

# North American **Clean Energy**

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## 2016 SOLAR Buyers Guide

### Measuring the True Costs and Benefits of Energy Storage

Part One: A quick guide to calculating cost & safety

### Blade Maintenance Strategies

### A Call for Net-Zero Energy

### Plus Show-in-Print Features:

- Solar Power PV Conference & Expo







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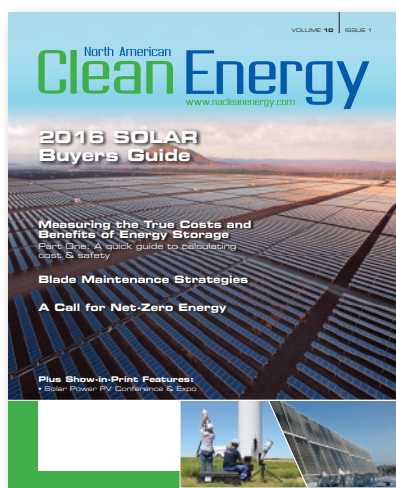
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## On our cover...

Centinela Solar is a 249MW project located in Imperial Valley, CA. It features Array Technologies' DuraTrack HZ single-axis tracker. The system is designed to code, and to withstand local wind speeds without the need to rely on active wind stow, and thus does not require a UPS.

**Array Technologies** | arraytechinc.com

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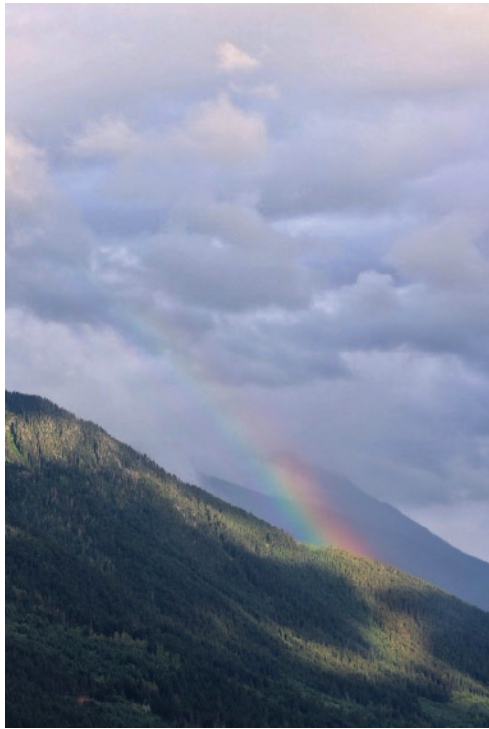


Photo by Ian C. Davis

**2016 IS SHAPING UP TO BE A PROMISING YEAR** for the renewable energy industries as initiatives formed in 2015 take hold and gather momentum.

Recently, Congress approved a five-year extension of the investment tax credit (ITC) and the production tax credit (PTC) which were set to expire at the end of this year. This federal support confirms The United States' commitment to clean energy, and will no doubt spur further growth in clean energy employment and therefore the economy.

In December, Representatives from 196 nations set aside their differences, came together, and agreed to take action against climate change for the global good at COP21. The ambitious Paris Agreement set a goal of capping global warming to 2°C or below and promising to pursue efforts to limit the increase to 1.5°C. This will ultimately lead to a zero emissions world.

Unlike the Kyoto Protocol, this Agreement doesn't categorize countries as "developed" or "developing" but instead, directs all nations to set non-binding climate targets for themselves. It also reassures the less industrialized countries of the world they will be supported by those with more developed economies, (read China and the United States), in their pursuit of clean energy, leading these countries to increased employment and higher standards of living.

To succeed at the goals set forth in the Paris Agreement, countries will have to shift their investment to clean and renewable energy, forest protection, and other green infrastructure. The five-year communication requirements of this agreement will demonstrate to investors there is an ongoing global demand for clean power plants, energy efficient buildings and factories, and low carbon transportation.

According to the White House "Americans have demonstrated their dedication to climate action through a wide variety of commitments."

- **Compact of Mayors:** 117 US Mayors have signed a pledge to capture the impact of cities' collective actions through the standardized measurement of emissions and climate risk, and consistent public reporting of their efforts.
- **Under-2 MOU:** States including California, Minnesota, New Hampshire, New York, Oregon, Vermont, and Washington not only agreed to cut greenhouse gas emissions by 80-95% below 1990 levels, but to also share technology and research, expand zero-emission vehicles, improve air quality, and assess the projected impacts of climate change on communities.
- **American Business Act on Climate Pledge\*:** 154 companies announced significant pledges to reduce their emissions, increase low-carbon investments, deploy more clean energy, and take other actions to build more sustainable businesses. These companies have operations in all 50 states, employ nearly 11 million people, represent more than \$4.2 trillion in annual revenue, and have a combined capitalization of over \$7 trillion.
- **American Campuses Act on Climate Pledge\*:** 311 colleges and universities representing over 4 million students have demonstrated their commitment to climate action.

With so much darkness occurring in the world, it's nice to take a breath of fresh air and see citizens come together with a collective interest in making their planet a better place to live. It's inspiring to see youth recognizing they are possibly the last generation with the ability to reverse climate change. Young people are stepping up to lead their communities and tackle the significant challenges of climate change so they can secure their future. Let's do all we can do to help them out.

*We wish you all the best in 2016!*

*Jill Walters*

\* Read more about the businesses and campuses committed to the Climate Pledge at [www.whitehouse.gov/ClimatePledge](http://www.whitehouse.gov/ClimatePledge)



### Farm from a Box

Trojan Battery Co., LLC, provides the energy storage solution for the Farm from a Box sustainable micro farming system. The Farm from a Box system will feature four Trojan AGM batteries which will serve as the systems energy storage solution.

Housed in a modified shipping container, Farm from a Box is a turnkey micro farming system that comes with all of the core components and tools required for off-grid food production in remote or rural locations. Designed to be a versatile, transportable, sustainable food production solution, the Farm from a Box components can be adapted to a range of conditions, making this the optimal plug-in for a wide variety of agricultural technologies.

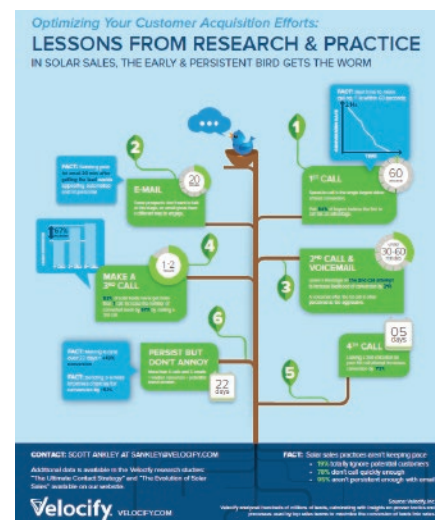
Farm from a Box is ideal for any application requiring a comprehensive system that enables sustained local food production, without need for an existing grid; from disaster response and humanitarian aid, to schools and community cooperatives. While each unit can be customized to fit the needs of the end user and location, the core components include:

- Solar-powered pump and drip irrigation
- Basic farming tools
- Water purification system
- High-efficiency solar panels
- Trojan Battery bank for energy storage
- High-efficiency LED lighting
- ICT and data mapping
- Mobile charging area
- Secured storage

The innovative concept offered by Farm from a Box is a terrific example of how to empower communities in developing regions to provide for themselves. Trojan is pleased to play a vital part in the Farm from a Box worthwhile mission to help developing regions establish a stable infrastructure for sustainable food production.

**Farm from a Box** | [www.farmfromabox.com](http://www.farmfromabox.com)

**Trojan Battery Company** | [www.trojanbattery.com](http://www.trojanbattery.com)



### Solar secret sales practices

As the solar industry continues to expand, competition is heating up and no lead should go untouched. In a recent secret shopper study by Velocify, nearly 40% of prospects waited weeks to receive a response to quote requests and 19% never even received a response. A new infographic highlights statistics from this study on solar sales teams' effectiveness in responding to online leads.

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# Measuring the True Costs and Benefits of Energy Storage

## Part One: A quick guide to calculating cost & safety

by Catherine Von Burg

A variety of new energy storage systems have emerged as business and government leaders rush to make advances in renewables and energy savings. Those systems include different chemical compositions, form factors (cylindrical cell, pouch, prismatic, flow), and battery management systems (BMS). That can make choosing a battery system challenging, even confusing. However, checking a few simple performance metrics can help calculate the true costs and benefits of competing systems. And it can help distinguish between what might look like a good price up front from what's actually a better buy in the long run.

When comparing battery options, be it lead acid, lithium ion, zinc bromide, flow, or others, it is imperative to understand the true cost of energy over time. That's called the Levelized Cost of Energy (LCOE), and calculating it means doing some simple math. The most basic way to check is to divide the cost of a battery system by the number of kilowatt hours (kWh) generated over its anticipated life. A more precise measurement is achieved by including such factors as the number of cycles the batteries are guaranteed to handle, the percentage a battery can be discharged while retaining full power, and ancillary costs which can be significant depending on the system. Following the formula in the accompanying sidebar will give a fairly objective estimate of cost over time.

### How to Calculate the Levelized Cost of Energy (LCOE)

To calculate the Cost of Electricity in Kilowatt Hours (kWh) over time:

#### Step One: Gather the Facts

- Size of Battery in Rated Amp Hours – Ah
- Voltage of Battery – V
- Depth of Discharge – %
- Number of Batteries – Qty

The battery rating is based on the manufacturer's stated capacity in watt hours at specific discharge rates.

#### Step Two: Calculate Watt Hours (Wh)

$Wh = Qty \times Ah \times V \times \%$

#### Step Three: Calculate Lifetime Watt Hours (LW)

$LW = Wh \times Cycle\ Life$

Cycle Life is the number of full (not partial) charge and discharge cycles expected over a battery's lifetime while it has at least 80% of its original published capacity. It is based on manufacturer's estimate using specific depth and rates of discharge and operating temperatures.

#### Step Four: Factor in Costs

- Price (per battery)
- Calculate Total Battery Cost (Qty x Price)
- Add Ancillary Costs including Cabling, Racking, Containment, Venting, Cooling, Installation, Transportation, Maintenance, etc.
- Calculate Actual System Cost = Total Battery Cost + Ancillary Costs

#### Step Five: Calculate Cost per Wh

$Cost\ per\ Wh = System\ Cost / LW$

#### Step Six: Calculate LCOE in kWh

$LCOE = LW \times 1000$

Keep in mind there are also costs and benefits beyond the immediate price point per kilowatt hour (kWh). Depending on the system, it's necessary to factor in costs for:

1. Maintenance
2. HVAC to cool or ventilate
3. Extra space for larger systems
4. Construction to support larger systems
5. Replacement of less durable systems

Also consider:

- A. Safety
- B. Potential limitations on usages, operation locations or transport methods because of temperature issues or thermal runaway risks
- C. Toxicity, environmental impact and disposal costs

Buyers often focus on the up-front price point without factoring in parameters like these, which greatly impact a system's true cost.

Different chemistries play a role in these costs. In this-two part article, two categories of Lithium-ion batteries will be compared: those with cobalt oxide and those without it.

#### Battery chemistries with cobalt include:

- Lithium Cobalt Oxide (LiCoO<sub>2</sub> or LCO)
- Lithium Nickel Manganese Cobalt Oxide (LiNiMnCoO<sub>2</sub> or NMC)
- Lithium Nickel Cobalt Aluminum Oxide (LiNiCoAlO<sub>2</sub> or NCA)

#### Chemistries without cobalt oxide include:

- Lithium Ferrous Phosphate, also known as Lithium Iron Phosphate (LiFePO<sub>4</sub> or LFP)
- Lithium Titanate (Li<sub>4</sub>Ti<sub>5</sub>O<sub>12</sub> or LTO), although LTO is rarely used in large format energy storage

#### Safety First

The Lithium Ferrous Phosphate, also known as Lithium Iron Phosphate (LFP), storage chemistry has a somewhat lower power density than LI chemistries containing cobalt, but this can be overcome with proper system architecture and battery management. Because it lacks cobalt, LFP is intrinsically safe, efficient, and environmentally benign. Rather than cobalt oxides, LFP uses inert ferrous (or iron) phosphates.

Importantly, LFP does not pose a risk of the chemical fire known as "thermal runaway" caused by cobalt oxide. There is no known flame retardant that can extinguish these fires, so they must be contained and allowed to burn out.

The temperature at which LFP and LTO could reach thermal runaway is significantly higher than that for other LI chemistries. Even if it did reach those temperatures, the lack of oxides to fuel a fire mean that it would just peter out. As a result, there have been no reported incidents of thermal runaway with LFP, in contrast to the fires and recalls that have impacted other LI chemistries.

Another key distinction of LFP is that it throws off no heat, again, unlike most other LI batteries. That makes LFP batteries by definition more efficient and durable than other lithium ion batteries.

All lithium-ion batteries are listed as Class 9 hazardous materials for transport because of the risk posed by cobalt, even though LFP and LTO do not contain cobalt. It is hoped in the future, government agencies will distinguish between chemistry types and remove unnecessary restrictions on LI batteries not containing cobalt.

Mitigating the heat buildup and potential for thermal runaway in LI batteries which do contain cobalt requires extra space for ventilation, internal cooling equipment, special manufacturing materials, such as liquid polymers and tubing, and balancing of hardware and software, adding significantly to the actual cost, size, and weight. It can also require additional precautionary equipment and installation and maintenance guidelines to safeguard against heat or fire.

Some, but not all, LFP manufacturers must ventilate and cool their batteries for optimum performance because their proprietary BMS, circuitry, and/or internal architecture need cooling and may create increased impedance or inefficiencies. Other batteries do not throw off heat, and do not require any ventilation or cooling.

In sum, the power electronics (BMS), and internal architecture of a battery can have as much to do with the overall performance, LCOE, and safety as the fundamental chemistry itself. But, a part of calculating the true costs and benefits of any battery system is calculating its LCOE as well as the other costs involved in installation, operation, and replacement over time.

In part two of this topic, in the March/April issue of North American Clean Energy, the impact of cycle life and environmental factors on LCOE will be discussed.



*Catherine Von Burg has been the CEO of SimpliPhi Power since 2010. Before her work in energy storage, she spearheaded national program, policy and business-driven initiatives with organizations such as Pew Charitable Trusts, Rockefeller Institute, Columbia University, NY March of Dimes*

*Foundation, John's Hopkins School of Biomedical Engineering, Wilderness Education Association and First 5 Commission of California. She graduated from Columbia University in New York and holds a Master's degree from University of Pennsylvania, School of Social Policy.*

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# The Benefits of Installing a Condition Monitoring System

by Ozgen Kilic



## EVERY DAY OF DOWNTIME AT A WIND TURBINE IS LOST REVENUE.

Transitioning from unplanned to planned maintenance, or preventive versus reactive maintenance, can offer considerable savings to a wind farm owner and other customers. Condition monitoring services are designed to maximize gearbox life through early detection of mechanical problems. Through remote, real-time multi-sensor monitoring of gearbox vibration, oil condition, and particle counts, potential problems which would otherwise be missed by a wind turbine SCADA system alone, can be detected, allowing required maintenance activities to be scheduled in advance and reducing costly downtime.

Condition monitoring services operate by having expert analysts and technicians keep watch around the clock, twenty-four hours a day, seven days a week, monitoring key variables reflecting drive-train health. Correlating real-time oil particle counting and real-time vibration analysis, two critical variables which speak volumes when their data is compared, backed by state-of-the-art software to interpret the sensor data can paint an important picture of what is happening in a gearbox.

and zero down leasing options are now being offered by some companies to get systems up and running quickly and cost efficiently. Data is collected and sent to a remote server over the internet using standard TCP/IP protocol or 3G/4G wireless networks, and users can choose to analyze data on their own, or receive expert data analysis, and a detailed report with a recommended course of corrective action. Remote monitoring systems can be beneficial for one, or thousands of units spread out over a wide geographical area, increasing cost efficiency significantly when technicians are deployed to fix more than one turbine on a single trip with overhead amortized over more work. This would not be possible without condition based monitoring of the drivetrain.

## Remote monitoring of the following variables can reflect drive-train health:

- **Bearing and Oil Temperature**  
Provides advance warning of possible malfunctions in cooling systems as well as problems with turbine lubrication
- **Vibration Analysis**  
Monitoring changes in vibrations provides early warning signs of bearing rolling element and race issues as well as gear wear and shaft misalignment issues
- **Oil Condition and Particulates Content**  
Provides advanced warning of wear-related problems due to contaminated lubricant, which can greatly limit gearbox life

## Who benefits from a condition monitoring system?

For end-users, condition monitoring guarantees the continuity of their energy yield and lowers the cost of energy. For energy utilities, it transforms conventional maintenance into smart, proactive maintenance, and longer, more trouble-free operations. For turbine and system suppliers, a condition monitoring system can provide a new, value-added dimension to their product offering. A large number of different parameters from multiple measurable locations can be handled for industrial gear applications as well.

## Does remote monitoring provide an acceptable return on investment?

The average gearbox failure rate over 10 years of operations is estimated at 5% according to a 2013 NREL report. The primary consideration to look at is the frequency and severity of failure. How often does the system fail and what is the cost impact of the failure? The underlying failure rate cannot be changed, but having a reliable condition monitoring system in place can reduce the cost impact per failure significantly, resulting in a slam dunk return on investment.

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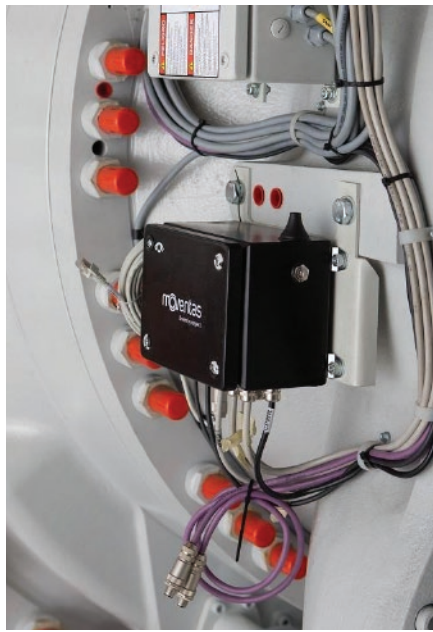
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## Costs savings of condition monitoring

If a gearbox runs to failure, costs can range anywhere from \$300K to \$450K to repair it. With a condition monitoring system, which can be retrofitted to existing equipment, technicians can arrive swiftly at a site and fix the turbine, often with just one day of downtime. Maintenance can be proactively planned even months in advance and shutdowns scheduled for repairs limiting turbine downtime.

Condition monitoring systems can cost under \$10K, and are available as easy-to-install smart, compact, value-added packages, custom tailored to monitor a range of performance parameters. Service agreements





Monitoring systems can grow and change as needs change, and the data provided can prove helpful in designing a preventative maintenance program which minimizes problems and avoids catastrophic failures, ensuring a longer unit lifetime. Monitoring how the gearbox and other drivetrain components are performing 24/7 anticipates possible upcoming failures, providing timely updates and even alerting maintenance crews. With the early warning provided by a dependable condition monitoring system, what could have been weeks or months out of service for a turbine, instead becomes a manageable up-tower repair and one day of downtime, bringing peace of mind, as well as considerable cost savings to customers.

*Ozgen Kilic is a CMA S Engineer for Moventas. Moventas Americas is a multi-brand wind drivetrain service company with over 35 years of wind turbine gearbox design, manufacturing, and service experience. Their comprehensive suite of wind drivetrain services covers over 85% of the installed wind fleet with shop repair, less expensive up-tower repair along with monitoring and inspection services to lower their customers' cost of electricity. Moventas' service and manufacturing facilities in North America are all located in the main wind energy corridors and offer fast and responsive services.*

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### Electric tensioner pump

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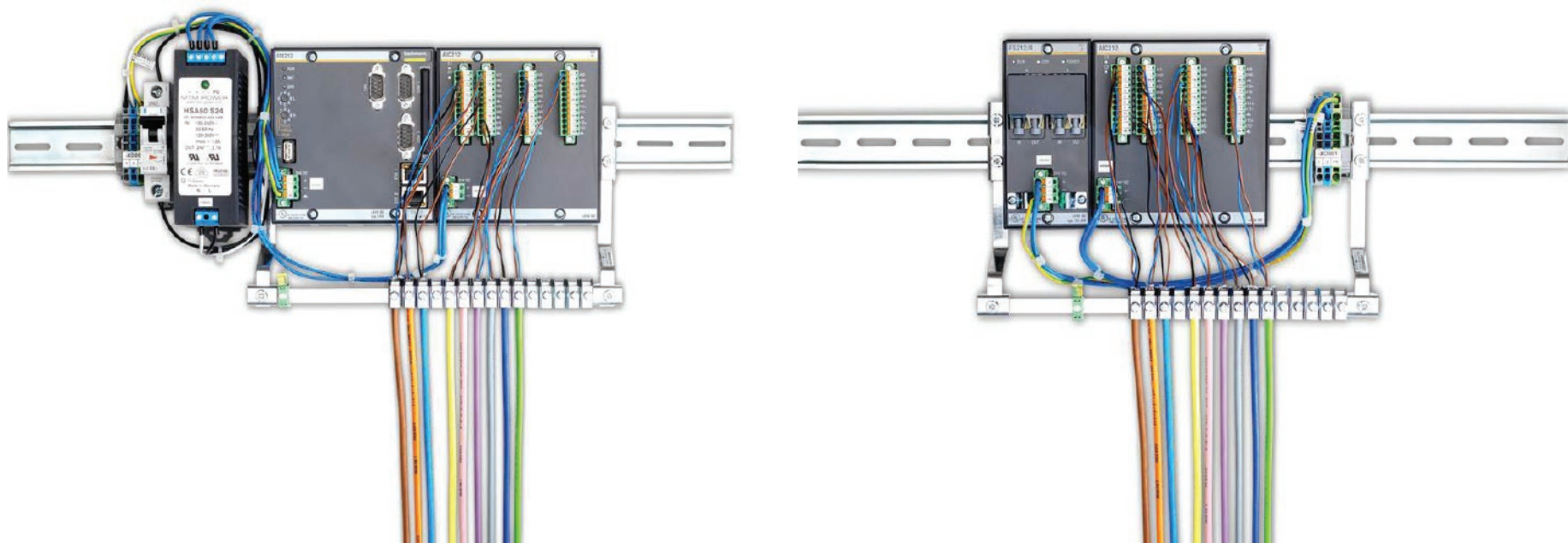
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# Lessons Learned from a Large-Scale CMS Retrofit

by Nicholas Waters

**LARGE-SCALE CONDITION MONITORING SYSTEM (CMS)** retrofits can present an assortment of challenges. Project management issues present in smaller sized wind turbine retrofits are magnified as the scope of the project grows, necessitating implementation of project management fundamentals.

