be used in temperatures of up to 1100° F (593° C). Their V-Series Segment Control Valves range in size from 2" to 12", and support temperatures up to 600° F (315.5° C). Plus, A-T Controls' Power-seal, High-performance Butterfly Valve comes with a pneumatic, spring-return actuator or double-acting actuator. All A-T Control valves are quickly and easily automated.

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



**Geothermal Development Associates**

Geothermal Development Associates (GDA) is a privately held US company that specializes in geothermal power and direct-use applications worldwide. Their staff of engineers, geologists, and geoscientists have the capability to oversee projects at every stage—from initial resource exploration and well-testing to the design, supply, and commissioning of a new power plant.

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

## MONITORING EQUIPMENT | DATA MAPPING



### Campbell Scientific, Inc.

Campbell Scientific offers packages for geothermal resource assessment and energy monitoring. These systems, such as their Utility-Met100, accurately measure a variety of onsite parameters, including: ground-water level and temperature; thermal gradient profiling; well-casing temperature profile; and integrity; water quality and flow. Campbell Scientific also makes programmable, field-based dataloggers with DNP3 support. These are known for quality measurements, versatility, and reliability, even in harsh and remote environments.

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

## POWER PLANTS | POWER PLANT DESIGN & CONSTRUCTION



### SNC-Lavalin Thermal Power

SNC-Lavalin Thermal Power has decades of specialized experience in the design, construction, and maintenance of high-efficiency geothermal and thermal power plants. They provide a one-stop shop for thermal power solutions. Services include: planning; pre-feasibility and feasibility studies; engineering, procurement, construction (EPC); as well as start-up and commissioning of power facilities. They're also ISO 9001 and ISO 14001 certified, and are committed to the highest quality and environmental management system standards.

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

## OTHER - Overpressure relief devices/rupture disks



### BS&B Safety Systems, LLC

BS&B Safety Systems' Reverse Buckling disk provides a pressure relief solution for burst pressures ranging from a few inches of water column / a few millibar to over 70,000 psig / 488 bar. They offer extensive application expertise and a variety of designs for geothermal applications including rupture disks for safety relief valve isolation or stand-alone protection of: steam and brine piping, binary fluid systems, separators, and flash vessels.

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

## DTEA II™ Sulfur Deposit Removal & Control in Cooling Towers



Geothermal energy systems experience a number of unique operational problems. Fluids produced from geothermal reservoirs include steam, brine and a variety of non-condensable gases (CO<sub>2</sub>, H<sub>2</sub>S, CH<sub>3</sub>, N<sub>2</sub>, etc.).

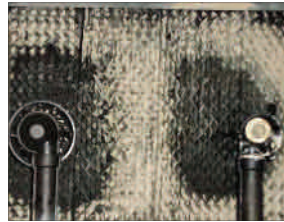
In water-cooled systems with direct contact condensers, elemental sulfur fouling in the cooling system can be a significant problem.

**H<sub>2</sub>S oxidation within the aerobic cooling water environment results in the formation of sulfur deposits in:**

**Condensers, Flow-lines, Tower fill and Spray nozzles above the fill.**



Sulfur deposit accumulation in flow-lines.



Sulfur fouling in the fill diverts water flow to less fouled zones.



Sulfur fouling on and in the spray nozzles results in uneven water distribution over the fill.

**End result:**  
Limited electricity generation by the facility and costly offline clean-up.

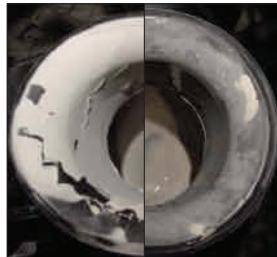
### The Solution

DTEA II™ is well-known as an organic deposit penetrant and dispersant. In rigorous testing in large geothermal plants in Mexico and the Philippines, DTEA II has been shown to be the only chemistry effective in removing pre-existing hard elemental sulfur deposits, and in preventing the formation of new elemental sulfur deposits.

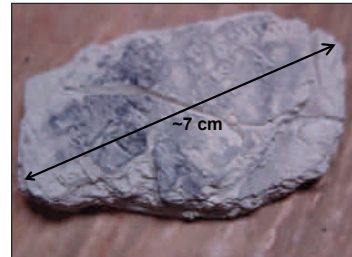
In a system in which elemental sulfur deposits have formed, DTEA II\* attacks the deposits, causing disaggregation and release of the deposits from system surfaces. Shown below are:



Sulfur cylinder from a flow-line, expelled through a nozzle orifice onto the upper surface of the tower fill.



**Before/after** DTEA II treatment comparison of a nozzle orifice.



A piece of sulfur deposit detached from the tower structure.

**End result:**  
Improved cooling system efficiency.

For a full case study or more information contact us at **888-739-0377** or [www.amsainc.com](http://www.amsainc.com)

\*Patent pending and patents issued



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AMSA, Inc. manufactures DTEA II™ Chemistry.  
AMSA, Inc. exclusively serves industrial water treatment service companies.