From 2012-2014, the CMS retrofit for 1310 turbines of 9 different make/models of wind turbines was undertaken. There were a total of 33 wind sites, with 23 locations in Europe and 10 locations in the United States. The CMS retrofits consisted of three styles of condition monitoring systems: stand-alone, top-box integrated, and fully integrated. Common amongst the CMS installations were the sensors, cabling, and CMS unit per tower. Outside of this standard hardware, some sites required customization to monitor additional components. Throughout the duration of the project, an assortment of challenges arose which can be separated into the following three categories: planning, documentation, and communication.

## Planning - Anticipate issues ahead of time

Anticipating potential issues down the road and putting together mitigation strategies ahead of time is crucial. In order to prevent a bottleneck in the retrofit progress, it is important to ensure contingencies can be handled by local management without waiting on the project managers' approval. Having predefined policies in place to deal with quality, change requests such as schedule and scope can significantly reduce pitfalls later on.

Gathering all relevant data ahead of time is vital to the successful completion of this scale of project with the deadlines given. For CMS, it is important to consider each unit as a complete integral system from sensors to the controller and the wind turbine communication system. Communication networks are the heart of CMS and it is easy to underestimate their importance. It is vital all communication infrastructure data and documentation be gathered ahead of time. This is one of the biggest sources of grievance seen with CMS retrofits.

## Documentation - If it isn't documented, it didn't happen

Create a central project email account to ensure records are kept for every aspect of the project discussed during meetings or phone conversations. The account will serve as a repository for any correspondence related to the retrofit. Require all contractors, client personnel, and the technical team to cc all emails to the project email account.

Maintain an extensive project manual encompassing every aspect of the project. Use international and industry standards wherever applicable in order to avoid reinventing the wheel, and to establish a common naming convention. As part of the project management infrastructure, implement a numbering structure for contracts and sites, disciplines, work packages, inquiries, and orders and cost accounts.

The project manual will later be recognized as the bible of the project. For this reason, it is important it be commented and agreed upon, not only by the client's project management team, but by the third party contractors as

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well. Completing this early on, helps to minimize future clarification efforts with sites, new team members, and subcontractors.

When anticipating the magnitude of data required for the project, make an effort to avoid what is termed “the Excel virus.” It is necessary to avoid everyone having their own private tracking documents. Implement a structured project management database for future reference and utilize the Reference Designation System for Power Plants (RDS-PP), a power plant specific nomenclature for standardized object structures based on ISO 81346 and ISO 16952-10.

Having clearly written documentation will prove itself invaluable throughout the project. The documentation will not only help with the planning of the project, but also directly lead to establishing clear lines of communication between all parties involved. This documentation will be one of the primary factors leading to project success.

### Communication - Keep everyone in the loop

Communication issues are inevitable when a small compact team meets a complex, distributed, large corporate structure. Maintaining multiple points of contact within a customer organization can lead to issues completing tasks, as communication falls short of necessary decision-making personnel on either side. Also, due to the project magnitude, issues may be anticipated for completing the project within the specified timeframe or with an in-house installation team alone. Contracting third parties to aid in installation efforts introduces even more points of contact, opening the project up for communication breakdown and potential sources of error.

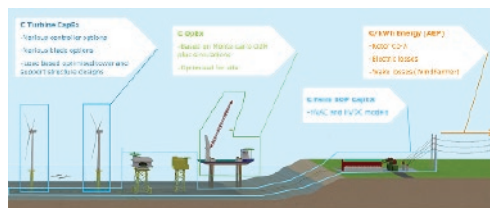
To mitigate issues arising from such a wide ranging project, hold status update meetings and rely upon extensive documentation. Hold periodic meetings with the entire project team every 6 weeks to provide a level of oversight for everyone to ensure the work is getting done according to schedule, and to guarantee no part of the project is left to interpretation. Clearly cover all project details and immediately address any issues. In the case of international projects, it’s important to hold status meetings in the country where the work is being performed.

### Summary

The major takeaways from this project can be boiled down to three basic fundamental concepts: preparation, documentation, and communication. By establishing good project management fundamentals surrounding these three main topics, potential issues, inevitable on any project, can either be avoided or mitigated. In addition, establishing a quality project management team can help reduce the workload on everyone as they work to ensure project success.

*Nicholas Waters is Bachmann electronic’s key account manager for CMS in North America.*

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



## Calculating LCOE

DNV GL, has unveiled Turbine.Architect, an in-house software tool enabling turbine engineers and component developers to quickly calculate the impact of their technology on Levelised Cost of Energy (LCOE) for a realistic wind project. Turbine.Architect supports turbine design and component technology development by quantification of the technical impact of design and component technology on both the turbine system as well as the entire wind farm, from the foundation to the electrical infrastructure. Turbine.Architect computes realistic values for the capital costs of turbine, Balance of Plant components, farm operational costs, availability, and farm annual energy production. The tool’s engineering models produce concept-level technical specifications for turbine components and farm items, with up-to-date market intelligence translating these specifications into appropriate capital costs. Similarly, operational costs and availability are quantified using models for Operation & Maintenance that are benchmarked with real field data. Its method to estimate energy production includes losses from rotor aerodynamics, drive train components, and farm wakes, the latter by linking with DNV GL WindFarmer. Turbine.Architect also contains a discounted cash flow model where estimated costs and yield are escalated to LCOE and Net Present Value (NPV). As well as quick LCOE calculations at the early phases of a given project, the tool allows users to overwrite various components. The user may then do everything from high level screening of potential wind turbine design projects to detailed assessment of a specific system or component level technology innovation in the same tool, providing a unified way of presenting costs and calculating LCOE. The flexibility of the tool also allows the user to test various cost reduction opportunities and perform sensitivity analysis, with the overarching objective of supporting an LCOE-driven design process.

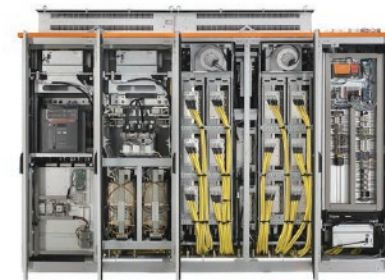
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## Site-wide resource visualization

Schweitzer Engineering Laboratories, Inc. (SEL) announced a new release of its ACSELERATOR Meter Reports SEL-5630 Software. This latest version includes support for dynamic viewing tools, faster database interrogation, and offline demonstrations. ACSELERATOR Meter Reports Software helps users organize, visualize, and optimize energy usage, using data from SEL-734 Advanced Metering Systems, SEL-735 Power Quality and Revenue Meters and SEL-751A Feeder Protection Relays. ACSELERATOR Meter Reports Software trends energy consumption data, so operators can avoid peak demand charges and optimize a schedule that moves overlapping electric processes to off-peak hours. Additionally, the software offers tools to diagnose voltage disturbances using historical data, so the user can assess the impact and improve system operation. The latest release of ACSELERATOR Meter Reports is accompanied by an integrated demonstration database. This feature gives anyone with a mySEL account the opportunity to download and evaluate the new features at no charge. The built-in sample database replicates a real-world metering system, so it can operate without an active ACSELERATOR TEAM SEL-5045 Software connection.

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## Utility-grade full-power converter

The Switch, has launched its new generation, full-power converter (FPC) for utility-grade electricity production. The FPC+ concept builds on the company’s experience from its installed base of over 11 GW throughout the world. Designed for high level performance in electricity production, the new robust FPC+ line of converters from The Switch ensures future-proof electricity quality to meet the strict international requirements for harmonics, flicker and fault ride-through (FRT). The affordable, state-of-the-art converter is optimized to work with permanent magnet as well as induction machines. Optimal power flow control guarantees minimum losses and smooth load transitions. By reducing sensitivity to the network, The Switch FPC+ produces a seamless interaction with the grid, even in the case of severe disturbances. New micro-grid functionalities are also available to enhance the proven FRT. Due to the high power density of the FPC+, the number of panels can be reduced. Moreover, its compact size makes the converter easily adaptable to different applications. FPC+ can be configured as an inline or back-to-back solution. The control system features a user-friendly, expandable design. The rugged IP54-class panel with easy access is designed to withstand even the harshest operating conditions.

**The Switch** | [www.theswitch.com](http://www.theswitch.com)





# Maximizing Annual Energy Production Using vortex generators

By Santhosh Chandrabalan

**DESPITE THE DECEPTIVELY SIMPLE DESIGN** of a wind turbine blade, there are a multitude of factors affecting the efficiency and annual energy production (AEP) of the device. Essentially, the problem lies in the construction of the blade as its design is not, and cannot be, exclusively aimed at maximizing aerodynamics. Additionally, the ideal structural twist and chord length that is required for optimal flow is very expensive to realize. In consequence, there is always potential for aerodynamic improvements to maximize performance.

Due to shape and operation limitations, the blades of large, pitch-regulated wind turbines often have suboptimal aerodynamic properties at the blade root. As a result, aerodynamic stall, or an undesired airflow separation can occur and additional issues such as blade surface roughness and leading edge erosion can exacerbate

the problem. Ultimately, these losses in efficiency will impact the bottom line for wind turbine owners by contributing to a loss of annual energy production.

In an effort to address the challenges associated with wind turbines, an advanced design and installation process for vortex generators (VGs) has been created.

VGs are small attachments made from durable materials which energize the laminar air flow around the blade, and reduce air flow separation. Due to the unique shape and properties of every wind turbine blade, the positioning of VGs is customized for each individual blade design. Most importantly, the placement of VGs on the blade is determined using a proprietary analysis process and flow visualization which provides the best performance increases.

## A custom-designed solution

Industry leaders in wind technologies are always looking for innovative solutions to address the pain points of wind turbine owners. By partnering with other companies, they are able to leverage each group's respective strengths – materials expertise, aerodynamic proficiency, and installation accuracy and efficiency.

Unlike traditional vortex generator applications, the current solution works as follows:

1. Aerodynamic studies and flow visualization analyses are conducted in the field to identify issues. Based on the results, each VG is tailored to the blade to improve its performance and energize flow over the blade.
2. Vortex generators are applied using acrylic foam tapes which provide a key component for success. Unlike other adhesives, acrylic foam tapes can accommodate the flexing and residual forces acting on the blade surface in challenging weather conditions, while still providing very high adhesive strength. This attachment solution also gives the VG the ability to better withstand variable forces and temperature changes.
3. It's important for a defined process and repeatable template for execution be devised. With this, installation companies can perform installations safely and efficiently – with an average of just one day per turbine – minimizing downtime.



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### Realizing the full potential of vortex generators

When properly installed, VGs improve the performance of wind turbine blades by energizing the flow around its surface and reducing aerodynamic separation. This improves the turbine's performance in terms of power, loads and service life.

Additionally, VGs have the potential to be a cost effective investment for turbine owners. A paper published in 2014 reported the findings of a study analyzing 85 wind turbines\*. After comparing data from pre- and post-installation, results demonstrated the VG solution enhanced annual energy production (AEP) by more than 2%. The analysis concluded when this AEP increase is applied to a standard wind farm with 60 GE 1.5MW turbines, a VG installation could pay for itself in under two years.

Due to recent advancements in vortex generators, wind turbine operators finally have a reliable, fast-installation solution which maximizes wind turbine performance and gives a substantial boost in AEP. Furthermore, the product offers a variety of comprehensive benefits including:

- **Stabilized aerodynamics** which balance load effects of unsteady wind conditions;
- **Reduced noise** due to less blade stall;
- **Adaptability** to different blade types independent of turbine OEM;
- **Payback time** of approximately one to two years including installation, materials and downtime; and
- **Proven performance** based on case studies based on actual performance improvement.

The bottom line is, vortex generators are an economically viable upgrade which will maximize ROI and reduce the costs associated with wind energy.

*Santhosh Chandrabalan leads the 3M Wind business in his capacity as the Global Business Manager. Chandrabalan's background is in Composites and he has spent a significant portion of his career in various leadership capacities in the wind, composites and solar industries. His past experiences include research in composites, process engineering, engineering management, and global key account management. He is an active member and held leadership positions in many global Wind/Composites communities and consortiums. He holds a BS in Composites Material Engineering from Winona State University, and MS in Engineering Management from Southern Methodist University.*

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\*[upwindsolutions.uberflip.com/hi/55004854-proving-the-value-of-vortex-generators](http://upwindsolutions.uberflip.com/hi/55004854-proving-the-value-of-vortex-generators)



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Image 1

# Potential and Limitations in Large Wind Turbine Blades

## Sweep- and laminate-induced torsion coupling

by A. A. Raina, K.T. Lee, and K.K. Wetzel

**WIND TURBINE RATINGS ARE INCREASING AND TRENDING** towards larger MW scaled rotors for lower wind class sites. Although rotors are getting larger in size, they must still be designed for root load targets which produce a favorable cost in energy savings. The load reduction for larger machines is obtained through both conventional and advanced methods. Conventional methods typically include incorporation of pitch regulation along with advanced control systems, however, high pitch rates can increase fatigue loads and reduce the life of the system. Advanced methods include incorporating aeroelastic tailoring techniques along with advanced control techniques. Aeroelastic tailoring of wind turbine blades to reduce transient loads is not a new concept and the fundamental basis for aeroelastic tailoring is to design the blade so it undergoes an out-of-plane flapwise deflection and twist during operation. This torsional deformation is known as Torsion-Bending Coupling (TBC).

The advantage of TBC happens when a blade is hit by a wind gust or transient wind condition. The downwind flapwise deflection of the blade caused by the gust induces the blade to twist so it changes the aerodynamic angle of attack and reduces its aerodynamic loading.

This technology reduces the cost of energy (COE) by increasing the annual energy production (AEP) of the wind turbine by allowing larger rotor blades to be used without a significant increase in the turbine system loads. Studies show load reductions through the use of TBC are 8-12%. Reductions in COE of approximately 8% are achievable and the use of larger rotor blades for as much as 16-20% increased energy capture offset the increased

rotor blade cost. While most of the early work on aeroelastic tailoring focused on the dynamics and impacts of loads and energy capture, later studies focused on the optimal off-axis fiber placement in order to maximize the magnitude of twist-flap coupling. Additional studies focused on the structural details of various blade designs to achieve twist-flap coupling.

### Laminate induced TBC

Aeroelastic tailoring, through the rotation of some of the fibers in a laminated fiber-reinforced composite structure away from the spanwise direction (the long axis of the blade), induces a torsion-flap coupling in the structure. In this approach, the resulting laminated composite structure must be unbalanced, and fibers placed at an angle  $\theta$ , relative to the long, spanwise axis of the blade cannot be balanced by an equal weight of the same fibers at an angle of  $-\theta$ . The presence of this unbalanced structure creates a coupling between axial tension and compression in the structure (parallel to the long axis) forcing in-plane shear and deformation. The net resultant deformation will induce the blade to deform torsionally and twist about its long axis.

### Sweep

Blade sweep refers to geometrically modifying the shape of the wind turbine blade to achieve loads reduction due to aeroelastic tailoring. This is achieved by geometrically sweeping the outboard-region of the blade in the plane of rotation aft of the pitch axis. The loads generated at the tip will introduce a moment about the pitch axis. Since the blade incorporates sufficient torsional flexibility, the tip will twist towards feather. This 'swept' shape allows the blade to respond to turbulent wind gusts through a process of controlled twisting and bending. As the blade twists, it sheds loads and material stresses which would normally be translated to the root of the blade.

It is estimated  $4^{\circ}$ - $7^{\circ}$  of tip twist is required to obtain an 8-12% reduction in blade root loading. Image 1 shows a swept blade.

### Benefits of TBC

TBC is an enabling technology when designing large wind turbine blades. Often, the challenge is to seek the largest rotor diameter for a given turbine rating. A performance and cost analysis should be performed to compare different rotor sizes based on different material configurations. The load target for some rotor configurations is provided in Figure 1 which shows increases in AEP of approximately 19% for the largest rotor configuration incorporating TBC either with off-axis laminates or geometric sweep. Note this is 6% higher than the largest rotor which does not incorporate TBC, as it only achieves an estimated 13%.

Another benefit of laminate induced TBC is its simplistic manufacturing with off-axis carbon through stitch bonding. Unlike geometrically swept rotor blades, laminate induced TBC can be incorporated in blades with conventional profiles. This reduces manufacturing cost and complexity for large blades. For swept blades, custom designed fabrics are not required, which reduces the lead time for manufacturing.

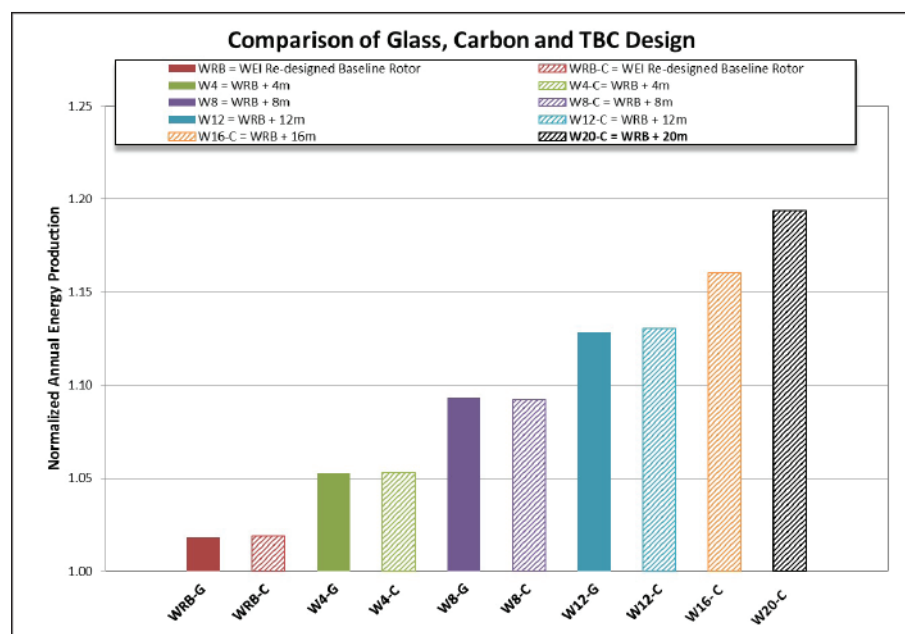


Figure 1. Comparison of Normalized AEP for Glass, Carbon and TBC Design



### Limitations of TBC

Although TBC is an enabling technology for large wind turbine blades, there are a few limitations associated with it.

1. Custom fabrics (carbon glass hybrid) required for the shell material of laminate induced TBC blades are more expensive than conventional triaxial glass material.
2. Manufacturing individual components for swept blades can be complicated; fabrication of the girder requires the use of prepreg material.
3. Swept blades are difficult to transport which increases transportation cost and time.
4. Due to the curvature in the swept blade profile, an external torque load is generated which can be transferred through the pitch system.
5. Although a reduction in total cost of energy is obtained, it increases blade cost. It should be noted, for large offshore machines, the total blade cost accounts for only a small fraction (~10%) of the total system cost.

The use of TBC in large blades results in reduction of blade root loads which, in turn, enables the design of larger, more energy efficient rotors. The load reduction obtained from TBC is estimated to be 8-12% of the uncoupled blade root loads. A TBC blade presents itself with a few limitations; the overall blade cost is higher than a conventional blade design, and there are manufacturing complexities relating to either custom fabric production for a laminate induced TBC or the manufacturing of the swept blade contour, but these obstacles are usually diminished by the gains in overall system life cycle.

*Mr. A. A. Raina is managing director, Dr. K.K. Wetzel is CEO/CTO, and Mr. K. T. Lee is technical project management & business development manager, wind at Wetzel Engineering Inc.*

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# Blade Maintenance Strategies

by Justin Forbes and Jon Salmon



An effective example of a vanguard blade inspection system, a super-zoom camera.

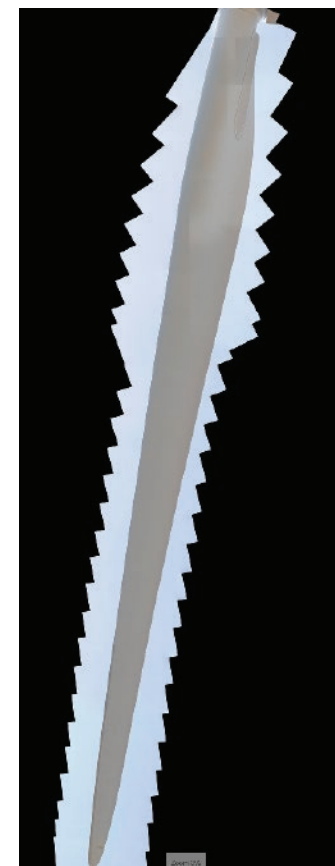


Image 1

**THE NORTH AMERICAN WIND TURBINE FLEET IS AGING.** According to Dan Shreve at MAKE Consulting, AWEA's US Wind Industry Fourth Quarter 2014 Market Report estimates approximately 45GW of wind turbine capacity in the Americas will be 10 years or older by the year 2020.

Original equipment manufacturers (OEMs) and independent service providers (ISPs) typically focus on common failure modes such as gearboxes, paying less attention to another looming concern, the ongoing maintenance requirements of blades. Blade failures have been occurring earlier than the industry expected due to erosion, lightning strikes, and other impacts.