# Paving the Road to a Carbon-negative Future

## Biomass, carbon-capture & the western U.S.

By Robert Sanders



A carbon dioxide injection well  
(Photo courtesy of CO<sub>2</sub>CRC)

Biomass power accounts for roughly half of all the renewable energy produced in the United States and, currently, the US uses more of it than any other country in the world. Impressive stats, but production can be good and bad—a double-edged sword of sorts, depending on how it’s sourced and generated.

Biomass can be produced in ways that reduce global warming pollution or in ways that increase it. Unfortunately, much of the biomass used commercially comes from resources that aren’t sustainable. The challenge for the renewables’ industry, therefore, is to ensure that biomass energy is created in ways that protect the environment and that reduce global warming and pollution.

As the Natural Resources Defense Council’s site on Renewable Energy for America points out: “Biomass energy should do the job better than the fossil fuels it replaces.” ([www.nrdc.org](http://www.nrdc.org))

By definition, biomass is biological material that’s carbon-based, derived from living or recently living organisms. Generating electricity from urban waste or sustainably sourced forest and crop residues, is seen as one strategy for reducing greenhouse gas emissions. Herein, biomass is considered carbon-neutral: it produces as much carbon as the plants suck out of the atmosphere.

Furthermore, a recent UC Berkeley study shows that if biomass electricity production is combined with carbon capture and sequestration in the western United States, power generators could actually store more carbon than they emit—thereby, making a critical contribution to an overall zero-carbon future by the second half of the 21st century.

### Understanding CCS

Carbon capture and sequestration (also referred to as carbon capture and storage, or CCS) involves a set of technologies, with the aim and process of capturing waste carbon dioxide (CO<sub>2</sub>) from large sources, such as fossil fuel power plants. The intent is to deposit and safely store it, thereby preventing the release of large quantities of CO<sub>2</sub> into the atmosphere.

According to the US Environmental Protection Agency (EPA), CCS is a three-step process\* that includes:

1. Capture of CO<sub>2</sub> from power plants or industrial processes;
2. Transportation of the captured and compressed CO<sub>2</sub> (usually in pipelines); and
3. Underground injection and geologic sequestration of the CO<sub>2</sub> into deep underground rock formations. These formations are often a mile or more beneath the surface and consist of porous rock that holds the CO<sub>2</sub> and prevents it from migrating upward.

By capturing carbon from burning biomass—termed bioenergy with carbon capture and sequestration (BECCS)—power generators could become carbon-negative even, while retaining gas- or coal-burning plants.

According to study leader, Daniel Sanchez, a graduate student in UC Berkeley’s Energy and Resources Group, the carbon reduction might even offset the emissions from fossil fuel used in transportation.

“There are a lot of commercial uncertainties about carbon capture and sequestration technologies,” Sanchez admitted. “Nevertheless, we’re taking this technology and showing that in the Western United States 35 years from now, BECCS doesn’t merely let you reduce emissions by 80%—the current 2050 goal in California—but gets the power system to negative carbon emissions: you store more carbon than you create.”

In fact, BECCS may be one of the few cost-effective, carbon-negative opportunities available to mitigate the worst effects of anthropogenic climate change, according to energy expert Daniel Kammen, who directed the research. This strategy will be particularly important should climate change be worse than anticipated, or should emission reductions in other portions of the economy prove particularly difficult to achieve.

“Biomass, if managed sustainably can provide the ‘sink’ for carbon that, if utilized in concert with low-carbon generation technologies, can enable us to reduce carbon in the atmosphere,” explained Kammen, a Professor of Energy in UC Berkeley’s Energy

and Resources Group and director of the Renewable and Appropriate Energy Laboratory (RAEL), where the work was conducted.

#### Covering the costs

Though the financial costs and the technological hurdles of capturing carbon from biomass power plants and compressing it underground are massive, the Intergovernmental Panel on Climate Change (IPCC)—the major international body studying the issue—assumes that it will become viable in 50 years.

The IPCC has even included it in their long-term predictions: “BECCS technologies figure prominently in the IPCC’s recent Fifth Assessment Report (AR5), which focuses in part on mitigating climate change, but previous models examining BECCS deployment have not investigated its role in power systems in detail, or in aggressive time frames,” said Kammen, who also serves as a coordinating lead author on the IPCC.

To remedy this, the UC Berkeley scientists used a detailed computer model they developed of the west’s electric power grid, so as to predict deployment of BECCS in low-carbon and carbon-negative power systems. The model of western North America was developed in the RAEL lab, and is referred to as SWITCH-WECC.

SWITCH can be used to study generation, transmission, and storage options for the US, west of the Kansas/Colorado border, as well as in northwest Mexico and the Canadian provinces of Alberta and British Columbia.

The study found that BECCS, combined with aggressive renewable energy deployment and fossil emissions reductions, can enable a carbon-negative power system in western North America by 2050, with up to 145% emissions reduction from 1990 levels. Such reductions can occur with as little as 7% of the power coming from BECCS.

In most scenarios explored, however, the carbon offsets produced by BECCS are more valuable to the power system than the electricity it provides.

This study relies on a detailed spatial and temporal inventory of potential bioenergy feedstocks, such as forest residues, municipal solid waste and switchgrass, as well as complimentary renewable energy, such as from wind and solar power. Sanchez noted that burning biomass as part of BECCS may have a greater impact on greenhouse gas emissions than using these same feedstocks for biofuels, solely because of the possibility of carbon capture.

“We’re evaluating a technology with some uncertainty behind it, but we are saying that if the technology exists, it really sketches out a different kind of climate mitigation pathway than what people are assuming,” said Sanchez.

\* Learn more at [www.epa.gov/climatechange/ccs](http://www.epa.gov/climatechange/ccs)

Sanchez, Kammen, and their colleagues published their analysis of BECCS in western North America, in the online journal “Nature Climate Change: Carbon capture & sequestration.”

Co-authors of the study are James Nelson of the Union of Concerned Scientists, Ana Mileva of Energy and Environmental Economics (E3), and Josiah Johnston of RAEL and the Energy and Resources Group. The study was funded by the National Science Foundation, the California Energy Commission, and the Link Energy Fellowship.

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# Keeping Score

## Ranking airlines for biofuel

By Debbie Hammel

As government and industries are researching new and innovative ways to reduce pollution and greenhouse gases on a national and global level, the aviation sector has also begun making strides in adopting environmental changes.

Sustainable aviation biofuels, or biojet fuels, are one of the most promising solutions to meet the industry's carbon emissions reduction goals. Change isn't always easy though, and some airlines are fairing better than others with incorporating these new fuels into their fleets.

### Biofuel scorecard

More sustainable biofuels allow airlines to ease their dependence on fossil fuels and the volatility of oil and fuel prices and, most significantly, reduce their carbon footprint. And, recently, airlines got assessed on how they measured up when it came to their commitment to a better environment.

The Natural Resources Defense Council's (NRDC) presented the first-of-its-kind Aviation Biofuel Sustainability Scorecards, which rated individual airlines on just how well they implemented and sourced sustainably produced biofuels.

The top-scoring carriers on the Sustainability Scorecards were:

- Air France/KLM;
- British Airways;
- United Airlines;
- Virgin Atlantic;
- Cathay Pacific, and
- Alaska Airlines.

As the world rises to the challenge of curbing climate change and cutting carbon pollution, addressing air travel pollution must be part of this mix.

### The stats

Air travel emits more than 650 million metric tons of carbon pollution annually—that's the equivalent of pollution from 136 million cars—making the increased use of sustainable biofuels a critical step in reducing the industry's carbon footprint.

Fortunately, the aviation sector has become fairly proactive about this issue, and an industry-wide increase in the use of sustainably produced biofuels is on the horizon. In the past five years, more than 40 commercial airlines around the world have flown an estimated 600,000 miles—powered, at least in part, by biofuels.

Lufthansa has completed a study of the long-term effects of aviation biofuels on plane engines, and they found no adverse impacts. To date, KLM has conducted 26 long-haul flights, demonstrating that it's possible to organize and coordinate a complex supply chain, while making regularly scheduled flights on aviation biofuel blends.

Although some of the major industry players have made impressive progress in terms of implementing sustainability commitments this past year, there's still more to do—particularly, in the face of biofuel competition.

### Prioritizing risks

As a newly released report from the World Resources Institute (WRI) reveals, turning plant matter into liquid fuel or electricity can be an environmentally risky and inefficient approach to meeting global energy demands.

Increasing competition for land—for the production of food, feed, carbon storage, and other ecosystem values—means that biofuel feedstocks will need to be sustainably produced from either waste (e.g. agricultural residues) or crops that don't compete with food production or other critical services (e.g. cover crops).

As a result, supply of these types of feedstocks is likely to be limited and there will be competition for related biofuel production. Aviation has fewer alternatives for reducing its carbon emissions as compared to, for example, ground transportation. It's, therefore, important that the industry make a powerful stance in its commitment to sustainability, ensuring it's a priority when it comes to biofuels. One way it has done so is via the adaptation of credible, sustainability standards, which are now fully operational in the marketplace.

### The future

The aviation industry has established a commitment to reducing emissions. Low-carbon fuels will play a key role in the industry's efforts to hold its carbon emissions steady after 2020. The intent is to cut net carbon emissions to half of the 2005 level by 2050.

In support of these efforts, the Roundtable on Sustainable Biomaterials (RSB) has adopted related industry standards. RSB is an international initiative that brings together a variety of stakeholders to help ensure the sustainability of biomass and biomaterial production and processing. They also provide a certification system based on sustainability standards, which encompasses environmental, social, and economic criteria.

However, to truly deliver on the promise of long-term sustainability, the aviation industry must leverage its market power. Airlines need to do more than agree to robust sustainability standards in biofuel sourcing by implementing these commitments through contracts with their suppliers. Such market signals are critical in driving adoption of sustainable practices through the supply chain.

Adoption of credible, third-party sustainability certification systems are necessary to ensure that the emerging aviation biofuels market is providing fuels that are sourced sustainably—and, ones that aren't competing with food production; causing severe damage to land, water, air quality, wildlife, and local communities; or generating more climate pollutions than their petroleum counterparts.