## Reasons for a comprehensive maintenance plan

- Blade repairs can be costly.
- Left uncorrected, damaged blades are often less efficient and can fail catastrophically.
- Replacement blades can take assets out of service for up to six weeks, resulting in lost revenue.

## It starts with inspections

Blade inspections vary greatly in quality and cost. The most basic inspection can be performed with binoculars from the ground or atop the nacelle. Spotting scopes provide an inspection similar to binoculars, but with the option of variable magnification. Unless augmented by a camera, these inspections give no photographic record, and the location and description of any anomalies found is by annotation only.

Telephoto camera inspections usually use a 35mm lens with 300-600mm focal length and are performed on the ground near the wind turbine to provide higher magnification inspections and a photographic record of the blade anomalies. The longer the focal length of the lens, the better to detect small, fine defects.

Ground-based photographic inspections go one step further by using a motorized computer scanning system which produces a complete photo-scan of the blade from root to tip. This semi-automatic system allows for a complete record of the blade surface, giving a permanent visual history for future reference. It also provides a single mosaic image of each blade surface, putting them all together as one image which is then optimized by image-enhancement algorithms.

The mosaic (Image 1) can be a significant time-saver because it allows an inspector to review just one combined image of a blade surface rather than 20-50 images of individual segments.

For fleet inspections involving thousands of blades, it is important to keep all the inspection reports, images, blade condition, and repair status well organized.

Frequently, there is value in viewing the history of the blade by referring back to images taken during previous inspections to understand how a defect, such as a crack, has changed over time, and its rate of development. The combination of photos into mosaic images provides a high level of organization of images and efficiencies in inspection and reporting.

## So many blades...how to prioritize and plan

Categorization of the defect is based upon the repair criticality, for example the impact on energy production, blade reliability, or additional costs if repairs are deferred. Using a simple A-B-C-D categorization of defects can assist in identifying and planning for the most critical repairs needing immediate attention.

Once all blades have been inspected and their conditions categorized, blade repair planning can begin. The most critical defects are identified first, and then other considerations are factored in to create the most cost-effective repair plan. These factors include other blade repairs on the same turbine or at the same site, proximity and availability of the blade repair crews, and the weather at the sites.

Setting the annual rate of maintenance is specific to the turbine fleet and its location. Vast differences in defect rates have been observed due to factors such as the blade materials, quality of the blade manufacture, site conditions, air-borne particle density and hardness, wind velocity and variability, and lightning intensity and frequency. These factors present a complex relationship which determines the blade deterioration rate at each site. The most effective inspection frequency for a given site is therefore best established empirically.

Ideally, the blades are fully inspected each year until a suitable inspection regularity is determined. Cost is a major consideration in the inspection schedule, but inspection and repair costs must be weighed against the cost of not repairing the blades. When taken to the extreme, a repair can become a replacement with

Bird and bat collisions with wind turbines are recognized as a conservation concern both for power generators and the general public.

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An effective blade maintenance will avert advanced stage blade erosion, impacting production and requiring extensive, costly repair.



Sometimes lightning damage can be subtle and only high resolution inspection can detect it.

additional expenses for lost energy production, removal, and replacement of the blade.

Each wind project site is unique. A comprehensive blade maintenance plan that includes regular inspections can avoid unplanned service outages and catastrophic blade failures. Telephoto camera inspections paired with image mosaics leave an accessible visual history that will aid OEMs and ISPs alike in scheduling the appropriate services in the most cost effective manner.



Justin Forbes is Director, Marketing & Business Development for EDF Renewable Services. Justin earned his MBA from Duke University, and a BS in mechanical engineering from the University of California San Diego.



Jon Salmon is Technical Services Manager for EDF Renewable Services. Prior to this role, he served for two years as operations manager for EDF Renewable Services, and three years as Field Engineering Manager and Technical Training Manager. Jon has degrees in materials science and mechanical engineering from the University of California Berkeley, and is a professional engineer in Iowa.

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### New gearbox technologies

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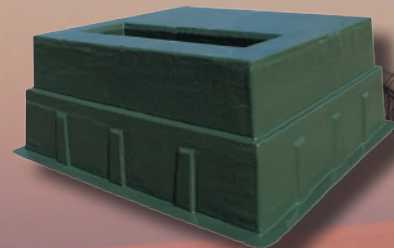
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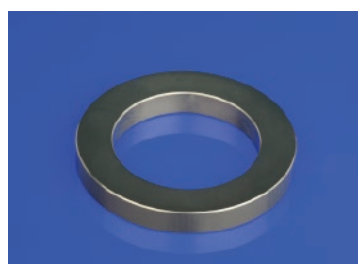




### High performance end mills

Sandvik Coromant launches a new series of end mills delivering high performance and security in side and pocket milling operations. The CoroMill Plura HFS (high feed side milling) end mills are developed for steel and stainless steel applications, but they can also enhance productivity in difficult-to-machine materials such as heat-resistant super alloys (HRSAs) and titanium. The CoroMill Plura HFS utilizes the complete cutting length of the end mill and achieves a high metal removal rate with smaller diameters. The result is lower tools costs and improved overall productivity. CoroMill Plura HFS features include: an unequal helix flute design that assures a variable angular pitch in every axial section to increase the chatter-free material removal rate; an asymmetrical chip-breaker profile that improves chip evacuation and minimizes the risk of edge chipping and tool breakage; and a conical core shape with a smaller core diameter at the face to improve chip evacuation capabilities, with a larger core diameter at depth of cut maximum (APMX) for maximum stability. The grade for the CoroMill Plura HFS is GC1740 which was developed to resist bending forces generated when using a 4xDC length of cut. This is needed when the component has a large depth of cut and cutting width. Furthermore, Sandvik Coromant's Tailor Made offer includes CoroMill Plural end mills for manufacturers or machine shops needing a 5xDC length of cut.

**Sandvik Coromant** | [www.sandvik.coromant.com](http://www.sandvik.coromant.com)



### Seal face component materials

Morgan Advanced Materials' Seals and Bearings business announces the availability of high performance materials ideal for seal face components in non-contact seal applications. The range of carbon graphite and silicon carbide materials feature high mechanical strength and highly predictable performance, making them a good choice for mechanical non-contacting gas seal applications in oil and gas, energy, chemical processing, and industrial markets. With more than 30 years of experience manufacturing seal components, Morgan's process yields materials with high mechanical strength, a high modulus of elasticity, and uniformity throughout the matrix – features integral to an elevated level of performance in the end application.

**Morgan Advanced Materials**

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



### High current in a compact size

Amada Miyachi America is pleased to introduce the new ISB-300A 300 amp inverter power supply, featuring a compact size that makes it ideal for customers and integrators who have limited space yet require higher output current than traditional fine spot welders can deliver. Small enough to fit on a bench top, the ISB-300A's efficient design allows easy integration within a small footprint. The ISB-300A is for small and medium scale applications where closed-loop feedback control and fast response times are required, the ISB-300A is especially useful for wire termination, switch assemblies, battery tabs, foils, and tang welds. The ISB-300A offers a range of key new and improved features. Six control modes are offered, which include primary limit, primary and secondary root mean square (RMS), secondary constant power, secondary voltage control, and fixed pulse. The ISB-300A provides .050-20 kA of power in 3 ranges. The low current ranges are ideal for fine applications. Pulsation and upslope/downslope can be set for WELD 1 to WELD 3. The unit provides a precisely controlled repeatable waveform, adjustable from 600 Hz to 3000 Hz in 100 Hz steps. It also offers triple pulse and is capable of setting any control mode in any pulse. Additional features include a current-shutoff function, primary short circuit protection, an I/O check screen, and a pre-weld check.

**Amada Miyachi America Inc.**

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

### High throughput, alkaline zinc-nickel process

ZINCROLYTE Sprint alkaline zinc-nickel process has been introduced by Enthone. The process is engineered to consistently deliver high throughput plating in bulk operation on complex parts commonly used in automotive and other high value applications. ZINCROLYTE Sprint features a high current efficiency maintained over the entire bath life, with an enhanced current load capacity to deliver fast plating speeds. The zinc-nickel process does not require any freezing such as carbonate crystallization and does not create any scales on anodes or other equipment. Higher conductivity results in reduced cooling. When used as part of a Perma SHIELD 1000 zinc-nickel system that includes a PERMA PASS passivate and ENSEAL sealant, ZINCROLYTE Sprint offers unsurpassed corrosion resistance.

**Enthone Inc.** | [www.enthone.com](http://www.enthone.com)

## COTEK SP Series Pure Sine Wave Inverters



SP-1000

#### KEY FEATURES:

- Models with output from 700W – 4kW
- Wide DC input range
- Light weight & low profile
- Intelligent software for power management
- Advanced protection features
- Adjustable power saving options
- Wide operating temperature

COTEK is a global leader in the manufacture of off-grid, battery-based pure sine wave inverters. This product-line enhances the reputation that COTEK has established since 1986 for innovative technology and total quality assurance. The SP series will soon become the industry standard. UL safety approved and 2 year warranty.



SP-4000

# COTEK

**COTEK The Americas - now serving Latin America!**  
For complete product specifications visit: [www.cotek.ca](http://www.cotek.ca)



# Cranes & Heavy Equipment

From rough terrains to great heights, the equipment needed to get the job done safely and efficiently at a wind power construction site must be tough and durable. Here are some of the latest cranes available today.



## Liebherr-Werk Nenzing GmbH

**Brand:** Liebherr

**Model:** Liebherr Crawler Crane Type LR 1300 SX

**Max boom length:** 282ft (86m)

**Max capacity:** 330 US tons

**Available attachments:**

- Carbon fiber reinforced plastic (CFRP) pendant links;
- 370ft (113m) luffing jib; and
- 393ft (120m) main boom.

**Additional features:**

- Able to self-erect 282ft (86m) of main boom and a 23ft (7m) heavy duty wind jib, lifting up to 83 tons and a radius of 50ft (15m);
- When disassembled, the crawler crane has a compact transport width of 9.8ft (3m);
- The self-assembly and self-loading system enables unloading and assembly without an auxiliary crane; and
- The control system includes all operating and control functions of the crane and permits delicate and secure lifting.

[www.liebherr.us](http://www.liebherr.us)



## Manitowoc Cranes

**Brand:** Manitowoc

**Model:** Manitowoc MLC650 Lattice-boom Crawler Crane

**Max boom length:** 341ft (104m)

**Max capacity:** 716 US tons

**Available attachments:**

- 515ft (157m) luffing jib; and
- VPC-MAX attachment increases boom and job combination lengths.

**Additional features:**

- Increased flexibility, with optional 71 US ton capacity fixed jib, 385 US ton luffing jib, and capacity enhancing VPC-MAX attachments;
- Performance and efficiency highlighted by best in class line pull and line speeds; and
- A new Manitowoc Crane Control System provides smooth operation, simple and in-depth diagnostic capabilities, improved function tracking, as well as increased commonality between product lines.

[www.manitowoccranes.com/MLC-VPC](http://www.manitowoccranes.com/MLC-VPC)



## Buckner HeavyLift Cranes, LLC

**Brand:** Liebherr

**Model:** LR1600/2

**Max boom length:** 453ft (138m)

**Max capacity:** 660 US tons

**Available attachments:**

- Fixed jib lengths 39ft - 118ft (12m - 36m); and Luffing jib lengths 79ft - 315ft (24m - 96m)
- Derrick attachment system utilizes either a suspended tray or a ballast wagon, capable of using up to 770,000 pounds of additional counter weight to enhance overall lifting capacity.

**Additional features:**

- Liccon Software system, which produces interactive lift-planning and load-chart selection in real-time, enabling the user to efficiently pre-plan any potential lift situations;
- Ballast wagon/Tray system allows user to hydraulically manipulate the counterweight fore and aft—during an actual lift to avoid site obstructions; and
- The popular wind turbine configurations include: the SL3F using 276ft main boom and 39ft of fixed jib (for 80m towers), and the SL3F using 344ft main boom and 39ft of fixed jib (100m towers).

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



## Maxim Crane Works, L.P.

**Brand:** Manitowoc

**Model:** Maxim Crane Works, L.P.

**Max boom length:** 610ft (186m)

**Max capacity:** 825 US tons

**Available attachments:**

- 380ft main boom;
- 55A heavy-lift boom; and
- 25ft upper boom point.

**Additional features:**

- Maxim Crane Works' fleet of five Manitowoc 18000's are well-suited for grassroot/maintenance on 80m to 1000m wind towers;
- Maxim Crane Works is a coast-to-coast provider of comprehensive lifting services, offering maintenance and service programs promoting maximum uptime with minimal delays; and
- To set the blades, Maxim Crane has an additional fleet of Manitowoc's, including All Terrain Cranes, and several Manitowoc MCL 300's.

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



## Lampson International, LLC

**Brand:** Lampson

**Model:** Lampson Transi-Lift LTL-3000

**Max boom length:** 540ft (165m)

**Max capacity:** 3000 US tons

**Available attachments:**

- Up to 120ft of Lampson jib; and
- 20ft jiblet.

**Additional features:**

- 3,000 ton front crawler;
- Hydraulic hoisting capabilities;
- Easily transportable by conventional trucks; and
- Counterweights assembled and filled on-site.

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



## ALL Erection & Crane Rental

**Brand:** Liebherr

**Model:** LTM 1750-9.1

**Max boom length:** 171ft (52m)

**Max capacity:** 900 US tons

**Available attachments:**

- N/A

**Additional features:**

- The LTM 1750-9.1 offers mobility, transportability, and quick assembly - all on a chassis no longer than that of a 600-ton crane;;
- The road-friendly LTM 1750-9.1 can travel at less than 155,000lbs GVW by easily removing the telescopic boom, the upper engine, and the rear outriggers;
- Once at a job site, the strong boom can be self-installed with the aid of an auxiliary rolling power pack (without the use of a boom launch trailer), and the rear outriggers also self-install so one outrigger can be done in less than 10 minutes; and
- The availability of crab steering mode on the fly offers a driver the ability to seamlessly switch between standard steer and crab steer without needing to raise an axel.

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





# 2016

# SOLAR BUYERS GUIDE

## DIRECTORY

ADHESIVES, SEALANTS, TAPES & PASTES  
ALUMINUM EXTRUSION & METAL FABRICATION  
BACKSHEETS  
BALANCE-OF-SYSTEMS (BOS)  
BATTERY | ENERGY STORAGE  
COMPONENTS | ELECTRICAL PROTECTION  
CONCENTRATED SOLAR POWER (CSP)  
CONSULTING SERVICES | BUSINESS & ENVIRONMENTAL CONSULTANTS  
CONTRACTORS | EPC  
ECONOMIC DEVELOPMENT  
EDUCATION | RESEARCH DEVELOPMENT  
ELECTRICAL WIRE, CABLE & CONNECTORS  
ENCLOSURES | COMBINER BOXES  
ENERGY SERVICE PROVIDERS  
ENGINEERING | OPERATIONS & MAINTENANCE (O&M)  
FINANCIAL SERVICES  
GROUND SCREWS | ANCHORS  
HANDLING | MANUFACTURING

INVERTERS  
LEGAL SERVICES  
LIGHTNING & SURGE PROTECTION  
MICROINVERTERS  
MODULES  
PERFORMANCE MONITORING  
POSITION SENSORS  
PV DISTRIBUTORS  
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SITE ASSESSMENT & FORECASTING

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SOLAR FASTENERS  
SOLAR GLASS | ENCAPSULATION  
SOLAR HOT WATER DISTRIBUTORS  
SOLAR INTEGRATION  
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SOLAR SUPPORT STRUCTURES & CARPORT SYSTEMS  
SOLAR THERMAL MANUFACTURING & EQUIPMENT  
SOLAR THERMAL SYSTEMS  
TEMPERATURE PROFILING  
TESTING & CERTIFICATION | TESTING CHAMBERS  
THEFT PROTECTION  
THIN FILM MATERIALS  
TOOLS  
TRACKING SYSTEMS  
TRANSPORTATION | LOGISTICS  
UTILITY SCALE SOLAR | PV  
WEATHER STATIONS

OTHER  
Aerial Imagery & Measurements  
Applied Light Spectrum  
Equipment Manufacturer  
Machine Vision  
Microgrid Control Systems  
Permitting Services  
Printing/Metallization Equipment & Services  
Radiant Heating  
Remote Asset Management  
Roof-Top Pipe Support  
Solar Solutions Provider  
Vacuum Chambers & Components  
Vacuum Valves  
Valves, Measurement & Control Systems

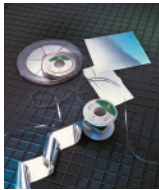


## Adhesives, Sealants, Tapes & Pastes



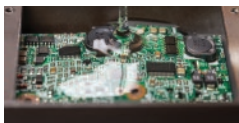
### H.B. Fuller

H.B. Fuller's TONSAN business offers a full range of bonding and sealing solutions for the whole solar production chain. Their silicone, acrylate, epoxy, and polyurethane technologies are solutions for meeting solar customers frame sealing, j-box attaching and potting, rail bonding, edge sealing, ingot bonding, backsheet lamination, and inverter potting needs. Whether it's liquid sealant, tape, or dispensing equipment, H.B. Fuller develops engineering adhesives solutions. [www.hbfuller.com](http://www.hbfuller.com)



### Indium Corporation

Indium Corporation provides a wide range of interconnect solutions for Thin-Film (CIGS, CdTe, a-Si), crystalline silicon and Concentrated PV (CPV) technologies. Products available are; Liquid Tabbing & Stringing Flux, Thin-Film Low Temperature Metallization Paste, CPV Solder Preforms, Indium containing and non-Indium containing Solder Wire, Flux-Cored Solder Wire, Solder Paste, and Low Temperature Soldering. [www.indium.com](http://www.indium.com)



### Quantum Silicones, LLC

Silicone encapsulants and sealants offer environmentally friendly, long-term protection to meet the demands of a variety of solar panel applications—from panels to junction boxes. UV-resistant encapsulating grades can outperform the durability of organics. Quantum Silicones offer optically clear and non-yellowing systems, with corrosion-resistant properties, as well as thermally conductive grades for heat management. UL-rated, flame-retardant, potting grades are also available for junction box applications. Additionally, silicones with primer-less adhesion are offered that work with a wide variety of plastics. [www.quantumsilicones.com](http://www.quantumsilicones.com)



**BUILDING TRUST**



### Sika Corporation

Sika supplies a full range of engineered silicones, polyurethanes, and modified silane adhesives and sealants that meet the stringent performance demands of customers in the solar energy industry. They offer solutions that have been optimized to provide for long-term performance, curing speed, and increased process throughput capabilities. Sika continually strives to exceed standards in terms of their product assembly operations and field installation services, as well as in terms of the global engineering support they provide customers. [www.sikausa.com](http://www.sikausa.com)

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BATTERY ENGINEERING

The longest lasting battery for your off-grid home.

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**Aluminum Extrusion & Metal Fabrication**



**American Roll Formed Products, Corp.**

American Roll Formed Products is a full-service metal fabrication corporation, serving a number of the solar energy market's needs. Services include: roll forming; press-braking; turret punching; galvanizing and welding. A true, one-invoice source for all solar panel mounting components, applications include: ground pilings; racking systems (ground and roof-mount); panel support rails; PV framing; and wire management solutions.

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

**sapa:**



**Sapa Extrusions North America**

Sapa Extrusions, a global manufacturer of aluminum profiles, works with customers to establish finished designs for custom features and improved end-use applications. Sapa's manufacturing capabilities include standard and custom extrusion, finishing (painting and anodizing), as well as full fabrication and logistic services. Sapa provides solutions to all solar market segments including: PV racking and mounting systems (open field, flat roof, and residential); solar thermal (H2O) applications; module frames and components; concentrated solar power collectors, inverter housings and components; and thermal management solutions.

[www.sapagroup.com/na](http://www.sapagroup.com/na)

**Backsheets**



**Coveme spa**

Coveme's polyester based, 100% recyclable, dyMat PYE backsheet was launched in 2008 and Coveme has recently developed a backcontact backsheet, called EBfoil. It features a flexible electronic circuit printed according to the customer's pattern and functions as a conductive element between the cells, reducing the loss of electrical conductivity and reducing the cell-to-module (CTM) efficiency loss.

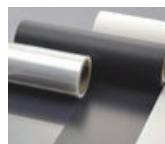
[www.coveme.com](http://www.coveme.com)



**FLEXcon**

FLEXcon has announced the expansion of its solar module backsheet offering with the addition of Black/White and Black/Black products. FLEXcon's existing white backsheet offering, which includes double fluoropolymer (TPT and KPK), single fluoropolymer (TPE and KPE), and non-fluoropolymer (PPE), is ideal for solar farms, commercial, and residential installations. The new, aesthetically pleasing black backsheet products appeal to the high-end commercial market as well as the residential market.

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



**Griff Applied Laminates**

Griff Solar is a manufacturer and supplier of photovoltaic films including polymeric based superstrates (front sheets), substrates (back sheets), masking films for buss bars and connection boxes, tapes, and release liners. Griff's backshot material layer options include: PVF/PVDF for UV protection & chemical stability; PET for dielectric & mechanical barrier; EVA for encapsulation; Primer with proprietary formulas for adhering layers together; Aluminum for structural integrity & environmental protection; and ECTFE, Fluoropolymer topsheet in lieu of glass.

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



**KREMPEL-GROUP**

KREMPEL's backsheets reliably insulate and protect crystalline and thin-film solar modules against environmental effects and UV radiation. Classical materials, including AKASOL PTL (TPT) and AKASOL PVL (KPK) with fluoropolymer film as the cell-side and outer layer, have proven their quality worldwide in over 20 years of use. The PTL type of material is TEDLAR-PVF film, whereas the PVL type uses KYNAR-PVDF film. In addition, AKASOL TPE and AKASOL KPE have been developed to provide a more cost-effective solution as in both cases; the outer layer is still a fluoropolymer film, whereas the cell side is in the form of a primer layer with outstanding UV absorbers. KREMPEL also offers a low-cost, fluoropolymer-free alternative AKALIGHT ECS 385.