Currently, biofuel operators are making long-term design, employment, and operational decisions to optimize production, and many are now focusing on aviation as a key market.

By implementing clear sustainability standards—that are independently audited and verified through certification programs, such as the RSB—helps to ensure biofuels build this market into their planning and operations. It also serves as an incentive for upstream biofuel operators to pursue their own compliance and certification.

It's crucial that the emerging aviation biofuel industry be built on a foundation of sustainability. Biofuels produced within this framework can provide environmental, social, and economic benefits. Without these standards, biofuels can cause severe damage to land, water, air quality, wildlife, and local communities. They can even generate more greenhouse gases than their petroleum counterparts.

As representatives of the aviation industry as a whole, airlines must also follow suit, adopting credible and independent sustainability certification for 100% of their biofuel sources. Working together, it's possible to launch a new, truly sustainable aviation fuel industry—and, one that ensures top scorecard rankings across the board.

*Debbie Hammel is a senior resource specialist at the Natural Resources Defense Council's (NRDC) Land & Wildlife Program.*

**Natural Resources Defense Council (NRDC)**

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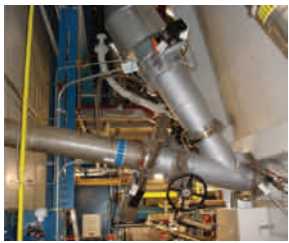


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Jeffrey Rader, a brand of TerraSource Global, offers material handling and size reduction equipment to unload, convey, screen, and crush bulk materials. Jeffrey Rader material handling equipment is used in the multiple stages of biomass energy generation, from truck/rail receiving through the metered in-feed into the boiler. The firm's products and experience can support applications, such as circulating or bubbling fluidized bed boilers, stoker or moving grate/floor boilers, cyclone and corner fired boilers, and wall fired pulverized coal boilers. In unison with that, they also have experience in the processing and handling of biomass and alternative fuels, including: wood chips; waste wood/C&D material; bark/hog fuel; sawdust; straw; sludge; tire derived fuel; pellets; briquettes; coal; oil shale; and others. With years of experience in screening, processing, and handling biomass fuels, Jeffrey Rader offers a wide range of reliable solutions for biomass needs.

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### Micro-chipper drum

A specialized micro-chipper drum from Bandit Industries is available for select Bandit whole tree chippers. This micro-chipper drum features double the knives found on a standard drum, delivering twice the cuts per rotation to produce wood chips as small as 1/4" (64cm). Bandit's micro-chipper drum is offered on the Models 2590, 3090, 3590, and is standard on the 3590XL. Bandit micro-chippers produce chips that are fine and uniform in size. The 3590 produces the majority of material used to produce industrial pellets, which are burned in lieu of coal in coal-fired boilers. Coupled with Bandit's redesigned Card Breaker system, oversized chips are broken down even more as they enter the discharge, creating a more uniform chip. The Card Breaker is easy to install and service, limiting downtime.

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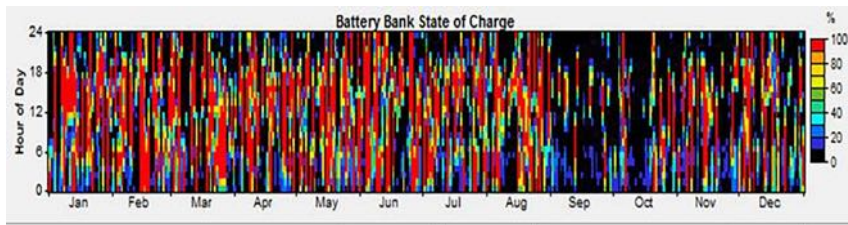
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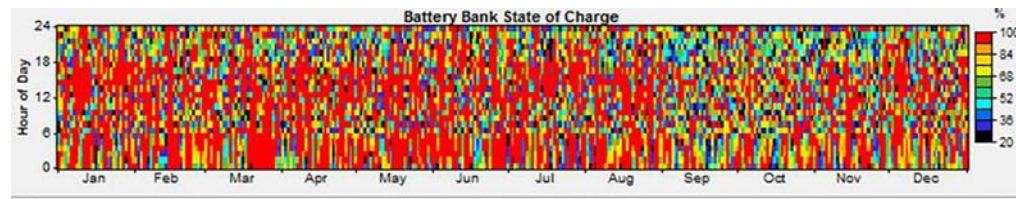
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# Powering Microgrid Applications

With renewable energy & battery storage By Craig Wilkins



**Image 1.** Homer model showing the near, top of charge state, where the battery commonly resides



**Image 2.** Homer model showing the balanced, charge state of the battery, greatly increasing the useable energy

**THERE ARE PROLIFERATIONS OF TECHNOLOGY** contributing to the evolution of microgrids. However, most microgrids rely heavily on expensive diesel generators. According to IHS research, gen-sets using diesel fuel accounted for the vast majority of total sales in the market in 2013, with \$12.1 billion, or approximately 75.6% of revenues (as well as 81.6% of units shipped).

When it comes to a more sustainable energy sources, technology has also come a long way. And, there is good news: diesel consumption in the form of microgrids can be reduced by as much as 75% or more with the incorporation of a well-designed hybrid, renewable generation and energy storage platform.

The combination of low-cost power conversion systems, based on newer insulated-gate bipolar transistor (IGBT) inverter technology—combined with the rapidly falling prices of renewable energy generation, such as wind and solar power or even biomass—are greatly contributing to the viability of energy storage as a cost-effective solution for microgrid applications.

This, in turn, is making renewable energy microgrids an attractive alternative to fossil fuel-based ones. However, to be successful in the field and on a project site, a stable microgrid that relies on renewables must also meet the heavy-duty cycle demands with an effective battery.

## The battery

Grid-level storage, when used in microgrid applications with a high level of renewable generation, requires batteries with a variety of important features.

These primarily include:

- High power;
- High capacity;
- Rapid cycling between charge and discharge;
- An ability to be fully discharged multiple times per day; and
- A cost-effective price point.

The duty cycles must be designed to minimize diesel fuel consumption by moving the diesel generator role of back-up power to the renewable/battery energy generators. Unfortunately, these duty cycles are hard on battery life, particularly with conventional batteries—which can experience a decreased lifespan anywhere between one-half to one-quarter of normal use.

Research has demonstrated that there are batteries with the right mix of power, capacity, rapid switching time, along with the ability to be deeply discharged without shortening life: namely, flow batteries. In particular, flow battery technology that incorporates a zinc-iron chemistry has been shown to eliminate the environmental and safety risks associated with using large batteries in remote, environmentally sensitive areas.

## The research

The configuration of energy storage systems and performance requirements in renewable microgrid applications must, simultaneously, be able to support the high variability and intermittency of the energy source, assist with ramp loads, and/morning and/or evening peak demand. In terms of economics, these technologies must have the capability of peak shaving for the morning and evening ramps, as well as fast-response applications, which require rapid cycling at all states of charge.

Ideally, the storage medium should be fully functional across the entire state of charge (SOC), with the ability to provide power equivalent to several full charges and discharges per day. And, as it turns out, these requirements fit quite nicely with modern flow batteries.

As one study demonstrates, mapping a two-megawatt (MW) energy storage system into a grid with wind energy, and 10,219,967 kilowatt-hours per year (kWh/year) of AC load, showed consistent utilization of the battery at the bottom of the charge, as well at the top, providing for available services across the entire SOC. A flow battery in this environment, therefore, provides a consistent capacity balance.

In contrast, other types of batteries, which don't have full access to the SOC (and, therefore, that must be mitigated with control software) tend to showcase a "weighting away" from the lower state of charges, so as to protect their own material structures. The storage medium, in this case, results in an imbalanced use of renewable generation into the grid. Either the battery is used minimally at the top of charge, or remains unavailable due to the bottom of charge (see Image 1).

Model	kWh/year	Battery	Renewable generation	Diesel
A	10,219,967	None	70 Wind turbines	1,600 kW
B	*	Plus *conventional battery	50 Wind turbines	Reduces use of peak diesel generation
C	*	Plus Flow Battery Zinc/Iron	40 Wind turbines	Further reduces the use of diesel generation

Table 1.

The following provides a breakdown, as demonstrated in Table 1.

- Model A: Model of a microgrid with 28 megawatt-hours per day (MWh/day) of AC load, and generation of a 3-MW nameplate of wind energy. This project includes one 4,200 kW diesel generator and one 1,600 kW diesel generator, yielding a system cost of anywhere from \$18 million to \$23 million.
- Model B: Installing a battery that has an adequate, fast-response capability, but limited energy storage to 70% SOC, reduces the numbers of wind turbines generation to 2.5 MW. It also reduces the use of peak diesel generation by 11%, and can decrease a system cost by 4% to 6%.
- Model C: Incorporating a flow battery with a zinc/iron system that has full capabilities, as well as access to the entire SOC, increases the amount of usable energy. This also decreases the number of wind turbines needed to 2.1 MW, cutting the use of diesel generation by 18%. By using renewable generation and a flow battery storage system, a microgrid can be optimized to achieve 75% savings, or greater.

It's worth noting that a microgrid can be further optimized by using a 2-MW/2-MWh alternative technology battery. But, the delivered energy cost would be higher because the battery is inherently limited in providing adequate load-shifting requirements, which are needed to support off-peak demands. A 2-MW/2-MWh flow battery, for example, is projected to provide 1,750,713 kWh/year energy input and 1,263,826 kWh/year energy output, for a levelized cost of energy (LCOE) of \$0.327/kWh. In contrast, an equivalent lithium-ion battery produces 649,386 kWh/year energy input and 506,898 kWh/year energy output, with a LCOE of \$0.391/kWh—a 20% increase over flow batteries (see Table 2).