[www.krempele-group.com](http://www.krempele-group.com)



**Nexus Plastics California**

Nexus is a manufacturer of poly films for polysilicon industry contamination prevention bags and film polysilicon chunk bags. They also provide leakproof seals and bags, high purity films, ultra pure films, clean room films.

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

**Tomark-Worthen, LLC**

Tomark-Worthen's backsheets are durable, have high RTI, and performance. Tomark-Worthen has created a new backsheet based on a proprietary polyamide alloy that is weatherable, dimensionally stable, cost effective, it does not contain any fluoropolymer layers, and does not use any adhesives. The core is not susceptible to hydrolysis or UV degradation and provides the structure with dimensional stability and strength.

[www.tomark-worthen.com](http://www.tomark-worthen.com)

**Balance-of-Systems (BoS)**

**Blue Sky Energy**



**Blue Sky Energy**

Blue Sky Energy offers one of the industry's most complete lineups of small to mid-power multiple power-point technology (MPPT) solar charge controllers. Quality materials and extreme efficiency make them ideal for deployment in mission-critical applications worldwide. The reliability and simplicity of their design ensures protection against most common user errors, allowing for easy networking set-up and use, including optional remote monitoring over the Internet. Programming or viewing of all settings is possible without extra accessories and via any computer. The two-wire network interface permits multiple controllers to function as a single coordinated charging machine. Made in the USA.

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



**CAB Products**

CAB Products system for Solar Cable Management in large-scale PV ground mounts uses messenger wire and CAB hangers to manage cabling in 1 or multiple runs. It saves on product, labor, troubleshooting, and O&M costs.

[www.cabproducts.com/solar-power](http://www.cabproducts.com/solar-power)

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







**Can Solar, Inc.**

Can Solar, Inc. offers their solar combiner box in three models, which require no internal cabling. All connectors, DIN rails, stoppers, and cable glands are formed on the combiner body, which can be set up in just four minutes. They are NEMA 4X, UL94V-0 flameproof, TUV, TUVus, and AS/NZS certified; plus US, Europe, Taiwan, and China patented. Can Solar's combiner boxes are for outdoor and indoor residential, and commercial scale solar systems. An available option is to have the fuses and/or surge arresters pre-installed.  
[www.cansolarenergy.com](http://www.cansolarenergy.com)



**Solar Data Systems, Inc.**

The Solar-Log & GE Meter combines residential solar PV monitoring and revenue grade metering in a single device. This plug-and-play socket meter does not require onsite configuration. A compact design with Solar-Log technology and GE's I-210+ residential meter, compatible with all 240 Vac Single-phase string and micro inverter systems. ANSI Certified and complies with UL 61010-1 and CAN/CSA C22.2 No. 61010-1. The product line offers solutions including power management, inverter direct monitoring, consumption monitoring, and battery storage monitoring. All Solar-Log & GE Meters come with a 5-year warranty, cellular data plan, and the Solar-Log WEB.  
[www.solar-log.net](http://www.solar-log.net)

# Trace the Sun CAPTURE THE BENEFIT

Get the most optimal energy with Sun Action Trackers' premium choice technology.



**Midnite Solar**

MidNite Solar manufactures balance-of-system (BoS) products for the solar energy industry. They specialize in combiner boxes, surge protection, prewired systems, AC/DC Disconnects, charge controllers, as well as Rapid System Shut down solutions.  
[www.midnitesolar.com](http://www.midnitesolar.com)



**Shoals Technologies Group**

Shoals' combiner-less BLA harness has helped streamline installation while creating between 20 and 60% material savings. The newest addition to this is the introduction of BLM which adds current and voltage monitoring along with autonomous I-V curve measurement. I-V curve measurement provides more information about the performance of a PV module or array than any other measurement method and is coupled with the fastest possible measurement tools. The entire system is plug and play and completely wireless - allowing for maximum functionality.  
[www.shoals.com](http://www.shoals.com)



PST-2AL  
Dual Axis Tracker



PST-1AX6  
Single Axis Tracker



[sat-energy.com](http://sat-energy.com)





### SolarBOS

SolarBOS Wire Harness Solutions are the latest addition to the company's product line and they include overmolded harnesses with or without inline fuses, homerun cable assemblies, and combiner box whips. All wire harness assemblies are custom manufactured to client specifications. Customers can choose from various American wire gauges (AWGs) and conductor jacket colors, industry-standard connectors, and custom labels at each connection point. SolarBOS manufactures its wire harness and cable assembly solutions at its Grand Rapids, Michigan facility.  
[www.solarbos.com](http://www.solarbos.com)



### BMZ USA

The new 6.8kWh ESS 7.0 lithium energy storage unit offers high performance in a modern, aesthetically pleasing design intended for residential and small commercial use. The 48V, high efficiency unit offers a seven-year warranty at 5,000 cycles, with a potential life span of up to 20 years. It is the only lithium product technically certified by SMA to work with Sunny Islands inverters worldwide. The plug and play system and can be programmed to accommodate other inverters using CAN Open, RS232, RS485, MOD BUS and UART for customized, white labeled solutions worldwide.  
[www.bmz-usa.com](http://www.bmz-usa.com)



### Humless

Humless offers an all-in-one, portable power storage for home, business, or recreational uses. Light, and versatile, its UPS capabilities enable users to be truly off-grid with zero installation configuration. Its plug and play with long-life (7yr+) expandable battery packs offer integrated solar and wind charge and discharge, pure sine wave output, and a range from 1.5kWh to 38kWh.  
[www.humless.com](http://www.humless.com)



### Maxwell Technologies, Inc.

Ultracapacitors by Maxwell Technologies can provide reliable and stable renewable energy firming for solar installations. Maxwell's 56V module provides scalable energy grid storage, fast-response power stabilization, and improves grid connection reliability.  
[www.maxwell.com](http://www.maxwell.com)



### Steca Elektronik GmbH

Steca Elektronik is a German manufacturer of solar electronic products which operates in the segments of PV off-grid, PV grid connected, and solar thermal. Steca's solar controllers TR A501 T U, TR A502 TT U, or TR A503 TTR U are offered as temperature differential, heating, and DHW controllers which are certified according to North American standards (UL). For use in off-grid PV systems, Steca provides a range of solar charge controllers; Steca PR 10-30, sine wave inverters, and DC appliances such as solar-powered refrigerators and freezers. The Steca PF 166/240 refrigerators can be used as either a refrigerator or a freezer.  
[www.steca.com](http://www.steca.com)



### Crown Battery Manufacturing Company

Crown Renewable Batteries are heavy weights with dense plates that use more active lead material, increasing battery performance and longevity. Crown currently leads the industry in lead content per ampere-hour of rated capacity. Their two-volt 2CRP3690 Power Module combines ampere-hour capacity availability to renewable energy system users. The battery delivers application flexibility, while providing an ideal solution for temperature management and electrical isolation.  
[www.crownbattery.com](http://www.crownbattery.com)



### Outback Power Technologies

OutBack's EnergyCell Nano-Carbon Partial State of Charge (PSoC) battery line offers all the safety and convenience of a VRLA battery with the cycling benefits of advanced energy storage. Nano-Carbon PSoC technology for applications where full battery recharge isn't always possible, like off-grid or limited sun hours, and can improve charge efficiency and deep discharge recovery and maximize overall cycle life by up to 44% versus a traditional VRLA deep cycle battery. Nano-Carbon technology is a high surface area carbon additive specially formulated to optimize the negative active material in lead-acid batteries to increase conductivity and add additional capacitance.  
[www.outbackpower.com](http://www.outbackpower.com)

## Battery | Energy Storage



### Alcad, Inc.

Alcad Standby Batteries provides engine start and stationary battery systems. Their Vantex New Generation Ni-Cd battery has a long cycle life, even when the charge/discharge cycle involves 100% DOD. Vantax employs an electrolyte which allows a normal operating temperature from -20°C to +40°C (-4°F to 104°F) and is available with an arctic electrolyte for use in extreme temperatures. Vantex can be stored for up to 2 years, is environmentally safe, and has a high resistance to electrical and mechanical abuse.  
[www.alcad.com](http://www.alcad.com)



### Discover Energy Corp.

Discover Tubular batteries provide maximum efficiency per discharge-charge cycle and reliability in remote, high temperature or unstable power network installations. The tubular technology features a multi-tube gauntlet construction which encapsulates the active material, resulting in cyclic stability, long life, and high capacity. Available in 2V, 6V, and 12V, Discover OPzS Flooded (Low maintenance) and OPzV Gel (Maintenance-free) provide a low overall cost of ownership in stationary and renewable energy applications.  
[www.discover-energy.com](http://www.discover-energy.com)



### Green Charge Networks

The Green Charge energy storage solution reduces energy costs associated with peak power demand charges. Charging when demand is low and discharging to shave down spikes in demand, this energy storage solution saves customers 20- 50% of their electric bill.  
[www.greencharge.net](http://www.greencharge.net)



### Rolls Battery Engineering

Specifically designed to deliver large-scale capacity and provide increased Amp-Hour over the current Rolls Renewable Energy range, the new 2 Volt 2 YS 62P offers 4860 AH capacity in a durable, dual construction case design, doubling the delivered Amp-Hour rating of the Rolls 2 YS 31P model, and providing storage capacity for large-scale off-grid and grid-tied applications. The 2 YS 62P is backed by Rolls' 10-year warranty and offers customers a versatile, high capacity 2 volt solution for use in a variety of applications and voltage configurations.  
[www.rollsbattery.com](http://www.rollsbattery.com)



/ Perfect Welding / Solar Energy / Perfect Charging



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- / Conveniently installed in under 15 minutes on a pole, rooftop, or ground mount.





**Sharp**

Sharp's SmartStorage system is an energy storage solution designed to reduce expensive peak demand charges for commercial and industrial buildings. The SmartStorage energy storage system combines Sharp's intelligent energy management system with pre-integrated system components, operating seamlessly as a stand-alone solution or when deployed along with a solar electric system. SmartStorage energy storage systems are available with an optional 10-year Asset Management Service Agreement and innovative demand reduction performance guarantee. If guaranteed performance is not met, Sharp will compensate for the deficit in promised peak demand reductions.

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



**Sun Xtender Batteries**

Since 1987, Sun Xtender AGM battery technology has been built for renewable energy applications, manufactured for energy storage and delivery. Absorbed glass mat deep cycle battery construction allows for cycles of varying charge and discharge lengths without the need for maintenance. Sun Xtender's AGM technology can sustain multiple deep cycles because the battery doesn't have a `memory` of cycle length and depletion state. Sun Xtender batteries are designed with a low impedance configuration which allows the batteries to tolerate high in-rush current levels without damage to the cells, allowing faster recharge time while absorbing the charge.

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



**SUNRRN of Virginia, Inc.**

SUNRRNs ("SunRunners") are portable, stand-alone, renewable energy power systems for off-grid electricity or emergency backup, delivering high-output, high-capacity stored solar or wind, for use any time or place electricity is required for commercial and residential applications. Applications include: water-pumps, small construction sites, agribusiness, off-grid locations, disaster relief, alternative to gas generator disadvantages, and blackout preparedness. SUNRRNs are plug-and-play and produce no noise, fossil fuels, or emissions. They are rugged, with a long-life design, and are easily expandable.

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



**SimpliPhi Power**

SimpliPhi Power storage creates energy security with a 98% efficiency charge/discharge rate, 5000+ cycles, and 10-year warranty. Its Smart Tech OES2.6 & OES3.4 kWh batteries scale up to hundreds of kWhs and integrate into residential and commercial systems, both on and off grid. They feature a safe, non-toxic, Lithium Ferro Phosphate chemistry with proprietary architecture and power electronics. The operating temperature of the Smart Tech batteries ranges from -4° to 140°, and does not require heat mitigation, nor pose a risk of thermal runaway. SimpliPhi has more than 5MW of products deployed around the world, including for the US Army and Marine Corps.

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



**SunSystem Technology**

SunSystem Technology (SST) offers a full complement of batteries and storage options and their installation for both new and existing systems. From initial commissioning to ongoing O&M and asset management support for large-scale solar energy facilities (SEF) and residential fleets, SST ensures its clients enjoy optimal system performance, minimal system downtime and maximized system production values.

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



**Tellus Power**

Tellus manufactures a rugged, high quality, affordable networked electric vehicle charging station made with ¼-inch marine grade aluminum. No safety bollards are needed, and dual port, level 2 chargers deliver a full 7.2 kW charge to two vehicles simultaneously. Tellus also distributes Asola building-integrated architectural solar glass and STGCON lithium-ion battery storage and capacitors.

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



*Clean energy for life.*



**Trojan Battery**

Trojan offers deep-cycle flooded, AGM, and gel products for a range of renewable energy hybrid systems and backup power applications. To address the issue of Partial State of Charge (PSOC), Trojan has developed Smart Carbon, a proprietary formula of carbon additives to enhance life and performance of Trojan's Industrial and Premium batteries operating in PSOC. Trojan offers Reliant AGM with C-Max Technology, a true deep-cycle AGM battery engineered for applications requiring deep-cycling power in a non-spillable design. Reliant AGM provides sustained performance and total energy output, delivering quality and reliability.

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



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All Your Commercial & Utility PV Racking Needs  
Ballasted Ground Post Ground Roof Tracker



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Independent Assessment by Black & Veatch  
ETL/UL 2703 Tested 20 Year Warranty







### U.S. Battery Mfg., Co.

U.S. Battery manufactures a variety of deep-cycle batteries, including for solar and renewable energy projects, which are all manufactured in the US and distributed worldwide. Products include: deep-cycle, flooded lead-acid batteries; AGM-sealed, low-maintenance batteries; and single-point watering systems. U.S. Battery's renewable energy (RE) series, deep-cycle batteries are available in two-volt and six-volt configurations.  
[www.usbattery.com](http://www.usbattery.com)



### ViZn Energy Systems

ViZn Energy designs and manufactures expandable building block Zinc/Iron Flow batteries in 1 MW to multi-MW installations. The GS200 Energy Storage System is self-contained, modular storage system delivering cost-effective and safe energy storage. The Zinc/Iron redox flow incorporates an efficient and worry free non-acid chemistry. The flexible GS200 modules can be interconnected for higher power and energy requirements  
[www.viznenergy.com](http://www.viznenergy.com)



### Win Inertia

Win Inertia's energy storage solution offers high power density, high energy density, is designed to ensure grid stabilization, and provide an optimal response for a wide variety of energy events. Win Inertia has developed a hybrid energy storage solution, SHAD, based on the hybridization of high power ultracapacitors with any other energy storage technology (batteries, flywheels, etc.) under a unique DC bus. This system, balanced to meet customer needs, is then combined with Win Inertia's power electronics and energy management algorithms, that enable the SHAD solution to offer a large portfolio of energy services.  
[www.wininertia.es](http://www.wininertia.es)

## Components | Electrical Protection



### Bal Seal Engineering, Inc.

Bal Seal Engineering, Inc. provides custom-engineered sealing, connecting, conducting, and EMI/RFI shielding and grounding solutions. The company's products employ its Bal Spring canted coil spring technology to promote enhanced equipment performance and reliability. Bal Seal works with OEMs to design and produce sealing, connecting, and conducting solutions used in solar power generation. These solutions enable engineers to protect precision components, design more compact, efficient electrical connectors, and compensate for misalignment caused by thermal expansion.  
[www.balseal.com](http://www.balseal.com)



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 At a water pressure of 30 psi, 6x more pressure than the industry testing standard,  
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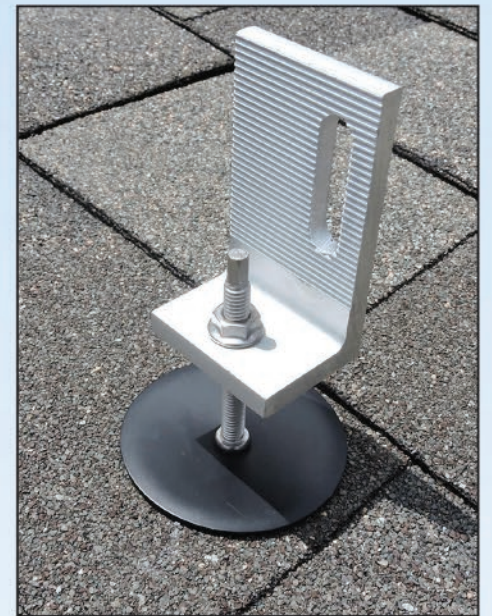
What does this really mean?

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**467 inches of rain.**

It would take rainfall of  
**BIBLICAL PROPORTIONS**  
 to get through the QuickBOLT!

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**Clark Rubber & Plastic**

Clark Rubber & Plastic is a custom manufacturer of extruded and molded rubber and plastic components used in the solar industry. Clark Rubber & Plastic develops and manufactures custom rubber and plastic quality components such as clamp inserts, grommets, rub strips, and fastening applications. [www.clarkrandp.com](http://www.clarkrandp.com)



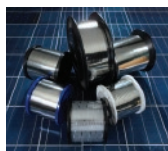
**Gigavac**

Designed and manufactured in the USA, GIGAVAC offers the smallest UL508 recognized contactors for high current switching at 1000Vdc. The patented series includes HX EPIC contactors rated to 350A+ and the cost effective GIGAVAC MiniTACTOR series rated up to 50A. GIGAVAC's patented sealing technologies provide complete protection beyond what is offered by traditional hermetic seals. Sealed switching technology means these contactors can safely be used in nearly any harsh environment, and at temperatures up to 85°C. They are not position sensitive and can be mounted in any axis. The HX series includes models with optional auxiliary contacts. [www.gigavac.com](http://www.gigavac.com)



**Littelfuse**

The Littelfuse SPXI 1500 Vdc solar fuse is designed to integrate into an in-line assembly within a wire harness. The fuse provides string protection that meets UL2579 for photovoltaic applications. The SPXI can be electrically insulated by either over-molding or using approved heat-shrink. Also available in 1000Vdc (SPFI), the products protect solar strings from 2 to 30 amps. Littelfuse offers numerous DC circuit-protection products uniquely suited to protect the equipment and systems subject to the harsh environments of PV installations. [www.littelfuse.com/solar](http://www.littelfuse.com/solar)



**Luvata**

Luvata has been manufacturing its PV solar ribbon, Sunwire, for over 20 years. With a high-purity oxygen-free copper core base, Sunwire ES offers notable electrical conductivity combined with guaranteed elongation (resistance to fatigue), and yield strength (softness). These mechanical properties reduce cell breakage rates and improve productivity. [www.luvata.com/sunwire](http://www.luvata.com/sunwire)



**Mersen**

Mersen now offers a complete portfolio of 1500VDC components for the solar market including string and NH style fuses, fuse gear, surge protective devices, power distribution blocks, and switches. This portfolio provides high technology products for early design into 1500VDC systems and furthers Mersen's ability to partner with customers for custom designed and integrated systems supported by a single trusted manufacturer. [ep.mersen.com](http://ep.mersen.com)



**POCO Holding Co., Ltd.**

POCO Holding Co. provides metal alloy powder, powder core, and application solutions for inductors. [www.pocomagnetic.com](http://www.pocomagnetic.com)



**Rotek Incorporated**

Rotek Incorporated is a manufacturer of large diameter slewing bearings and rolled ring forgings. Rotek slewing bearings are used in various applications, including in solar energy panels where tracking is critical. Offering full engineering support, Rotek manufactures large diameter, lightweight solutions with consistent repeatability for intermittent or oscillating needs. They're also ideal for any design scenario where precision is needed with other components. [www.rotek-inc.com](http://www.rotek-inc.com)

**BITIMEC WASH-BOTS .COM**

Wash 10,000+ panels in a single shift – 59HP Kubota Turbo-diesel – rubber tracks – 640 gallons water tank – 4 sizes of brushes – twin joystick controls. **203-637-1900** [info@wash-bots.com](mailto:info@wash-bots.com)





### Schurter Electronic Components

SCHURTER's ESO 10.3x38 is designed to safely and securely insert and extract 10.3x38mm fuses into clips, as well as provide a touch-safe cover according to IP20 specifications. Applications include solar inverters, string fuse boxes, and battery charge controllers in the energy and industrial sectors. Rated up to 32A at 1500VAC/VDC, the ESO carries cURus certification when used in combination with SCHURTER's CSO fuse clips. [www.schurterinc.com](http://www.schurterinc.com)



### WILEY

BURNDY now offers the Wiley WEEB (Washer, Electrical Equipment Bond), a simple, consistent, and low-cost method to bond PV module frames and racking together. The WEEB is inserted between the module frame and mounting rail. When the WEEB's teeth pierce the anodized coating, the result is conductivity without oxidation, bonding the PV module frame with the metal racking structure. [www.burndy.com](http://www.burndy.com)



### STEGO, Inc.

STEGO's CSF 060 is a touch-safe heater for use in enclosures. The design of the heater utilizes natural convection which results in a circulating current of warm air. The surface temperatures on the accessible side surfaces of the housing are minimized as a result of the heater design. This model with plug-in thermostat does not require additional wiring. The CSF 060 is also available in a version without thermostat (CS 060). [www.stegousa.com](http://www.stegousa.com)



### Telergon S.A.U.

Telergon's S6000 and S5000 DC load-break switches are UL listed to the UL98B standard at 1000 VDC. They're typically used in string combiner boxes, re-combiner boxes, and inverters, and can be used to safely disconnect live, direct current at up to 1000 VDC. Telergon's S6000 switches are rated for 250 amps 1000 VDC, allowing grounded and ungrounded configurations without the use of jumpers. The S5000 switches are available for 400 amps, 600 amps, and 800 amps, with external jumpers. [www.telergon.es](http://www.telergon.es)

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Why is Skyline Solar of AZ Chosen Time and Time Again? **QUALITY, CUSTOMER SERVICE AND DEDICATION**

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ECHO Systems provides commercial and institutional solar thermal systems as well as flat plate collectors, evacuated tube and solar concentrators, custom thermal storage, and immersed heat exchangers. Their systems provide domestic hot water, heating and cooling, and process and power generation.

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

**Consulting Services | Business & Environmental Consultants**



**DNV GL**

DNV GL is currently the largest global provider of independent renewables and energy advice. They work with investors, project developers, owners, and equipment manufacturers to help manage risk throughout the entire project life cycle to ensure the performance and safety of systems from residential solar rooftops to multi-megawatt power plants. DNV GL's services include: energy assessment; independent engineering; owner's engineering; technology reviews; pre-construction engineering, environmental, and permitting; asset management; solar grid integration; solar storage applications; certification testing; and PV module and inverter testing.

[www.dnvgl.com/solar](http://www.dnvgl.com/solar)



**Ecology and Environment, Inc.**

Ecology and Environment, Inc. (E & E) offers all the professional environmental support required to site, permit, and operate solar energy generation and transmission facilities. E & E covers all the bases—from water supply, wetland considerations, and ecological impact studies, to land use, socioeconomic analyses, and community outreach. Operating across the US, with subsidiaries and affiliates around the world, E & E provides global energy industry experience, including environmental support for more than 3,565 MW of PV capacity. Their skilled, multidisciplinary project teams help solar energy developers get the green light faster when it comes to solar projects.

[www.ene.com/service/energy/solar.aspx](http://www.ene.com/service/energy/solar.aspx)



**Luminate, LLC**

Luminate offers solar resource consulting and independent engineering services in support of the development, financing, construction, and operations of solar PV and thermal power generation. They provide the full complement of solar resource consulting and independent engineering services in-house, providing for seamlessly integrated work product. Their experience includes dozens of utility-scale and distributed solar projects and portfolios comprising nearly 10 GW, ranging from rooftop installations to large utility-scale PV and CSP projects.

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



**R.J. Burnside & Associates, Ltd.**

R.J. Burnside & Associates provides environmental and engineering consulting services in support of renewable energy generation and energy conservation. They have experience on solar, wind, water, biogas, and biomass electricity generation and transmission projects. Their broad spectrum of experience and expertise in balancing the environmental, technical, and economic and social responsibilities associated with energy projects enables them to manage renewable energy projects throughout all phases from planning through to decommissioning.

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

**Contractors | EPC**



**Blattner Energy**

Blattner Energy is an EPC contractor in renewable energy construction with more than a century of large-scale project experience and over 25,000 megawatts of renewable energy installed across North America. Blattner provides EPC services for solar, energy storage, wind, and high voltage transmission and substation projects. Within the solar market, Blattner's services include: project feasibility, engineering and design capabilities, material procurement and management, pre-construction activities, full-service construction, testing and startup, operations and maintenance (O&M), and collaborative construction management. Blattner delivers a construction experience with adding value throughout all phases of the project lifecycle and raises industry standards for safety and quality assurance.

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



**Fagen, Inc**

Fagen, Inc. is an international industrial contractor headquartered in Granite Falls, MN. Utilizing a database of over 25,000 direct-hire employees, Fagen, Inc. has constructed a variety of successful projects including solar, wind power, biomass to power, conventional power, renewable fuels, and other industrial process facilities. Fagen, Inc. has been ranked among contractors and design-builders by Engineering News-Record (ENR) top 400. Fagen, Inc. has a bonding capacity of \$1.5 billion and no corporate debt. Fagen, Inc. self performs civil, structural, siding, insulation, millwright, piping, instrumentation, electrical, and start up services.

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



**Franklin Electric**

SubDrive SolarPAK combines solar technology with groundwater pumping equipment to offer a rugged, high-output system which tackles the challenges of off-grid pumping. With the option to partner with Franklin Electric's network of professional pump installers, solar pumping in 5 to 90 gpm flow rates is available. SolarPAK features a standard four-inch Franklin Electric pump and motor packaged with a solar controller. It works with both new and existing solar arrays containing as few as three solar panels. A low voltage option is also available. The system uses a 100 V motor combined with a 0.55 kW control to operate on less overall power.

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



**Bombard Renewable Energy**

Bombard Renewable Energy has installed more than 120 megawatts of solar energy in Nevada. They build systems utilizing solar photovoltaic (PV), wind energy, and concentrated PV. Bombard Renewable Energy offers turnkey services from conception to maintenance, as well as planning, proposals, cost analysis, design, procurement, and installation for commercial, utility, residential, non-profit solar, and wind projects.

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

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### Polaron Solartech Corp.

Polaron Solartech Corporation is a BBB accredited business providing residential, commercial, and wholesale customers a complete solar solution. From design developing, financial planning, permit acquisition, and installation to ongoing monitoring, professional maintenance, and support of solar energy systems. Polaron delivers engineered solutions with Free Solar, Co-Investment, and other programs across Ontario to ensure their customers solar power systems with savings.

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



### Rosendin Electric

Rosendin Electric, an employee-owned company, is one of the renewable energy industry's largest engineering, procurement, and construction (EPC) builders of mid- to large-scale solar PV systems. With over 1.2 GW of project installation experience to date, Rosendin Electric brings the turnkey expertise and EPC capabilities to develop efficient and cost-effective solar solutions to customers.

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



### Signal Energy Constructors

Signal Energy Constructors is a full-service design/build general contractor, providing engineering, procurement, and construction (EPC) services for utility-scale solar/PV projects throughout North America. They have the ability to self-perform the key components of any solar project, including the structural foundations, mechanical completion, and installation of fixed and tracking systems. They can also complete the HV electrical design of substations, collection systems, interconnection facilities, and transmission lines, while assuring clients that their construction projects will be completed on time and within budget.

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



### SunSystem Technology

SunSystem Technology (SST) offers complete contracting services for industrial and utility-scale photovoltaic systems. In addition, from initial commissioning to ongoing O&M and asset management support for large-scale solar energy facilities (SEF) and residential fleets, SST ensures its clients enjoy optimal system performance, minimal system downtime, and maximized system production values.

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

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NEC code revisions are being made so that first responders can operate in safe, non-life-threatening conditions. That's the same reason behind SOLARCHECK Rapid Shutdown (RSD) from Phoenix Contact.

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**Economic Development**



**Kansas Department of Commerce**

Kansas is committed to renewable energy and is on track to meet its goal of generating 20 percent of the state's energy from renewable sources by 2020. International clean energy companies, including solar glass producers, have found Kansas to be an ideal location from which to serve the U.S. market. The state offers a 10-year property tax exemption for projects generating electricity from renewable sources to encourage continued development in this area. There has been strong growth in the use of solar in both urban and rural locations across the state.

[www.kansascommerce.com/kbiz](http://www.kansascommerce.com/kbiz)



**Pampa Economic Development Corporation**

The Pampa EDC works to help start-up companies develop, existing companies expand, and recruit new companies to the community. They provide business counseling at no charge. The Pampa EDC Board of Directors will also consider providing low interest loans and forgivable loans. The Pampa Energy Center industrial park, is in a reinvestment zone of almost 4,000 acres. Clean energy is quickly becoming a major player in Pampa and surrounding counties. They invite clean energy related companies to consider locating in Pampa/Gray County and experience the development of the renewable energy industry.

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



**Rutland City Vermont / RRA**

Rutland City, Vermont, has become a green leader for the Northeast by embracing solar development, adopting innovative policies and partnerships, and supporting energy based technology. The City will continue to support this industry sector by assisting companies working in the fields of energy innovation, renewable energy, and environmental technology to grow and succeed. In an effort to become a regional technology hub the City has developed a Business Incentive and Assistance Program which includes grants, loans, free workspace, workforce training, even relocation assistance, to encourage growing companies to locate or expand in Rutland.

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

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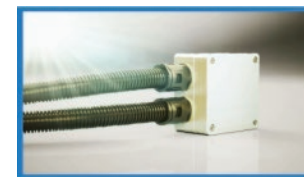


**Everglades University**

Everglades University is an accredited, private, not-for-profit university offering bachelor's and master's degree programs. They offer undergraduate degrees in Alternative and Renewable Energy Management, Environmental Policy and Management, Construction Management, Land and Energy Management, Surveying Management for Construction and Roadway, International Business, Alternative Medicine, Aviation/Aerospace, Hospitality Management, Business Administration, and Crisis & Disaster Management. In addition, they offer graduate degrees in Public Health Administration, Business Administration, Aviation Science, and Entrepreneurship. Concentrations are available. With small class sizes, innovative degree programs, and convenient scheduling to accommodate working students and adult learners, Everglades University's focus for sustainability in 2016 is on the horizon.

[www.EvergladesUniversity.edu](http://www.EvergladesUniversity.edu)

**Electrical Wire, Cable & Connectors**



**AeroUSA**

AerosUSA offers high UV-stabilized conduits and cable protection systems, rated to last upwards of 40 years in solar applications and outdoor environments. These conduit systems are characterized by their resistance to high-impact forces, along with their ability to protect and secure control cables. These systems are resistant to chemicals, and are free of silicone, cadmium, and halogen. They also have flame-retardant and self-extinguishing properties. AerosUSA's 1-piece integrated IP68/69K fitting system ensures a quick, safe, and reliable installation designed to save time and money, while eliminating potential failures. Accessories include straight, 90, 45, Y, and T's.

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



**American Wire Group**

American Wire Group (AWG) is a global supplier of wire and cable to the solar, wind, and utility industries. Specific to the solar power industry, AWG offers PV, power, control, transmission, and fiber optic cables. Handling large, utility-scale, as well as smaller, residential projects, AWG offers a variety of products to meet wire and cable needs, including the following: 15 kV to 35 kV TR-XLPE/EPR; ACSR/AAAC/AAC; PV AL cable; bare copper, aluminum, or copper clad steel; static/guy wire; OPGW; and related hardware.

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



**Electrotech Sales Group, LLC**

ESG is a wholesaler of control panel products featuring: flat cable, terminal blocks, power supplies, contactors, overload relays, smart relays, pushbuttons, pilot lights, stacklights, and enclosures.

[www.esgllc-usa.com](http://www.esgllc-usa.com)

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## General Cable



### General Cable

General Cable is a global wire and cable solutions provider for solar applications from the sun to the outlet. Engineered to withstand the harsh operating environments of solar applications, their full line of SunGen aluminum and copper PV wire is made in accordance with UL 4703 and CSA RPU90, offers superior resistance to UV sunlight, and meets the requirements for direct burial. General Cable's STABILOY Brand MC Cable, an all-in-one metal clad assembly installed as DC feeder cables for connecting combiner boxes to inverters, eliminates the need to install conduit while providing increased reliability. From low-voltage DC and AC connections and medium-voltage distribution, to high-voltage overhead and underground transmission lines, General Cable has the offering to comprise a complete cable solution for solar power applications.

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



### Helukabel USA, Inc.

HELUKABEL offers a complete line of cables and cable systems for photovoltaic installations. Their solar power products include SOLARFLEX Photovoltaic Cables, Pre-Assembled Cables Solutions, PVC Control Cables, Allweather & Rubber Cables, Medium Voltage Cables and Power Cables, as well as Cable Glands and Connectors. HELUKABEL's cables have been thoroughly tested and are resistant to UV, ozone, oil, chemicals, ammonia, cuts, abrasion, and extreme temperatures.

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



### ILSCO

ILSCO is a component manufacturer to the renewable energy industry. The ILSCO brand provides grounding, bonding, and connectivity solutions. Their BPad Solar Bonding Connectors come with an exclusive Viridium green-plating process which designates the ground points when these connectors are installed. The BPad offering is UL 2703 Recognized, as well as UL 467 Listed for grounding and bonding. ILSCO also has the ability to custom design and build products for specific installation needs.

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

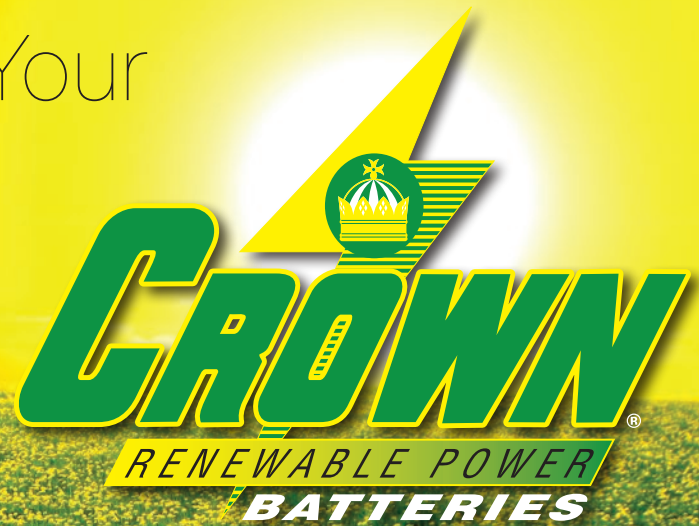


### Priority Wire & Cable

Priority Wire & Cable is a supplier of electrical wire and cable with twelve distribution centers located for overnight delivery to most customers. They supply a range of aluminum PV cable in sizes from 8 AWG up thru 1000 MCM 1/2KV PV Cable. Their cable is all UL listed PV Wire under UL 4703 in addition to Medium Voltage cable. Priority Wire & Cable also offers services including cutting, stripping, and paralleling.

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

## The Center of Your Solar System



This is where your investment in Solar & Wind Power Equipment pays off.



Crown Battery's proven array of Renewable Energy Deep Cycle Batteries. Unlike some deep cycle battery manufacturers who lump a few of their industrial products into a group and call it their RE line, Crown Battery evaluated the marketplace needs and re-engineered an entire line of 2-, 6- and 12-volt batteries to fit contemporary solar and wind power systems.



- ▶ The most complete, dedicated array of RE batteries with unmatched application flexibility and ease of handling
- ▶ Battery capacity ratings that range from 120 to 3690 ampere-hours (100 Hour Rate) and unmatched application flexibility
- ▶ Recognition of Crown Renewable Power Batteries as best-available and most-reliable by serious RE system owners

You've researched the renewable energy equipment you've bought. Now it's easy to select the storage batteries you need. Crown Batteries. Once you compare all the other renewable energy batteries in the world today, you'll find there's really no comparison. It's truly the best batteries for your solar system.

Contact us for more information: 419.334.7181  
[www.crownbattery.com](http://www.crownbattery.com)  
[sales@crownbattery.com](mailto:sales@crownbattery.com)





**Remke Energy**

Remke Energy offers an expanded family of Helio-Link solar products, including: MC/Type 4 field wireable and bulkhead solar connectors; eight- to 18-gauge PV/USE cable; assembly and installation tools and kits; thin-film junction boxes and combiner boxes; custom cable assemblies; as well as grid-tie products for grounding, binding, and termination. With shipping in one to two days, they offer 15,000 electrical products in stock at the Remke Energy Online Warehouse.  
[www.remkeenergy.com](http://www.remkeenergy.com)



**Thomas & Betts**

Thomas & Betts (T&B), a member of the ABB Group, is a solar-power system component and connections supplier. Some of T&B's products that are available for the solar power industry include metal framing, current-limiting fuses, connectors, conduit and fitting systems, and UV-resistant cable ties. T&B also provides training for the correct installation and maintenance of these products.  
[www.tnb.com](http://www.tnb.com)

**Enclosures | Combiner Boxes**



**Allied Moulded Products, Inc.**

Allied Moulded Products, Inc. offers robust, non-metallic enclosures for the solar and renewable energy industries. These non-conductivity enclosures provide increased strength, reduced weight, as well as UV- and corrosion-resistance. They are UL Listed and RoHS Compliant. Easy to install, with many options available—including full-length viewing windows—Allied has an enclosure to fit any project requirements.  
[www.alliedmoulded.com](http://www.alliedmoulded.com)



**Fibox**

Fibox is a global manufacturer of corrosion-resistant polycarbonate enclosures for the electronic and electrical industry. Fibox enclosures are designed not only to protect and insulate components and controls in the harshest of environments, but also to provide a stylish, more robust alternative to metallic and fiberglass enclosures. Fibox polycarbonate enclosures offer a stronger, yet lighter and more flexible solution, which can easily be modified to exact needs and specifications. Fibox can also customize enclosures in advance, providing customers with a ready-to-use product right out of the packaging.  
<http://fiboxusa.com>

**wöhner®**



**Wöhner USA, LLC**

SECUR Panel is for North American solar combiner box and inverter manufacturers who build to the UL1741 standard. The product offers a UL4248-18 listing at 1500 volts DC for 10x85 and 14x85 fuses as large as 30 amps. The 10/14x85 fuse holder is suitable for use with both 1500Vdc rated UL2579 listed PV fuses or IEC60269-2 certified gPV fuses. The SECUR Panel is IP20 touch-safe and provides a safe, tool-free fuse insertion and extraction, for easy fuse installation and replacement. This fuse holder uses an advanced grade plastic material in the fuse carrier to satisfy the higher operating temperatures associated with PV fuses.  
[www.woehner.com](http://www.woehner.com)

**Energy Service Providers**

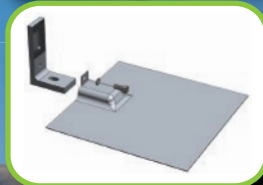


**AeroVironment**

TurboDock is a low-cost, easy-to-use commercial and workplace charging station with access control. It uses Bluetooth to provide smartphone access. With easy set-up, it can provide one universal PIN, individual PINs to each driver, or it may be configured for open access, where no codes are required. TurboDock is a solution for workplaces and apartment buildings, and can be used at retail and destination locations, or anywhere easy-to-use, affordable EV charging is needed. TurboDock is managed from a smartphone app, so software upgrades and new features are easily downloaded.  
[www.evsolutions.com](http://www.evsolutions.com)

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**Telergon**

Telergon's S6000 1500Vdc load break switch is used in string combiner boxes for load-break switching of up to 400 amps. The design of the S6000 DC load break switch allows a smaller footprint in photovoltaic combiner boxes. The elimination of bridging link accessories reduces the total installation space, cost of building the unit, and saves on the amount of required labor.  
[www.telergon.es](http://www.telergon.es)

**wöhner®**



**Wöhner USA, LLC**

Wöhner produces DIN-rail and busbar-mounted fuse holders rated for 1000Vdc PV applications. These fuseholders are targeted at North American solar combiner box manufacturers who build to the UL1741 standard. The products offer a UL4248 marking at 1000 volts DC for 10x38 fuses as large as 30 amps. They are available with or without LED-indicator lamps. The busbar mounted holder clips directly to UL-listed metric dimension busbar, eliminating the need for fabricated comb-style busbars.  
[www.woehner.com](http://www.woehner.com)



**REC Solar**

REC Solar is a renewable energy provider for businesses. REC Solar tailors financing and technology solutions to deliver bottom line savings, working with customer operations to deliver ongoing clean energy.  
[www.recsolar.com](http://www.recsolar.com)



## Engineering | Operations & Maintenance (O&M)



### Abengoa

Abengoa applies technology solutions for sustainability in the energy and environment sectors, generating electricity from renewable resources, converting biomass into biofuels, and producing drinking water from sea water. In solar, Abengoa has more than 2,200 MW completed and 484 MW under construction worldwide.

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

### BUFFALO TURBINE

[WWW.BUFFALOTURBINE.COM](http://WWW.BUFFALOTURBINE.COM)



### Buffalo Turbine

Buffalo Turbine manufactures a turbine style debris blower for touch-less snow removal from solar panels. Available models include: hydraulic, gas, and PTO. With the built-in flow and pressure control system, it allows the unit to fit a wide variety of skid steer style vehicles. The PTO unit incorporates a direct drive gearbox in place of belts, pulleys, jackshafts, and pillow blocks resulting in a light, powerful turbine style debris blower.

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

### EDF

renewable energy



### EDF Renewable Services

EDF's full range of O&M services begins prior to commissioning and goes through decommissioning. During the warranty period, they provide scheduled and unscheduled maintenance options such as balance-of-plant management, remote monitoring, and OEM oversight. They also provide total project operations and maintenance during the post warranty period. EDF's Asset Administration Services include managing projects and their commercial agreements to optimize returns over a project's lifecycle.

[www.edf-renewable-services.com](http://www.edf-renewable-services.com)

### ENERRAY

Don't worry, be sunny



### Enerray SpA

Enerray is a solar photovoltaic EPC and O&M provider, with headquarters in Italy and a presence in Mexico, Costa Rica, Brazil, Chile, Romania, Thailand, Morocco, Jordan, Egypt, Turkey, and the U.S.A. The company delivers turnkey solutions of large photovoltaic systems for industrial roofing, shelters, grounds, and greenhouses. Enerray has over 200MWp installed, and 430MWp projects currently under construction. They have working relationships with all the major international suppliers. Enerray SpA is part of a large group having over 130 years of history, more than 70 subsidiaries, and 57 factories operating in 5 continents.

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

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E & E's environmental planning teams perform all required studies for solar intensity, meteorology, hydrogeology and water availability, terrestrial and aquatic/wetland habitats, sensitive species impact, land use, socioeconomics and cultural resources.