Battery	Capacity/Production	Energy Input	Energy Output	Levelized Cost of Energy (LCOE)
Flow Battery	2-MW/2-MWh	1,750,713 kWh/year energy in	1,263,826 kWh/year energy out	\$0.327/kWh
Lithium-ion Battery	2-MW/2-MWh	649,386 kWh/year	506,898 kWh/year	\$0.391/kWh

Table 2

## Conclusion

Renewable energy generation offers sustained cost savings over traditional generation methods, such as with diesel generation. The addition of a storage device greatly enhances the stability of the energy generated, while greatly decreasing the cost of energy. Using advanced flow batteries provides an even greater mix of capacity, power, and long life to maximize such savings.

The long-life benefit of flow batteries, along with their ability to support deep discharges multiple times per day, provides evidence of their significance when used in energy storage applications. Simultaneously seeing 100's or 1,000's of rapid, short-duration charge/discharge cycles at partial states of charge increases their value.

And, this is especially true when it equates to a substantial return on investment (ROI) for a renewable energy project developer.

Craig Wilkins is the chairman of ViZn Energy Systems, Inc.

**ViZn Energy Systems, Inc.** | [www.viznenergy.com](http://www.viznenergy.com)

# Developing the natural gas cooling market

By John Cole, CEO Intellicochoice

**THE NATURAL GAS INDUSTRY** has clearly entered a new era. Through an ever-expanding natural gas supply resource base, the U.S. has adequate natural gas supplies to meet its needs well into the foreseeable future. As a result, consumers are enjoying very affordable and stable natural gas pricing.

On the other end of the spectrum though, as of 2014, Americans are now paying some of the highest electricity rates in history, and the cost burden of adding new electric generation capacity in many instances is not feasible. Electricity production in the U.S. has been declining since 2007, while some areas' electrical infrastructures are at such a full capacity, that they cannot expand and must incentivize local businesses and citizens to begin using alternative energy products to save electric grid capacity. Additionally, the aging of the power grid infrastructure is causing more outages and problems, and by one account, would cost \$107 billion by 2020 to fix and upgrade.

This dichotomy between the gas and electric industries has paved the way for new innovative technologies and products in the residential and commercial natural gas cooling market. As such, Americans are now taking notice of innovative and energy-efficient alternative technology and creating tremendous new opportunities for gas cooling businesses across the country.

Intellicochoice Energy, LLC (ICE) has begun to seize this opportunity by offering products in the U.S. natural gas cooling market. One of the most efficient and innovative products offered by ICE is the NextAire gas heat pump (GHP). The ICE NextAire commercial GHP can provide a good heating and cooling solution for many building owners. Not a new technology, this product has been evolving in the U.S. since the 1980s. Worldwide, there are over 700,000 GHP units installed, and the U.S. has only a fraction of these installations. Given the current natural gas price environment, and the higher electricity prices, the NextAire heating, ventilating and air conditioning (HVAC) system can reduce a building's space conditioning costs by as much as 50-80 percent. Also, when a natural gas heat pump is deployed, an electric utility can benefit through less utilization during peak summer periods.

The NextAire eight-ton units can function for up to 17 separate and distinct areas, while the 15-ton units can function for up to 33 separate and distinct areas of a building. In new construction, product lines can earn LEED points, which help satisfy local requirements for more green-oriented and environmentally responsible properties within communities. These units simply require standard electrical and gas infrastructure hookups available in most buildings, and they can be used for many construction areas including commercial, residential (above 3,000 square feet), schools, government, and military bases.

Public natural gas systems are capitalizing on these attractive statistics. Several public natural gas systems are working with ICE to develop the gas cooling market within their service areas. By focusing on return on investment for owners, value engineering, and HVAC contractor training and development, ICE understands it is critical to bring the right HVAC heating and cooling solution to clients.

Several public natural gas utilities that have installed a NextAire unit are below.

- **Okaloosa Gas District in Valparaiso, Fla.**, installed two 15-ton NextAire units in its corporate office in 2012. This 30-year-old corporate facility was in need of a complete HVAC system replacement. Reports now show substantial energy savings and efficiency for this 12,700 square foot facility.
- **City of Dublin, Ga.**, installed one 15-ton NextAire unit at its city hall in April 2014. This historic building utilizes over 30 tons of cooling and now has a section of the building where heating and cooling are delivered by the NextAire GHP. Included in the installation are 11 Daiken air handling units that create a multi-zone climate control solution for occupants. The Gas Technology Institute (GTI) has installed performance monitoring equipment at this site to get detailed performance data on the unit.
- **City of Statesboro, Ga.**, installed one 15-ton NextAire unit at a renovated city fire station in August 2014. This installation, also in need of multiple zoning, features zone temperature control and is

expected to provide up to 50 percent savings in heating and cooling costs.

In all of these projects, the public natural gas systems partnered with ICE in training contractors, developing case studies, and they all now plan to showcase the NextAire GHP to other building owners in their service areas. The process begins with a good HVAC solution and system, then develops with trained mechanical contractors, and eventually works its way into the building design community.