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### Transmission

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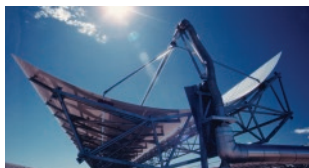
[www.ene.com](http://www.ene.com)





**RES - Renewable Energy Systems**

RES provides development and 3rd party EPC/BOS construction, and O&M services for solar, energy storage, wind, and transmission projects. [www.res-americas.com](http://www.res-americas.com)



**Sargent & Lundy, LLC**

Helping clients evaluate and implement solar technologies is an integral part of Sargent & Lundy's leadership mandate. The firm supports developers, owners, investors, contractors, manufacturers, and research organizations with diverse projects. Experience includes: solar resource assessments; owner's engineer; due diligence and conceptual/detailed facility design; as well as grid interconnection for PV, trough, tower, and dish technology. Sargent & Lundy offers complete engineering, project services, and consulting for power generation and transmission projects. [www.sargentlundy.com](http://www.sargentlundy.com)

**Stantec**

Stantec provides complete site planning, permitting, engineering, and design services for solar projects throughout North America. Their engineering services include the full range of electrical, civil, structural, geotechnical, and mechanical engineering disciplines, and can be provided either as an Owner's Engineer or as a member of an EPC team. Their environmental services for solar projects range from support in due diligence evaluations through baseline studies, permitting, and post-construction monitoring. [www.stantec.com](http://www.stantec.com)



**SunSystem Technology**

SST offers comprehensive O&M service, from initial commissioning to ongoing system monitoring, supervision, and proactive maintenance through a suite of needs-based support services. Their O&M services are designed to deliver the technical asset management actions fundamental to ensuring optimal energy production with minimal operation costs. SST understands the financial impact of their O&M services and the interdependent relationship between O&M and asset management. [www.sunsystemtechnology.com](http://www.sunsystemtechnology.com)



**Westwood Professional Services**

Westwood is a multi-disciplined engineering and surveying firm with experience gained from supporting more than 5GW of utility-scale and distributed solar projects across the U.S. Their services include: environmental studies, permitting, civil engineering, electrical engineering, geotechnical engineering, land surveying, and construction support. Westwood has offices across the nation and is licensed in engineering and surveying in nearly every state. [www.westwoodps.com](http://www.westwoodps.com)

**Financial Services**



**Rodman & Rodman, CPA "Green Team"**

The Rodman & Rodman, CPA "Green Team" provides solar energy companies with expert counsel and services in solar energy tax accounting and business strategy. They 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's highly personalized approach and reasonable fees allow companies in every stage of the business lifecycle to take advantage of their renewable expertise and experience. [www.rodmancpa.com](http://www.rodmancpa.com)



**Wunder Capital**

Wunder Capital's financing products are designed for small to mid-sized commercial solar PV projects. They work with EPCs, developers, and distributors to provide easy access to procurement, construction, and long-term financing. Their loans are project-backed, so there are no all-assets liens or personal guarantees. [www.wundercapital.com/financing](http://www.wundercapital.com/financing)

**Ground Screws | Anchors**



**American Earth Anchors**

PE46-Hex 46" Penetrator is an affordable alternative to concrete footings. Fast and easy to install, the PE46-Hex requires no digging, no pouring, and no waiting. This strong, lightweight (10lbs), aircraft-quality, cast aluminum screw anchor is tested to 14,000 lbs. pullout, and 9,000 lbs. down pressure, and can be used for easy leveling of the array on horizontal ground as well as on a hillside. Installs with a 2" socket using an electric or air impact wrench or pto from Bobcat or tractor. Bracket for post bolts to top of anchor using the 3/4" threaded hole, or if post ID is over 2.25" it will rest on flange and use the 3/8" clear hole to secure. [www.americanea.com](http://www.americanea.com)



**Ancora**

Ancora manufactures single-post foundation piles for ground-mounted systems with fixed tilt or single axis racking. Strict adherence to engineering specifications and ASTM standards are guaranteed. Foundation systems are manufactured to site specific designs for all major racking systems including pile to rack connectors. Pile options include driven wide flange beams (W6x9) with holes or slots on the web or flange, or helical piles for expansive soils or frost susceptible soils. Helical piles are available in 4.50" or 5.50" diameter pipe with the length, wall thickness, and helical size optimized for each site. All foundation piles are hot dipped galvanized for optimum corrosion protection during the project service life. [www.ancorapiling.com](http://www.ancorapiling.com)

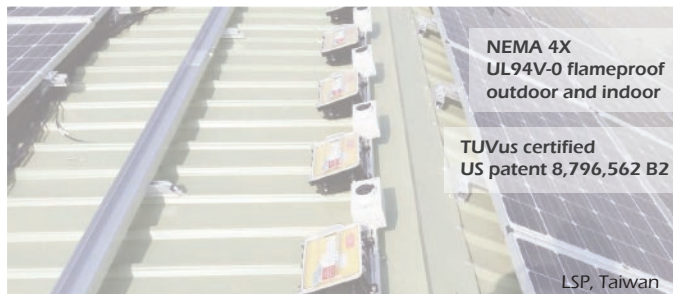
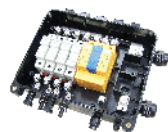


**TerraSmart**

TerraSmart's turn-key ground-mount solution includes an integrated foundation, racking, and installation service. TerraSmart also provides the patented ground screw which supports over 3GW of installed capacity worldwide. The fixed-tilt racking (with wire-management) is fully integrated with the ground screw foundation and has generous tolerances built in to accommodate difficult site conditions. Additionally, TerraSmart's rack mitigates grading, cutting, fill, and permitting fees during the site preparation process. TerraSmart also has a sizable construction fleet to ensure projects are completed on time and within budget. [www.terrasmart.com](http://www.terrasmart.com)



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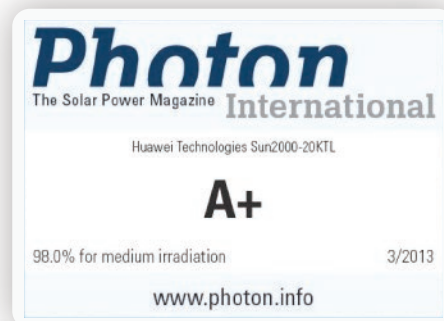
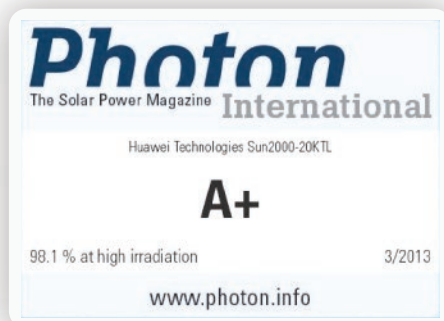
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Handling | Manufacturing



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GfE offers a wide range of planar and rotatable sputtering targets for thin film photovoltaics such as CIGS, a-Si, a-Si/ $\mu$ c-Si, CdTe, and Si wafer based cells. Standard materials include ZnO/Al<sub>2</sub>O<sub>3</sub>, i-ZnO, high purity Si, Mo, TiO<sub>x</sub>, and Cr in different qualities as well as numerous other materials as per specific customer requests. GfE's rotatable bonding technology enables them to offer a variety of materials to be bonded stress-free onto stainless steel carrier tubes.

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

**Hammond Group, Inc.**

Hammond Group's K2 Expander line reflects their most recent development work and is a comprehensive, high-rate partial state-of-charge (HRPSoC) product line for the battery industry. Hammond Group provides batteries which fulfill a wide range of requirements, including HRPSoC cycle life, moderate cycle life performance, and cold crank and capacity performance.

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



**Meyer Burger Technology, Ltd.**

Meyer Burger specializes in the development and production of advanced equipment for high efficiency solar cells; from its MB PERC upgrade cell technology to its high performance Heterojunction (HJT) and SmartWire Connection (SWCT) technologies. HJT combines the advantages of crystalline silicon solar cells with excellent absorption and passivation characteristics of amorphous silicon. SWCT employs a foil-wire electrode, creating a dense contact matrix which results in high module efficiency. The combination of HJT and SWCT has achieved module efficiencies of more than 20%.

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

Inverters



**Alencon Systems**

Alencon Systems utility scale energy harvesting inverter system will be commercially available in the second half of 2016. The system will increase financial returns by increasing yield and reducing capital costs for PV systems 10MW and above. Increased energy yields will be provided by its distributed string level MPPT control. Capital cost reductions combine a 2,500V power harvesting system using smaller conductor sizes and reduced labor costs. Its centralized inverter further reduces installation costs and operates at higher efficiency than current industry best practices. This performance is based on Alencon's patented Harmonic Neutralization technology.

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



**Bonfiglioli, USA**

Bonfiglioli's unique solution for the North American utility PV market is a fully, pre-integrated skid enclosure including modular inverters, a medium-voltage transformer, auxiliary power for tracking system, communication interface equipment, zone monitoring, and a UPS supply. The Bonfiglioli RPS Station is configurable from 1.5 MVA to 3.35 MVA, with a power factor range from near 0 to 1 lag/lead. The new RPS TL-UL boasts a market record of 1,575 kW in a single inverter or 3,150 kW in a power conversion system with enough reactive power capability to meet the project dynamic and static reactive power requirements, eliminating the need for capacitor or reactor banks. With over 2.5 GW of installed capacity worldwide in utility-scale applications equipped with advanced features such as voltage and frequency ride-through, voltage or power factor control, automatic frequency response and more, Bonfiglioli is grid-connecting PV power plants and not just PV systems.

[Bonfiglioliusa.com/PV](http://Bonfiglioliusa.com/PV)



**COTEK The Americas**

COTEK offers five unique series of pure, sine-wave inverters and inverter chargers for off-grid and backup applications. Each series delivers features to satisfy the needs of the solar power market. COTEK inverters models range from 150W-4000W, with a DC input of 12V, 24V, or 48V. The new SD series, is available in 2500W and 3500W models, with full parallel function and redundant capabilities up to 14 units. Also new is the SP series. SP models range from 700W-4000W. Both series are UL safety approved, and include advanced features unavailable on existing product lines.

[www.cotek.ca](http://www.cotek.ca)



**CyboEnergy**

The On/Off-Grid CyboInverter has an on-grid AC output port and an off-grid AC output port. Each inverter has 4 input channels that can connect to solar, wind, or batteries and produce 1150W AC power. Each input channel has its own MPPT to eliminate partial shading issues. It can work in either on-grid or off-grid mode, and switch between the two modes automatically depending on the grid condition. The system can generate power to the grid when the grid is on and can provide backup power when the grid is down. The product is patented, UL1741 certified, NEMA 6 (IP67) rated, and made in the USA.

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



**Enphase Energy**

The Enphase M215 Microinverter with integrated ground delivers increased energy harvest, and reduces design and installation complexity with its all-AC approach. With the M215, the DC circuit is isolated and insulated from ground, so no Ground Electrode Conductor (GEC) is required for the microinverter. This further simplifies installation, enhances safety, and saves on labor and materials costs.

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



SHIFTING THE LIMITS



**Fronius USA**

The Fronius SnapINverters deliver residential and commercial applications for systems of all sizes. The SnapINverters offer a range of features and options completely integrated, including revenue grade metering, rapid shutdown, arc fault protection, Wi-Fi, and free lifetime monitoring. The dual and single MPPT line of SnapINverters feature a wide voltage window, the SnapINverter hinge mounting system, and design flexibility.

[www.fronius-usa.com](http://www.fronius-usa.com)



**Heart Transverter**

Heart Transverter has developed a patented technology, the Transverter system. This complete system provides scalable solar with local energy storage, combined with automatic demand response and the smart grid with autonomous energy security. The Transverter's small intelligent nodes can both cooperate and share with their neighbors, as well as operate autonomously. These microgrids can be aggregated into small groups, and small groups aggregated into larger groups.

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



**Huawei Technologies Co., Ltd.**

Huawei's 6 string inverter provides intelligent monitoring and 80% time saving for fault detection. With real-time operation monitoring, it offers adaptive edge MPPT for fast tracking. The maximum efficiency reaches 98.6%, and CEC efficiency of 98.0%. It doesn't require an N-line, providing an AC cable savings up to 20%. The DC is AFCI compliant to UL 1699B, and the DC disconnect is integrated, offering safety and convenience for maintenance and ground fault protection with Category C surge arresters for both DC and AC. This reliable inverter has no need for external fans due to its natural cooling technology and rates an outdoor application of NEMA 4X.

[www.huawei.com/solar](http://www.huawei.com/solar)



**Ideal Power, Inc.**

Ideal Power's Grid Resilient 30kW Multi-port Power Conversion System is based on the Company's transformerless Power Packet Switching Architecture (PPSA) making it a small, light, and efficient power converter. Its bi-directional AC/DC/DC multi-port design makes it flexible for use across many applications and simplifies the integration of PV and storage. It is also ideal for off-grid or grid-tied applications. The system functions in both 50Hz and 60Hz environments giving it global functionality, and the converter's robust command and control interface simplifies code creation and maintenance, enabling fast systems integration and deployment.

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





## Ingeteam

### Ingeteam

Ingeteam has launched their new central inverter series, with a power output ranging from 610 to 1,165 kVA in a single power block. Some of its main features include, NEMA 3 protection class, Ethernet and RS-485 communications as standard, 99% maximum efficiency, low voltage ride-through capability, reactive power deliverance, and active power control. This inverter series integrates a fast running control unit, which performs an efficient and sophisticated inverter control, using a last-gen digital signal processor. The hardware of the control unit allows accurate measurements and reliable protections.

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



### KACO new energy

KACO new energy offers Blue Planet TL1 residential solar PV inverters which handle 2kW - 5kW. These single-phase inverters come with an optional AFCI. An Ultraverter module with a level inverter is also available from 1.5kW - 9kW.

[www.kaco-newenergy.com](http://www.kaco-newenergy.com)



### Northern Electric and Power, LLC

NEP is the only certified micro inverter manufacturer in Japan. It offers 250W and 300W micro inverters. In addition, it also offers 600W (for dual module) micro inverter. NEP has its product lines in both Japan and China. NEP micro inverter has very low field failure rate.

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

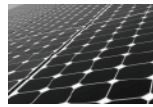


### Rhombus Energy Solutions

Rhombus Energy Solutions' power conversion products range from 1-500kW and are based on efficient sub-systems designed for flexibility and control. Rhombus integrates these sub-systems into standard & semi-custom platforms and provides either complete turnkey solutions or participates in joint development programs. Their programmable power conversion systems include a cloud-based, remote monitoring for customer and utility messaging, and are field proven with over ten years of reliable installations.

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

### Legal Services



#### Droel, PLLC

Droel, PLLC assists clients in the Renewable Energy Industry with solving complex issues, or completing intricate deals. They address every matter, large or small, with equal amount of dedication, care, and attention. Droel, PLLC has years of successful representation on record, helping them to become trusted advisors, as well as helping to create long-term relationships with all of their clients.

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



#### Troutman Sanders LLP

Troutman Sanders offers innovative solutions developed from over a century of service to the energy community. Their Renewable Energy Practice attorneys represent lenders, tax equity investors, borrowers, and lessees in various solar and other renewable energy project loan and lease financings, as well as in the development, acquisition, and disposition of renewable energy projects in the US and abroad. Their team has served as counsel on over 400 utility-scale and other renewable energy projects. Troutman Sanders understands the unique issues associated with renewable energy development and finance.

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



#### SALES OFFICE

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USA

##### Rodney Esposito

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To maximize the effectiveness of your solar energy system, you need to know how it is performing. A Kipp & Zonen pyranometer accurately measures the solar radiation available to your system in real time. Comparing this with the power generated allows you to calculate the efficiency of the system. A drop in efficiency indicates the need for cleaning, ageing or a fault, allowing you to schedule preventive maintenance and to monitor your return on investment.

Make that difference and contact Kipp & Zonen for the solutions available.



**Lightning & Surge Protection**

**Raycap**



**Raycap**

Raycap's Strikesorb and ACData electrical protection PV product lines continuously shield solar power inverters and electronic systems from damage caused by lightning and electrical over-voltages. Suitable for AC and DC applications, Raycap's products are fully compliant to the UL 1443 3rd edition, as well as to EN 50539-11 safety and performance standards for PV systems.

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

**Microinverters**



**APsystems**

The APsystems YC500 microinverter handles two PV modules independently with dual MPPT, halving the number of microinverters required on the job site. Maximum power output is 500W per module pair; serve up to 14 panels (7x YC500s) in a string with a single 20A breaker. Ten and 25-year warranties are available. The APsystems microinverter solution includes intelligent monitoring through the integrated Energy Communication Unit and full-featured Energy Monitoring & Analysis software.

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

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

**Modules**

**AUO**



**AU Optronics Corporation**

AUO's made-in-USA high power solution, SunVivo PM072MB0, is a mono-crystalline module with power output up to 330W. With its high power output, this module can be used for residential as well as small commercial applications. It is equipped with anti-reflection coated glass which helps enhance power performance. Additionally, it has passed the flammability test to be safely utilized under diversified circumstances, and therefore ensure users' safety. SunVivo PM072MB0 also comes with a black frame and black backsheet design for aesthetically pleasing installations.

[solar.auo.com](http://solar.auo.com)



[www.axitecsolar.us](http://www.axitecsolar.us)

**AXITEC®**  
high quality german solar brand

**Axitec, LLC**

Axitec's product line includes 60- and 72-cell modules to benefit any size installation. Poly- and monocrystalline modules are available with black and silver frame for implementation on residential or commercial solar applications. The AXIplus module offers an integrated optimizer solution with panel-level monitoring, maximum power point tracking (MPPT), aesthetics, and an easy installation.

[www.axitecsolar.us](http://www.axitecsolar.us)



**Boviet Solar USA**

Boviet Solar USA's polycrystalline or monocrystalline solar modules and kits are available with 60- or 72-cell modules, 1,000 VDC, maximum efficiency of 16.49%, power tolerance from 0 to +5 W, 5400 Pa snow load, and 2400 Pa wind load. They are internationally tested and certified; Type 1 fire rating per UL 1703, High salt and ammonia resistance certified (TUV Rheinland), and come with 12-year product and 25-year linear power performance warranties.

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

**SUNTEGRA™**  
SOLAR ROOF SYSTEMS by ist



**Integrated Solar Technology**

SunTegra Solar Roof Systems, designed and manufactured by Integrated Solar Technology (IST) integrate directly into the roofline of a home or building, providing a durable roof and a low-profile solar system in one. SunTegra products are designed with rugged materials, high performance crystalline technology, a ventilation system for improved efficiency, and an integrated wiring system for simple and fast installation. SunTegra products are also tested to stringent solar and roofing requirements.

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



**LG Solar**

LG Solar is introducing their new NeON 2 modules with Cello Technology which improves power output and appearance. LG NeON 2 modules produce energy from both the front and back in order to increase efficiency. A reinforced frame design makes these modules durable in even the toughest weather conditions.

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



**MiaSole**

The FLEX-02 Series module is a CIGS based flexible thin-film PV module providing high power density for many types of roofs. The panels are high efficiency, flexible, thin-film product, with >16% cell efficiency. The low weight of the module (<0.7 lb/sq ft) allows installation on roofs which cannot support the weight of traditional glass solar panels. With no roof penetrations, leakage and damage to valuable contents within the building is eliminated. The FLEX-02 Series module also has high wind resistance and a seismic advantage over traditional rack-and-panel systems.

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

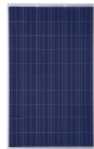




### Solar Frontier Americas, Inc.

Solar Frontier's CIS Module, SF 150-170S has among the highest thin-film efficiencies at 13.8%. CIS modules have a low temperature coefficient, enabling them to generate more power in hot conditions and they offer high performance at lower irradiance levels. Solar Frontier modules have a non-glare, black appearance with a black frame made of long-life anti-corrosion aluminum for reliability and aesthetics. CIS modules are free of cadmium and lead, and are RoHS compliant. Shipped in virtually cardboard-free packaging with recyclable corner pieces, CIS modules by Solar Frontier are economical and ecological.

[www.solar-frontier.com](http://www.solar-frontier.com)



### Trina Solar

Trina Solar DUOMAX is a PID resistant, reliable, and durable dual glass frameless module. The product comes with a 30-year power warranty and low annual degradation. The 1500V system voltage allows more modules per string, resulting in reduced BOS costs. The DUOMAX is engineered for extreme climates.

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



### Vikram Solar USA

Vikram Solar's 255 W Clear Frame/White Backsheet Polycrystalline PV Module is made in India, so it's tariff-free and competitively priced. Made with the quality and reliability expected from a Tier-1 manufacturer, the VSP.60.250.A3 is Vikram Solar's 60-cell workhorse module for residential and commercial rooftop applications. With a PTC rating exceeding 93%, it is 1000 VDC-rated, with 1000 mm, MC4-compatible connectors.

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

## Performance Monitoring



### Apogee Instruments

Apogee Instruments' silicon-cell pyranometers measure total solar radiation to within 5%, under clear sky conditions. They are a cost-effective alternative to black-body pyranometers for performance monitoring, panel placement, and site prospecting. With rugged performance, long-term stability, and ease of maintenance, Apogee sensors are available in different outputs including: the self-powered SP-110 with a 0-350 mV output, and amplified models with outputs of 0-2.5 VDC, 0-5 VDC, and 4-20 mA. Additional options are available to integrators, such as custom multipliers, lead lengths, and connectors.

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



### Continental Control Systems

Continental Control Systems specializes in high-accuracy electric power monitoring for measuring AC production and/or AC consumption. The company's meters and current transformers are designed to provide key electrical system measurements, including power (kW) and energy (kWh), through a variety of communication protocols. These include revenue-grade BACnet, Modbus, and LonWorks, and as pulse outputs. The WattNode Revenue, along with the Accu-CT, is ANSI C12.1, as well as PBI, UL, cUL, and CE Listed.

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



Applied Energy Technologies

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**eGauge Systems**

The eGauge energy meter displays real-time data for renewable energy systems, utility feeds, and electricity consumption of sub-panels, circuits, and equipment. The hardware features a 30-year data-logger, web server, and 12 current transformers. Communication options include Ethernet, PLC, and GSM. The eGauge web-based interface is best suited for renewable system performance reporting, measurement, and verification of energy efficiency projects, baseline load and peak demand analysis, and historical energy trend evaluation. The user interface displays the company's logo to increase referrals and return web traffic back to their site. There are no subscription fees for the eGauge platform.

[www.egauge.net](http://www.egauge.net)



**Itron**

The Itron Solar Gate communication gateway addresses operational issues for solar generation installations by bringing together solar production data and premise consumption data, while providing granular data on the health of the solar panel relative to its surrounding environmental variables. The Itron Solar Gate communications gateway combines revenue-grade metrology with 4G cellular to collect production data from the on-premise solar array and inverter for comparison against the on-premise energy load and can also connect to an in-home device and transmit the data to cloud applications for analysis, reporting and dashboard presentation. The Itron Solar Gate will be available in Q2 2016.

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



**Parker-Hannifin Corporation**


With Parker's SensoNODE Blue sensors in place, workers within range can use their mobile devices with SCOUT Mobile software to monitor pressure readings on a solar panel's tracker. Scanning for pressure spikes helps workers pinpoint which panels need immediate attention, increasing maintenance efficiency. SensoNODE Blue and SCOUT Mobile also allow users to monitor trackers for steady increases in pressure trends.

[www.solutions.parker.com/spmonitoring](http://www.solutions.parker.com/spmonitoring)



**EKO INSTRUMENTS**

**EKO Instruments**  
EKO Instruments introduces the MS-80 Secondary Standard Pyranometer. The MS-80 begins a new generation of pyranometer technology while remaining cost-effective for all applications. Major performance gains have occurred in response time (<1 sec) and reduction in zero-offset A. Users will also benefit from reduced maintenance costs by not needing to recalibrate or exchange desiccant for many years. Every MS-80 comes standard with an industry exclusive ISO 17025 calibration. The affordable MS-80 provides the lowest field measurement uncertainty.  
[www.eko-usa.com](http://www.eko-usa.com)



**KIPP & ZONEN**  
SINCE 1830


**Kipp & Zonen**  
Kipp & Zonen have expanded their range of instruments; the new SMP6, SMP21, and SMP22 pyranometers, the SGR3 and SGR4 pyrgeometers, and the SUV5 total UV radiometer. This expanded line provides for Smart solar and sky radiation monitoring stations at all performance levels. Their Smart range has as the main benefit of a RS-485 Modbus interface, combined with an amplified analogue output. Instruments can now be connected directly to a digital data acquisition system for live radiation measurements, to monitor the status and power supply, and to keep track of the calibration history.  
[www.kippzonen.com](http://www.kippzonen.com)



**PHOENIX CONTACT**


**Phoenix Contact USA**  
Providing energy meters for solar installations, Phoenix Contact's EMpro energy meters offer scalable functionality in small, low-cost packages. EMpro energy meters collect energy information from the AC circuits commonly found in and around solar electricity installations. This includes circuits used on the output of inverter stations to power loads, and for power transmission and distribution in microgrids. EMpro meters are listed as Eligible System Performance Meters with the joint California Public Utility Commission/California Energy Commission's Go Solar California! initiative.  
[www.phoenixcontact.com/us](http://www.phoenixcontact.com/us)

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**MOXA**



**Moxa Americas, Inc.**  
Moxa's UC-8100 programmable wireless communication gateway allows both new and existing solar plants to connect to monitoring platforms on a network or in the cloud. It acts as a compact, highly flexible, vendor-agnostic datalogger that connects inverters, string combiners, smart meters, and other devices - transmitting data over Ethernet, Wi-Fi, or cellular.  
[www.moxa.com](http://www.moxa.com)



**SUNSYSTEM Technology**

**SunSystem**  
SunSystem Technology (SST) offers complete performance monitoring services for industrial and utility-scale photovoltaic systems. Complex monitoring systems form a basis for providing vital data that is fundamental to managing day-to-day operations and ensuring long-term operational goals are met. Whether they are being used to monitor the performance of a single facility or roll up to an entire portfolio of facilities, SST has experience with all of today's leading monitoring systems. From installation, through configuration, to validation of the data being captured, SST provides comprehensive performance monitoring and related IT support services.  
[www.sunssystemtechnology.com](http://www.sunssystemtechnology.com)





### Trimark Associates, Inc.

T1-S Gateway SCADA provides control functions to optimize power generation from an interactive dashboard. The unified system enables end-to-end management from the operations center to field devices, allowing a resource to capture, store, and forward data in real-time from inverters, meters, and MET stations. The interface initiates control commands from an operator, follows pre-defined logic, and issues alerts for defined thresholds. For delivery of precise power and quality at the point of interconnection, the system automates complex commands and provides control over peak shaving, back-up power, voltage support and frequency regulation, and ramping.

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

### Position Sensors

## POSITAL FRABA



### POSITAL-FRABA

POSITAL-FRABA supplies innovative position sensors for the solar power industry. IXARC absolute rotary encoders and TILTIX inclinometers are ideal for single or dual-axis solar trackers, and for PV or concentrated light systems. Superior accuracy ensures precise positioning, while reliability is assured, through effective environmental sealing and rugged packaging. Available analog, serial, CAN-open, DeviceNet, Modbus, or Industrial Ethernet interfaces simplify integration into projects of any size or budget.

[www.posital.com/en](http://www.posital.com/en)

### PV Distributors



### BayWa r.e. Solar Systems, LLC

BayWa r.e. Solar Systems is a distributor dedicated to supporting local, independent installers in the solar industry. They offer a select group of products coupled with dedicated customer support. BayWa r.e.'s newly launched r.e.connect Partner Program is platform enabling small and large installers access valuable tools and increase their operational efficiency.

[www.baywa-re.com](http://www.baywa-re.com)



### Bridgewell Renewable Resources

Bridgewell Resources offers start-to-finish, full service solar solutions worldwide. They source the latest, innovative solar PV systems, including panels, inverters, and racking systems. Along with offering quality solar products, Bridgewell's role comprises of procuring equipment, financial support, and project development. Added-value services include site clearing, installation, as well as electrical services. Bridgewell also offers flexible financing terms and development assistance that, in turn, secures maximum working capital for everyone involved in a project.

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



### HES PV

With over 25 years of industry experience, and trained installers across the country, HES PV has solar electric solutions for residential and commercial applications including, MicroFIT, grid-tied, and off-grid. Distributing Hanwha and stocking Enphase, Fronius, Outback, Magnum, and Rolls products, HES PV has warehouses in Victoria, Vancouver, Edmonton, Barrie, and Montreal.

[www.hespv.ca](http://www.hespv.ca)

### PV Installers



### PCI Solar

The team at PCI Solar applies more than 60 years of commercial construction experience toward each project they undertake. Their service offering ranges from design and engineering, to finding the right financing solution for their customers' projects. Their team evaluates the property, conducts feasibility studies, contracts, and constructs every project on schedule and within budget.

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



### Sun City Solar Energy

Sun City Solar Energy designs, sells, installs, and services solar electric systems including off grid, grid-tie, and grid-tie with battery backup.

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



### Twin Turbines Energy

Twin Turbines Energy provides custom design/build services including solar, wind, hydrogen, and other renewable energy systems. They do fixed, single axis, and dual axis trackers in projects of sizes up to 2.5MW including commercial, residential, military, agricultural, government, and banking.

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



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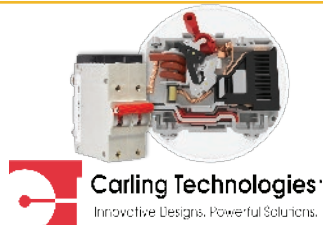




## PV Manufacturers &amp; Equipment

**ASYS Group**

The ASYS Group manufactures machines and production lines for the electronics, life-science, and solar industries, helping customers maximize their productivity and optimize cell efficiency. The ASYS SOLAR brand features cost-effective metallization lines, next-generation technologies, and scalable production solutions. With a throughput of 4800 cells per hour and low breakage rates, ASYS ensures optimum efficiency for solar cell production. [www.asys-group.com](http://www.asys-group.com)

**Carling Technologies**

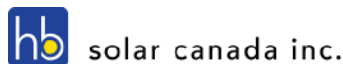
Carling Technologies' circuit breakers can be integrated into a PV system to achieve protection against harmful overcurrent. Carling's circuit breakers utilize the hydraulic-magnetic principal, protecting not only the power system itself, but also safeguarding the structure where these systems are installed by eliminating the potential fire hazard caused by overcurrent. [www.carlingtech.com](http://www.carlingtech.com)

**CertainTeed**

The aesthetically pleasing Apollo II and Apollo II Tile PV roofing systems offer solar integration for new and existing shingle and tile roofs, while eliminating the need for rack-mount or structural reinforcement. Each module contains 14 high-efficiency solar cells, which provide a recently enhanced power rating of 60 watts per module. Apollo II and Apollo Tile II systems are available in Class A and Class C UL790 fire ratings, and meet UL 790, UL 1703, and IEC 61215 requirements. All Apollo II systems are backed by the industry's only warranty for electricity output and installation workmanship, a 25-year limited power warranty, and a 15-year installation workmanship warranty. [www.certainteed.com](http://www.certainteed.com)

**Despatch Industries**

Despatch Industries provides thermal processing equipment for advanced photovoltaic production, including their metallization firing furnace. The Safire Firing Furnace with DriTech Dryer is designed to ensure stability, repeatability, and cell efficiency. The Safire's twin chamber design features two independently controlled furnaces which eliminate the lane-to-lane influence found in traditional dual-lane furnaces. Micro-zone Technology provides the ability to precisely tailor thermal profiles around advanced materials and architectures. The Safire is available with PowerLock technology which suppresses LID on PERC cells from 3-6% down to ~1%. [www.despatch.com](http://www.despatch.com)

**hb solar canada inc.**

hb solar provides engineered PV mounting for all types of roofs, including flat, pitched, shingled, and metal. All hb solar racking projects commissioned, 450+ to date, have been individually designed and engineered for optimal system performance and minimal impact to the roofing surface. Wind tunnel tested by renowned RWDI, the mechanical integrity of the system designs have also been verified by several Ontario Engineering firms. hb solar supports customers along the complete process—from initial rooftop PV design and optimization of the layout, to final inspection of the installed rooftop array. [www.hbsolar.ca](http://www.hbsolar.ca)

**JinkoSolar (U.S.), Inc.**

JinkoSolar provides a selection of high-quality polycrystalline modules designed specifically for the US market. JinkoSolar's UL-certified JKM320P-72 (300-320 Watt) and JKM270P-60 (250-270 Watt) modules have a conversion efficiency of up to 16.5%, in addition to its comprehensive 25-year linear warranty. These modules are designed for performance in extreme weather, harsh environments, and low light conditions. [www.jinkosolar.com](http://www.jinkosolar.com)

**Kurdex Corporation**

Kurdex is a supplier of vacuum deposition and etch systems for HVM, R&D, and PILOT. Their products include, PVD, EVAP, PECVD, ALD, Arc Deposition, and Etch/Strip Tools. Available in in-line, cluster, with full automation for any substrate size up to 2300MM. Kurdex supplies equipment for applications in solar cell, semiconductor (packaging), FPD, HDI, hard disc, automobile, thin film, batteries, OLED, and lighting. They offer turnkey automation, discrete pieces, and roll-to-roll. [www.kurdex.com](http://www.kurdex.com)

**LI-COR Biosciences**

LI-COR provides solar radiation measurements. For solar resource assessment, LI-COR's LI-200 Pyranometer is a cost-effective alternative to first class thermopile-type pyranometers. The newly redesigned LI-200R features a robust case, designed to shed water efficiently. It also includes a modular, removable base and cable which allows the sensor to be removed for recalibration, without affecting existing mounting architecture. This makes the sensor ideal for PV efficiency measuring systems having an extensive network of cables, that would otherwise make sensor removal difficult. [www.licor.com/env](http://www.licor.com/env)

**Lumos Solar, LLC**

racking The Lumos Solar LSX Solar Module System is a frameless solar module design which has bridged the gap between architecture and renewable energy. The LSX Solar Module System is composed of the LSX Frameless Solar Module and LSX Rail. The design provides a system which is aesthetic and also fast and easy to install. The LSX Solar Module System is ideal for overhead applications, such as awnings, canopies, and carports. LSX can also be integrated into BIPV designs. [www.lumossolar.com](http://www.lumossolar.com)

**Mühlbauer**

Mühlbauer's modular reel-to-reel automation solutions cover all processes for manufacturing of finished solar products like flexible solar cells, solar panels, or others. The input is usually loaded as pre-manufactured solar absorber material. The reel-to-reel manufacturing of flexible thin film solar products effects cost savings and increases the manufacturing flexibility. Their automation technology enables the conversion of thin film or organic solar materials, like CIGS, a-Si, organic photovoltaic, or any other flexible absorber material, to flexible solar panels or other solar products. [www.muehlbauer.de](http://www.muehlbauer.de)

**SMARTTECH****Smartech International**

Smartech provides Steinbach diaphragms and PTFE sheet materials for PV laminators, including Steinbach's EVA-resistant Lami-bran diaphragm. Steinbach's wide variety of PTFE materials are used for transport belt and release sheets in the lamination process, as well as for other applications. [www.smartechonline.com](http://www.smartechonline.com)

**Solar Automation, Inc.**

Solar Automation is a provider of small-scale module assembly equipment for labs, experimental production, and start-ups. The Cell Soldering Press Model SP21 is one component of their Combined Tabber Stringer Model CTS21. CTS21 is a complete cell tabber-stringer with cell orientation and precision ribbon placement. It uses conduction soldering for efficient and gentle heat transfer. CTS21 is a manual/semi-automatic system for small volume production. Solar Automation also offers custom BIPV product development. [www.solarauto.com](http://www.solarauto.com)





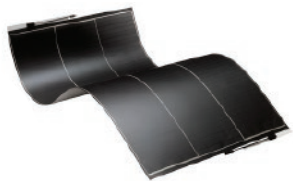
**SOLARLAND® USA**  
SOLAR TECHNOLOGY AND SOLUTIONS

### Solarland USA Corporation

Solarland USA Corporation now offers Class 1 Division 2 solar panels for use in hazardous environments. These panels are stocked in their California warehouse with immediate delivery and were developed in collaboration with their customer base. The panels are available in various wattage sizes from 20W-150W. They offer several configurations with different frame sizes and junction box options. Solarland USA also offers pole/wall mounts, cabling, and other balance-of-system components to provide complete solar solutions.

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

**SOLOPOWER**  
SYSTEMS



### SoloPower Systems

SoloPower Systems SP1 and SP3 Series modules are suited for installation where roof integrity, weight, and wind load factors are of paramount importance. SoloPanel SP3 is their second-generation, large-format flexible module engineered for commercial and industrial building applications. The SP3 module is configured for multiple adhesive applications, enabling rapid installation, and low-cost system integration with a wide variety of roof substrates such as EPDM, TPO, and Built-up-roofing / Modified bitumen. Designed and manufactured in USA, SoloPower modules are built to meet or exceed UL 1703, IEC 61646, and IEC 61730 standards.

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



### Sunpreme, Inc.

Sunpreme offers a bi-facial, high-efficiency solar module using its proprietary Heterojunction Cell Technology (HCT) and all-glass module design. Sunpreme's 60-cell PV module is rated 310W STC on the front-side with up to 20% additional power from the back-side, above the rated power. Sunpreme's 72-Cell PV module is rated 370W STC on the front-side with up to 20% additional power from the back-side. These bi-facial, double glass modules are fire rated class A and Type 3 rated, do not require grounding, or cleaning due to their frame-less design. The company offers conventional framed versions of 310W and 370W modules available upon request.

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



### TSS Technologies

TSS Technologies provides custom assembly automation for solar panel build as well as wafer handling and inspection. They also produce prototypes and provide build-to-print services for existing equipment designs, and CNC machining services.

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



### Wanxiang New Energy

Wanxiang New Energy produces solar panels at their Rockford, Illinois facility. They provide panels for residential, business rooftop, and utility solar projects. They are made with Tier 1 materials, backed by a 25-year warranty. Wanxiang New Energy panels produce high outputs even when covered with snow in the winter.

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



### Zebra Energy, LLC

Zebra Energy offers a full range of off-grid solar modules for 12V applications. This includes 150w, 100w, 50w, 25w, and 10w polycrystalline solar modules, all available from their Las Vegas area fulfillment center.

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

**SR20** | Secondary Standard Pyranometer



## The invasion for global measurement dominance has begun...

No alien to the high performance solar resource instrument assessment market, Hukseflux solar irradiance sensors are revered worldwide for both accuracy and reliability. When it comes to value and performance, the SR20 Secondary Standard pyranometer is second to none!

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**PV Washing System**



**Bitimec PV WASH, Inc.**

Bitimec's RoboKlin is a washing machine for large PV arrays, that's able to wash two megawatts of flat panels in one day, using only 4500 gallons of water. The system runs smoothly on a rubber track dumper undercarriage. With twin joy-stick controls, a telescoping boom, ultrasonic sensors and a hybrid foam brush, feather-light and mechanized panel washing is done simply and gently. Operators and owners can now avoid losing up to 20% of revenue due to soil film deposits that accumulate on panels over relatively short periods. This ability to economically wash solar panels can repay buyers many times their investment.  
[www.wash-bots.com](http://www.wash-bots.com)

**Racking & Mounting Systems**



**Advanced Racking Solutions, Inc.**

Advanced Racking Solutions delivers cost competitive mounting solutions designed to work with the roof. Systems are UL2703 have attained the California fire test rating and the designs have undergone years of structural and wind tunnel testing. With attachment hardware for any type of low pitch metal roof, VICERACK2, tilted mounting, will not increase the wind loading on the building. Arrays can be designed for the south and north roof slopes. ARS' SKYRACK is a mounting solution for shingle roof PV systems. The system includes a shingle flashing, is designed by installers, requires no pre-drilling, and only a few components. With a light and heavy rail offering, user friendly module clamps, and a tested flashing system, EPC's and homeowners approve the system.  
[www.advancedracking.com](http://www.advancedracking.com)



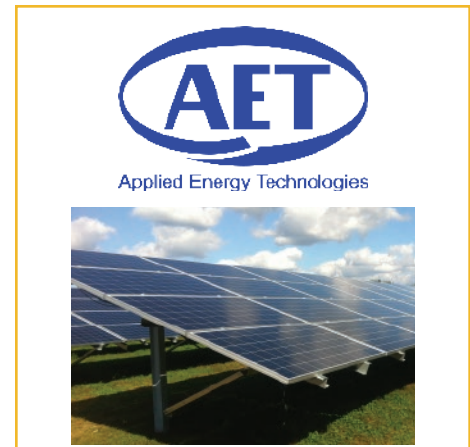
**AllEarth Solar**

The AllEarth Solar tracker is a complete grid-tied, dual-axis solar electric system that uses GPS and wireless technology to follow the sun throughout the day for optimal energy production. The tracker's 360° range allows it to produce up to 45% more electricity than fixed systems, resulting in more guaranteed savings from a solar installation. Made in America, the tracker comes with an industry-leading 10 year warranty, a 120-mph wind rating, and superior snow shedding. Its simple, durable design and complete system pallet simplifies costly procurement and installation time.  
[www.allearthrenewables.com](http://www.allearthrenewables.com)



**Anar Solar, LLC**

Anar Solar's patent-pending approach provides an efficient, economical, and eco-friendly solution. Their non-invasive, surface ballast system can be used on sloped surfaces to increase total power generation. No field trenching or site grading is needed, so costly heavy machinery is eliminated and ecosystem impact is minimized. For capped landfills, no invasive fasteners are used that could damage the landfill cap, and they do not disrupt settling because the weight is evenly distributed. Anar Solar's racks can be assembled quickly and easily, and can be fine-tuned to further optimize production.  
[www.anarsolar.com](http://www.anarsolar.com)



**Applied Energy Technologies (AET)**

The Rayport-G ECO is a solution for developers and EPCs looking for a ground-mount system which is easy to install, scalable, and delivers significant savings on total installed costs. The Rayport-G ECO is strong and durable, having been engineered to withstand challenging environmental conditions. It is also light and compact, allowing for high shipping density, which reduces freight costs and enables easy handling on the job site. The Rayport-G ECO is wind tunnel tested, UL 2703 listed, and comes with a 25-year limited warranty.  
[www.aetenergy.com](http://www.aetenergy.com)



**Brittmore Group**

Brittmore Group supplies EPCs with turnkey, structural balance-of-systems (BoS) solutions for MW-scale fixed-tilt ground-mount PV projects. Through the use of onsite pre-panelization and robotics, the Brittmore System delivers robust racking installed and populated with modules at twice the install rates as manual methods and with up to 10% total project cost savings. Brittmore's SolStak panelization and back-bonding technology is approved for use with framed or frameless c-Si and thin-film modules, giving the end users the ability to select the very best module technology for their application.  
[www.brittmore.com](http://www.brittmore.com)



**Cooke & Associates**

Cooke & Assoc. licenses a full line of solar roof- or ground-mounting, and tracking systems including rail extrusions, steel towers, and mounts as well as a GPS based azimuth tracker drive and electronics. All designs are performance tested to 50lbs/sqft snow and ice and 90mph or higher wind loads, and engineer stamped from Ontario, Canada. Cooke & Assoc. provides ongoing manufacturing and sourcing assistance as well as field installation with tech support.  
[www.truenorthpower.com](http://www.truenorthpower.com)

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All HT Installation Testers and PV Curve Tracers now support up to 15 Amps. The 15Amp capability is keeping to our commitment to be the best supplier to the PV Industry.

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**AP ALTERNATIVES**  
 Modular Solar Racking Systems

**AP Alternatives**

AP Alternatives racking solutions utilize proprietary shallow helical anchors which allow them to complete large utility projects. They are able to provide value to project sites with soft soils, shallow bedrock, high water tables, and rolling topographies. APA has two core utility racking solutions; Ready Rack, a two high portrait arrangement that can easily be optimized for any site, and The Modular Series, a unique solution which is pre-panelized offsite, allowing for savings on high wage projects. Both solutions allow for rapid install, reduction of onsite labor, and maximum material utilization backed by years of experience.  
[www.apalternatives.com](http://www.apalternatives.com)





### DPW Solar

DPW Solar's mounting structures are manufactured by Preformed Line Products (PLP) in Albemarle, NC. They have been a manufacturer and supplier of PV mounting hardware solutions since 1993. Their POWER PEAK mounting systems, with factory pre-assembled components, are for larger scale installations requiring fast build rates. The high strength steel attachment components feature built-in field adjustments and integral wire management. Code compliant, POWER PEAK is wind tunnel optimized for site specific conditions.