*"At locations all over the county, our clients are saving substantial dollars on their utility costs over what they would be paying with more conventional units. And with electric rates continuing to climb as fast as they are, natural gas rates staying relatively stable because of production increases, and given the quality of our NextAire product line, it makes a lot of sense for new and retrofit projects to consider the NextAire brand for their HVAC systems," says Tom Young, CTO and Founder of Intellicochoice.*

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# Geological Storage

## Holding hydrogen for electric vehicles & more

In the power market, the amount of electricity that can be generated is often relatively fixed over short periods of time, even if the demand is not. This is especially true for renewables, as the sun isn't always shining and neither is the wind always blowing. Not surprisingly, the energy storage industry has evolved over the last few years, converting energy from forms that can be difficult to store, into more economically storable and usable forms.

Usually, this involves a battery. However, when it comes to storing energy for the growing fuel cell and electric vehicle market, researchers have begun to study the possibility of geologic storage via the use of underground formations. Large-scale storage of low-pressure, gaseous hydrogen in salt caverns and other underground sites, for example, could be advantageous for transportation fuel and grid-scale energy applications.

According to a study\* recently released by the Sandia National Laboratories, and sponsored by the Department of Energy's Fuel Cell Technologies Office, geologic storage solutions can service a number of key hydrogen markets and offer several advantages over above-ground storage.

Case-in-point: Geologic storage of hydrogen gas could make it possible to produce and distribute large quantities of hydrogen fuel for the electric vehicle market. "[As] costs are more influenced by the geology available, rather than the size of the hydrogen market demand," explained Sandia Lab's Anna Snider Lord, the study's principal investigator.

Storage above ground requires tanks, which cost three to five times more than geologic storage, Lord said. In addition to cost savings, underground storage of hydrogen gas offers advantages in volume. "Above-ground tanks can't even begin to match the amount of hydrogen gas that can be stored underground," she said\*\*.

This research could provide a roadmap for further research and demonstration activities, such as an examination of environmental issues and geologic formations in major metropolitan areas, which could hold hydrogen gas.

### Advancing hydrogen's potential

Should the market demands for hydrogen fuel increase with the introduction of fuel cell electric vehicles, the United States will need to produce and store large amounts of cost-effective hydrogen from domestic energy sources, such as natural gas, solar, and wind power, acknowledged Daniel Dedrick, Sandia hydrogen program manager.

As Toyota, General Motors, Hyundai and others move ahead with plans to develop and sell or lease hydrogen fuel cell electric vehicles, practical storage of hydrogen fuel at large scale is necessary to enable widespread hydrogen-powered transportation infrastructure.

According to Dedrick, these storage options are required if the full potential of hydrogen for transportation is to be realized and attained.

Moreover, installation of electrolyzer systems on electrical grids for power-to-gas applications, which integrate renewable energy, grid services, and energy storage, will also require large-capacity, cost-effective hydrogen storage.

As cost and quantity wouldn't be a major issue, the massive quantities of hydrogen that can be stored in geologic features can subsequently be distributed as a high-pressure gas or liquid to supply the hydrogen fuel markets.

### Finding favorable storage locations

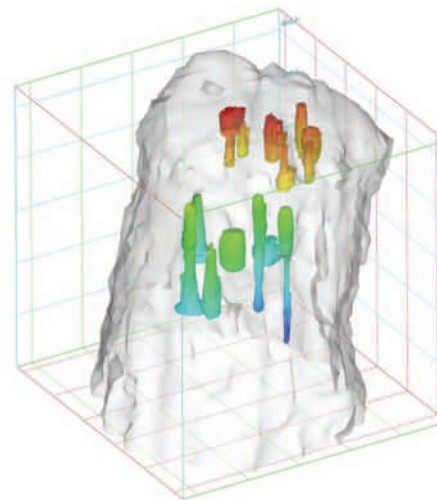
Although geologic storage may very well prove to be a viable option, several issues still need to be explored, said Lord, including permeability of various geologic formations.

For her study on geologic storage, Lord and her colleagues analyzed and reworked the geologic storage module of Argonne National Laboratory's Hydrogen Delivery Scenario Analysis Model (learn more at: [www.hydrogen.energy.gov/h2a\\_delivery.html](http://www.hydrogen.energy.gov/h2a_delivery.html)). To help refine this model, however, Lord studied storing hydrogen in salt caverns to meet peak summer driving demand for four cities: Los Angeles, Houston, Pittsburgh, and Detroit.

She determined that 10% above the average daily demand for 120 days should be stored. She then modeled how much hydrogen each city would need if hydrogen met 10%, 25%, and 100 percent of its driving fuel needs.

Los Angeles has three times the population of Detroit, and more than six-and-a-half times the population of Pittsburgh. But, the nearest salt formations are in Arizona, so Lord included the cost of getting the stored hydrogen from Arizona to Los Angeles.

Even so, Los Angeles' modeled costs are significantly less than those for Detroit and Pittsburgh. Salt formations in Arizona are thicker than those for Detroit and Pittsburgh, with larger and fewer caverns. As a result, Houston was found to have the best conditions of the four cities because the Gulf Coast offers large, deep salt formations.



*Salt caverns, such as the one depicted here, could provide a low-cost solution for the geologic storage of hydrogen. The colors in the illustration represent depth, with blue as the deepest part of the cavern and red the most shallow (Image courtesy of Sandia National Laboratories)*

To examine the cost of geologic hydrogen storage, Lord started by selecting geologic formations that currently store natural gas. Working with Sandia economist Peter Kobos, Lord analyzed costs to store hydrogen gas in depleted oil and gas reservoirs, aquifers, salt caverns, and hard rock caverns. (Note: Their paper, "Geologic storage of hydrogen: Scaling up to meet city transportation demands," was published in the *International Journal of Hydrogen Energy*).

### Meeting peak period storage

Geological storage isn't anything new. In fact, other fuels are already stored geologically. Oil from the Strategic Petroleum Reserve, for example, is held in large man-made caverns along the Gulf Coast. Natural gas is stored in more than 400 geologic sites to meet winter heating demands.

Lord envisions that excess hydrogen produced throughout the year could be brought to geologic storage sites, and then piped to cities during the summer, when the demand for driving fuels peaks. It seems depleted oil and gas reservoirs, as well as aquifers are most economically attractive options for now.

"Just looking at numbers," said Lord, "because they can hold such a larger volume relative to any cavern you create, they look cheaper."

But hydrogen gas is a challenging substance to store. "Because it's a smaller molecule than methane, for example, it has the potential to leak easier and move faster through the rock," Lord said.

Depleted oil and gas reservoirs and aquifers could leak hydrogen, and cycling—filling a storage site, pulling hydrogen out for use and refilling the site—apparently, can't be done more than once or twice a year to preserve the integrity of the rock formation.

With a salt cavern or hard rock cavern, "there are no permeability issues, there's really no way anything can leak," Lord explained. "You can bring more product in and out, and that will, in the long run, decrease your costs."

Hard rock caverns are relatively unproven; only one site holds natural gas. But salt caverns, which are created 1,000 to 6,000 feet below ground by drilling wells in salt formations, pumping in under-saturated water to dissolve the salt, then pumping out the resulting brine, are used more extensively and already store hydrogen on a limited scale.

### Future challenges

Lord said her work could lead to demonstration projects to further cement the viability of underground hydrogen storage. Salt caverns are the logical choice for a pilot project due to their proven ability to hold hydrogen, she said. Environmental concerns such as contamination could also be further analyzed. However, salt formations are limited. None exist in the Pacific Northwest, much of the East Coast and much of the South, except for the Gulf Coast area. Other options are needed for development of a nationwide hydrogen storage system.

\* Download the full study at [www.sciencedirect.com/science/article/pii/S0360319914021223](http://www.sciencedirect.com/science/article/pii/S0360319914021223)

\*\* Quotes and information from Sandia Labs News Releases: "Storing hydrogen underground could boost transportation, energy security"

*Anna Snider Lord's work adds to Sandia's capabilities and decades of experience in hydrogen and fuel cells systems. Sandia leads a number of other hydrogen research efforts, including the Hydrogen Fueling Infrastructure Research and Station Technology (H2FIRST) project co-led by the National Renewable Energy Laboratory (NREL).*

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Washington Hilton Hotel—Washington, DC; [www.greenjobsconference.org](http://www.greenjobsconference.org)
- 16-18 Northeast Biomass Heating Expo 2015**  
Cross Insurance Arena—Portland, Main; <http://nebiomassheat.com>
- 20-22 International Biomass Conference & Expo**  
Minneapolis Convention Center—Minneapolis, Minnesota; <http://biomassconference.com>
- 22-23 2015 Acore Renewable Energy Policy Forum**  
The Westin Washington, D.C. City Center, Washington, D.C.; [www.acorepolicyforum.com](http://www.acorepolicyforum.com)
- 27-28 CanWEA Western Forum**  
Vancouver Convention Centre—Vancouver, BC; <http://canwea.ca/canwea-western-forum>
- 27-29 National Hydropower Association Annual Conference**  
Capital Hilton—Washington, DC; [www.nationalhydroconference.com](http://www.nationalhydroconference.com)
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Dallas, Texas; [www.actexpo.com](http://www.actexpo.com)
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Atlanta Marriott Marquis, Atlanta, GA; [www.events.solar](http://www.events.solar)
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Orange County Convention Center—Orlando, Florida; [www.windpowerexpo.com](http://www.windpowerexpo.com)
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Allstream Centre—Toronto, Ontario; <http://bio-energyexpo.com>

**JUNE**

- 03-04 National Geothermal Summit**  
Reno, Nevada; [www.geo-energy.org/events.aspx](http://www.geo-energy.org/events.aspx)
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Paradise Point Resort & Spa—San Diego, California; [www.algalbbb.com](http://www.algalbbb.com)
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The Grand Hyatt, New York, NY; [www.refwallstreet.com](http://www.refwallstreet.com)

**JULY**

- 14-15 42nd IEEE Photovoltaic Specialists Conference**  
Hyatt Regency New Orleans—New Orleans, Louisiana; [www.ieee-pvsc.org](http://www.ieee-pvsc.org)
- 14-16 Intersolar North America**  
Moscone—San Francisco, California; [www.intersolar.us](http://www.intersolar.us)
- 19-22 12th Annual BIO World Congress on Industrial Biotechnology**  
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