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



**Ecolibrium Solar**

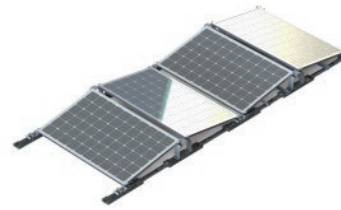


### Ecolibrium Solar

EcoX is a simple, rail-free racking product, optimized for residential installations. EcoX is designed with small components and condensed packaging, which improves transportation and logistics costs, and makes EcoX simple and easy to handle on the jobsite. By optimizing attachment placement, EcoX systems use up to 30% fewer penetrations. The EcoX system is fully certified to the UL2703 standard, including Grounding and Bonding, Class A Fire testing for both Type I and II modules, and Mechanical Load testing. This validation provides seamless permitting, and the module-specific UL2703 certification eliminates rough inspections. Universal clamps support standard framed modules, and flexible component positioning helps designers maximize modules on the roof. EcoX is designed with the installer in mind, and Ecolibrium Solar's field trainers offer on-site field support to help ensure a smooth transition.

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

Mounting systems for solar technology



### Everest Solar Systems

Everest Solar Systems offers mounting systems for residential, commercial, and utility scale solar deployments. The latest innovation is its East/West System D Dome Railless system, which reduces labor on the roof. Pre-built parts are delivered to the site and enable a simple, fast installation in 3 steps; align the components, add the modules and ballast, and connect the wiring. Everest Solar Systems' D Dome System Railless Version is wind tunnel tested and SEAOC peer-reviewed.

[www.everest-solarsystems.com](http://www.everest-solarsystems.com)



### FABRACK Solar Inc.

FABRACK Solar designs and manufactures a diverse line-up of solar racking solutions, including flat-roof and ground-mount, or seasonal racking solutions. Their traditional, fixed-tilt array solution for a flat rooftop project, offers a unique design, which automatically sets spacing and eliminates measurement. Fabrack's four-season, adjustable solar mounting racking systems are made from corrosion-resistant aluminum and stainless steel hardware for a durable maintenance-free product. All Fabrack systems are designed and supplied with engineered-stamped foundation drawings, and with installation options in mind.

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



### EcoFasten Solar

EcoFasten Solar recently launched their latest product line of solar roof mounts. Their new tile flashing systems is available in configurations for flat tile, as well as W-tile and S-tile profiles. Aluminum flashing replaces one complete tile, eliminating the need for cutting, drilling, grinding, or replacing tiles. A watertight seal is created when the flashing is paired with an EcoFasten Solar compression bracket, as a result of the embossed cone shape that's stamped into the flashing and fitted with an EPDM rubber bushing. Documentation and testing for these patent-pending systems are available online.

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



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Solar Balance of Systems. It's what we do.



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**GameChange Racking**

GameChange Racking provides utility and large commercial solar racking systems which are UL/ETL 2703, CPP wind tunnel tested, and Black & Veatch assessed. Their Pour-in-Place ballasted ground is a patent pending protected system with self leveling technology providing a fast installation time. With Integrated grounding and wire management, this system is available in both one and two panels up in portrait and comes with a 20-year warranty. [www.gamechangeracking.com](http://www.gamechangeracking.com)



**Grupo Clavijo**

Grupo Clavijo provides distributed and concentrated single axis trackers, fixed-tilt systems, and dual axis trackers. They also offer Tesla Energy storage systems. Grupo Clavijo provides full engineering support and installation is available. [www.grupoclavijo.net](http://www.grupoclavijo.net)



**Magerack Corporation**

Magerack provides a solution for solar mounting systems with integrated bonding (integrated grounding). The system can be bonded and grounded without using any WEEB or bonding jumper which saves installers time and effort. The system is UL2703 certified with Class A Fire Rating tested. For roof attachment, Magerack products are designed user friendly and compatible with major mounting systems. The patented L-foot w/ flashing provides a waterproofing solution for shingle roofs. The stainless steel tile hook is height adjustable for flat and curved tile roofs. [www.magerack.com](http://www.magerack.com)



**Green Sun Rising**

Green Sun Rising is a turnkey supplier of solar PV and solar thermal systems. Their portfolio includes mounts4solar, an in house designed and manufactured solar mounting system in aluminum and stainless steel. These A-frame systems are flexible, allowing for custom made solutions. The mounting systems are available at a fixed or adjustable angle for ground or roof installations. All module fasteners are accessible from the front and utilize snap-fit C-clips for quick and simple assembly. [www.greensunrising.com](http://www.greensunrising.com)



**Kinetic**

The watertight flashing kit made by Kinetic includes a baseplate that flush-mounts to the roof, a 9" x 12" black flashing that maximizes coverage of the penetration points, as well as stainless steel hardware. The baseplate is secured to the roof with up to two lag bolts and has a separate blind stud on top for L-Bracket attachment, eliminating the through-hole that may cause water leakage and lead to dry-rot. The unique raised channel provides an ideal place for sealant application on the underside, while also diverting water off the top of the flashing. The black textured, powder-coated flashing blends well with all asphalt roofs, and easily slides under shingles during installation. [www.kineticsolar.com](http://www.kineticsolar.com)



mounting systems

**Mounting Systems**

Sigma Steel, for commercial to utility-scale projects, merges the design of aluminum with the strength of steel. The ground mount system features a self-healing magnesium-aluminum-zinc coated cold rolled steel structure. Corrosion resistance is superior to G235, with a price point similar to G90, for protection in harsh environments. Sigma Steel uses Mounting Systems' patented click, set, and done Clickstone clamp technology. Clamps securely attach and electrically bond modules at any point along the supporting rail. ETL Listed to UL 2703, Sigma Steel's additional features include: factory pre-assembly, minimal part count, minimal labor requirements, and on-site installation flexibility. [www.mounting-systems.us](http://www.mounting-systems.us)

**RT-[E] Mount® / E Mount AIR®**

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[www.roof-tech.us](http://www.roof-tech.us) [info@roof-tech.us](mailto:info@roof-tech.us) 333 H Street, Suite 5000, Chula Vista, CA 91910



**Kinetic Solar Racking and Mounting**

Kinetic Solar Racking and Mounting's Aerocompact S (south oriented), is the solution for mounting framed modules on flat roofs. It's the fastest and least expensive mounting system on the market, with excellent installation features. With Aerocompact S, an assembly time of 10 minutes per kilowatt can be achieved. With the Aerocompact+ (east-west oriented), an assembly time of five minutes per kilowatt can be achieved. These systems are wind-tunnel tested, conform to UL 2703, and are delivered fully pre-assembled, with protective matting and a barrier to prevent diffusion of the plastic softener. An analysis of the flat-roof design is also included for accurate ballasting. [www.kineticsolar.com](http://www.kineticsolar.com)



**OMG Roofing Products**

PowerGrip Plus, from OMG Roofing Products, is watertight, easy-to-install, and provides a secure connection directly to the roof deck or structural members, thereby taking the wind load off of the membrane or roof cover and onto the structural deck. Once heat welded in place, properly installed PowerGrip Plus units help eliminate rack movement that can damage commercial roofing systems. With 2,000 lbs. of tensile strength and 1,075 lbs. of shear strength, PowerGrip Plus is designed for use with ballasted solar racks on roofs covered with thermoplastic (TPO and PVC) roofing membranes. [www.omgroofing.com](http://www.omgroofing.com)





### Opsun Systems Inc.

Opsun Systems custom designs high-quality solar racking systems. To eliminate risks of racking failure, they run an extensive simulation to guarantee each project will resist any weather challenges for its location. Ensuring safe and cost-effective solar installations, Opsun also offers complete engineering support. From smart designs within a building's limitations, to high-quality drawings for building permits and installation support, Opsun engineers pay attention to the details and provide high-quality solar racking designs. Opsun's mounting systems offer more aluminum per watt than any other systems currently on the market. They offer a fully structural racking system, made from aluminum, and designed to resist the harshest environments for years.

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



### Orion Solar Racking

Orion Solar Racking introduces the VersaTile Hook. Suitable for residential and commercial tile roofs, the VersaTile Hook offers a wide range of vertical and lateral adjustability for a fast, easy, sturdy, and secure installation. Its lightweight aluminum design incorporates a stainless steel hex drive bolt for high strength and ease of fastening. VersaTile Hook includes a mini flashing which goes above the tile, and a sub flashing which covers the VersaTile base to provide increased waterproofing. This hook works well independently of the location of tile top with respect to the position of the rafter, and shape of the tiles.

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



### PCM Solar

PCM Solar provides 200mph+ PV solar racking, ground mounts, and non-penetrating ballast. For barrel tile and commercial rooftop installs, they offer 7" L-feet and new "self-flashing" O-mounts (RSB) with no need to hit the trusses. PCM Solar also offers custom designs to suit customers specifications.

[www.pcmsolar.us](http://www.pcmsolar.us)



### PVcobra

PVcobra has an in-house engineering team equipped to custom tailor their designs to a project's specific criteria for optimized performance. The PVcobra is 100% made and engineered in the USA, and is designed to be durable, low-maintenance, and rapidly deployed in the field. With only five components, PVcobra utilizes structural, light gauge steel, providing low material costs while remaining robust.

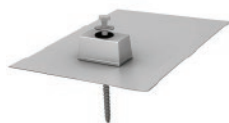
[www.pvcobra.com](http://www.pvcobra.com)



### Rack 10 Solar, LLC

It only takes three components to make Rack 10 Solar's patent-pending, ballasted, rapid-installation, solar mounting system. With a ballast pan, a spacer bar, and one grounding top-clamp per PV module, the mounting system's weight is evenly distributed to minimize roof-point loading. Easy to install, with single-point grounding, the Rack 10 Shark series' built-in wind deflector keeps ballasting weight to a minimum (as low as 3 psf). Standard module angles include: 0°, 5°, 7.5°, and 10°.

[www.rack10solar.com](http://www.rack10solar.com)



### Quick Mount PV

Quick Mount PV's E-Mount Lag uses the patented QBlock Elevated Water Seal technology to provide waterproofing on composition/asphalt shingle roofs. It is backed by solid engineering and certified for strength and waterproofing by the ICC-ES (ICC-ESR-3744). All required stainless steel hardware is included for fast, single bolt installation. The E-Mount Lag includes a 20-year limited product warranty.

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



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**Renusol America**

Renusol America provides solutions in flat-roof and pitched-roof mounting systems for solar PV modules. Combining German engineering with American innovation, Renusol America has systems installed across the country. Renusol America provides sales, service, and customer support from its headquarters in Atlanta, Georgia, and operates full-scale warehouse and distribution facilities across the country. Renusol America was acquired by Ohio-based RBI Solar in June 2014, creating a complementary source of solar rooftop and ground. [www.renusolamerica.com](http://www.renusolamerica.com)



**SnapRack Solar Mounting Solutions**

SnapRack Residential Roof and Ground Mounting Solutions offer solar module installation systems that have been developed to lower the cost of ownership by reducing install times and costs. Utilizing unique, snap-in, pre-assembled hardware, and built-in wire management, only a single tool is needed to install a solar system, removing the need for cutting or drilling. This solution is designed to withstand extreme environmental conditions. It has achieved UL2703 certification for grounding/bonding and Class A Fire Rating. [www.snaprack.com](http://www.snaprack.com)



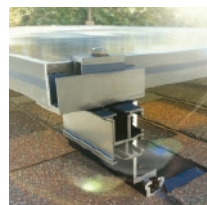
**SolarRoofHook.com**

SolarRoofHook.com provides mounting solutions for Flat Tile, Spanish Tile, Stone Coated Steel, and Asphalt Shingle Roofs. SolarRoofHook.com's QuickBOLT for Asphalt Shingle Roofs is an affordable mounting system with only five components, yielding a fast install time. The QuickBOLT uses a small EPDM washer, and is 100% waterproof. [www.solarroofhook.com](http://www.solarroofhook.com)



**Sollega**

Sollega designs and manufactures solar mounting solutions serving worldwide markets. The FastRack510 (FR510) is manufactured with the advanced plastic Ultramid, engineered to weather extreme rooftop conditions, and weighs only 4.5 pounds. It utilizes a UV inhibitor for durability and extended life. The FR510's lightweight material and streamlined design reduces overall project costs while maintaining system reliability. Their patented FastRack510 (FR510) high efficiency solar racking system, is a one-piece injection molded, low profile solar mounting system available in 5° and 10°. This system is compatible with all framed modules and can accommodate most frame-less modules. [www.sollega.com](http://www.sollega.com)



**Spider-Rax**

The all new Black Widow Comp mount for composite shingle applications has been redesigned to improve aesthetics, adjustability, and installation speed. Needing only one part number to order improves job efficiency. The mid clamp and end clamp have a patented panel lock system fitting modules from 1.125" - 2" and the direct to plywood fastening system has a new 2-course aluminum flashing. This system is UL 2703 listed for integrated grounding, a leveling height adjustment of 1.5" snow load rating at 45 lbs/ft, Class A fire rating, and 50 state engineering reports are available. [www.spiderrax.com](http://www.spiderrax.com)



**Steel Tree Structures, Ltd.**

Steel Tree Structures is a manufacturer of light gauge steel structures, including the introduction a modular concept for solar racking for ground-mount and roof-mount applications. Racks are pre-assembled, with modules mounted onto racks prior to shipment to the project site. Steel Tree racking systems have the ability to span building beam lines, as well as over rooftop equipment, thereby increasing PV density. [www.steeltreestructures.com](http://www.steeltreestructures.com)



**SunLink Corporation**

In addition to roof-mount, fixed-tilt, and tracker systems suitable for projects of any size, in any environment, SunLink now also offers SureLink installation and StrongLink O&M as part of its signature PowerCare program. StrongLink includes a full-range of turn-key installation services: geotechnical/pre-project pull testing, post driving, onsite ballast casting, prepanelization, mechanical installation, and module installation. SureLink provides a unique combination of O&M services: boots-on-the-ground field support, remote diagnostic capabilities, precise controls, and smart maintenance triggers coupled with robust mounting systems which deliver guaranteed energy production and long-term ROI. [www.sunlink.com](http://www.sunlink.com)



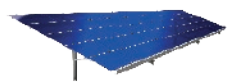
**SunModo Corp.**

The SunModo next generation Self-Grounding System includes convenient T-bolts with locking features, mid and end clamps, rail splices, shared rail adaptors, and lugs, all featuring grounding pins. It handles landscape or portrait configuration to minimize roof time and parts required. The self-grounding system spares installers the need to order, stock, and transport additional grounding hardware to the rooftop. The product line is the subject of two patents and one patent pending, and has completed UL 2703 certification. [www.sunmodo.com](http://www.sunmodo.com)



**TRA Snow & Sun**

TRA Snow and Sun provides customized solar mounting systems for all roof types and awning applications, portrait and landscape arrays. Their systems are designed for corrugated roofs, east/west elevated mounts, flush and ballasted mounts, and utilize easily installed mounting for all tile profiles. All clients receive free engineered layouts within 2 working days for each project's specific requirements. [www.trasnowandsun.com](http://www.trasnowandsun.com)



**Schletter**

Schletter manufactures solar mounting systems for utility-scale, commercial, and residential PV projects. The FS Uno, for utility-scale projects, offers a rugged all-steel design, able to meet diverse environmental conditions. The FS Uno is IBC 2006, 2009, and 2012 compliant. In addition, the FS Uno is ETL Classified to UL Subject 2703. [www.schletter.us](http://www.schletter.us)



**FOUNDATION POSTS FOR GROUND MOUNTED SOLAR PROJECTS**

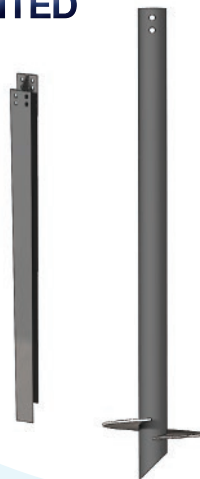
**HIGH VOLUME PRODUCTION**

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**Helical Piles**

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

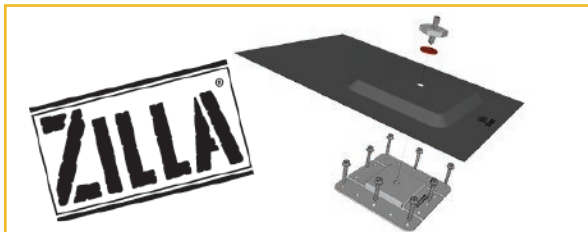




### Unirac, Inc.

SOLARMOUNT (SM) enhancements are designed to get installers off the roof fast. Components are pre-assembled and optimized to reduce installation steps and save labor time. Their new grounding and bonding process eliminates copper wire and grounding straps to reduce costs.

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



### Zilla Corporation

The Zilla Double Stud XL Flashing attaches to sheathing or structural members for faster and more aesthetically pleasing flush-mount solar installations on pitched composition roofs. The Zilla Double Stud XL Flashing provides a strong, watertight attachment that allows for a more flexible installation into structural supports or directly into sheathing. It gives those in the field a fast and efficient flashing option for any desired installation arrangement. The Zilla Double Stud XL Flashing also provides flexibility and time-saving engineering to solar professionals who demand quality installations.

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

### Recruiting Services



## ENERGEIAWORKS

### EnergieaWorks

EnergieaWorks' exclusive focus on clean energy markets provides them an advantage in locating the right solar energy talent for those in the renewable energy business. EnergieaWorks provides access to in-demand clean energy experts, consultants, and executive level candidates; even those who are not actively job searching. Their clients represent a cross-section of the industry, from start-up to Fortune 500 companies in North America and globally. They work with leading EPCs, utilities, OEMs, distributors, developers, integrators, and financiers that understand the value of having a recruiter working with them to help grow their business and improve their bottom line. EnergieaWorks' proprietary database of over 30,000 global contacts contains all the major players in solar and renewable energy.

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



### Solar Recruiting

Solar Recruiting provides recruiting services to companies who develop, install, and finance solar projects as well as manufacture, distribute, represent, and sell solar equipment and components. Solar Recruiting finds the right person to meet a company's personnel requirements including executives, engineers, project managers, estimators, field and plant supervisors, sales, business development, asset managers, R&D, logistics, and supply chain management. Solar Recruiting also provides solar employers with Talent Acquisition services where the employer manages the hiring process but specific functions are outsourced to Solar Recruiting.

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

### Research & Development | Testing



### Chroma Systems Solutions, Inc.

Chroma's power conversion test instrumentation includes, Regenerative Grid Simulators and Programmable DC Solar Array Simulators for PV Inverter validation and testing. They provide automated test system integration and software for many applications in renewable energies.

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



### Stratasense, LLC

The Stratasense IV Tracer is the only in-situ wireless IV tracer capable of performing one-time or continuous monitoring of solar panels under load. The product is in use across the world for research and testing, and the scalable wireless architecture makes it easy to deploy and maintain.

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



### tec5usa

The MultiSpec series from tec5usa is a family of reliable, low-maintenance, fast measuring spectrometer systems (detector-array technology). A wide spectral range from 190 nm to 2200 nm can be covered with high sensitivity and high signal-to-noise ratio. Systems are used for a multitude of applications, including: solar irradiance; monitoring of sunlight simulators; concentration determination in wet chemistry; plasma detection in dry-edge processes; and thin-film analysis of all kinds of coatings.

[www.tec5usa.com](http://www.tec5usa.com)

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 Self Reliant Energy Company installs multiple renewable energy sources including their Photovoltaic Electricity Generating Systems, and Solar Water Heating Systems which heat 100% of domestic water in summer months and 40% of domestic water during winter months.  
[www.selfreliantenergycompany.com](http://www.selfreliantenergycompany.com)

Robotics



**Hash Machinery Systems**  
 KOLCHAR robot, an automatic scanning and cleaning system for solar projects, dramatically improves solar system performance by keeping solar panels always clean. Hash Machinery's smart scan technology can detect damaged solar panels automatically while cleaning them, helping customers eliminate manual cleaning and panel inspection, lower total operation costs, and improve both system performance and solar panel lifetime.  
[www.hashmachinery.com](http://www.hashmachinery.com)

Roll Forming



**Hynes Industries, Inc.**  
 Hynes is a custom roll former specializing in structural parts used for solar racking. They produce Z-Purlins, C-Purlins, Posts, Beams, and many other custom roll formed shapes. They install holes, slots, and other features in these products. Additionally, Hynes Industries provides slit coil products from their on site steel service center.  
[www.hynesindustries.com](http://www.hynesindustries.com)



**Johnson Bros Metal Forming Co.**  
 Johnson Bros Metal Forming is a manufacturer of panel frames and other solar energy components, such as the supports and structural components for panels, as well as reflector troughs for solar concentrators. They offer a wide variety of custom shapes for various different solar panel frames and structures.  
[www.johnsonrollforming.com](http://www.johnsonrollforming.com)



**Samuel, Son & Co.**  
 Samuel is a solar market metal supply specialist. They supply and process domestic metal products to the solar energy industry, including aluminum sheets and extrusions, stainless/carbon sheets/plates, and roll-formed sections. Samuel stocks large inventories of metal products, enabling them to provide JIT, customized kitting of parts and stock, as well as hold programs. Samuel provides comprehensive processing services and produces exacting tolerances to meet customer specifications.  
[www.samuel.com](http://www.samuel.com)

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**voestalpine Roll Forming Corporation**  
 RFC is part of the voestalpine Metal Forming Division highlighting roll forming capabilities in 13 countries worldwide including South America and China. Within the United States, voestalpine RFC has over 35 roll lines with capabilities designed to handle a variety of metal types for both open profiles and in-line welded custom tubes. voestalpine RFC has advanced roll forming technologies and techniques and tackles unique shapes with challenging features and tolerances. They have been manufacturing their products in facilities located in Kentucky, Pennsylvania, and Indiana for 70 years.  
[www.voestalpine.com/RFC](http://www.voestalpine.com/RFC)

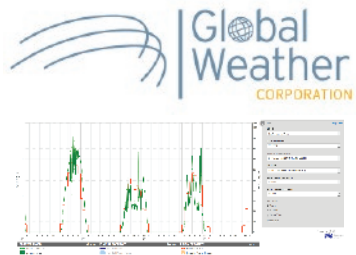
Safety



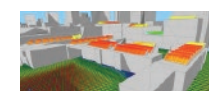
**BLÅKLÄDER**  
 WORKWEAR

**Blaklader, LLC**  
 A global brand in workwear since 1959, Blaklader originated in Sweden. Blaklader produces more than two million garments a year and is one of Sweden's largest manufacturers in the heavy-duty workwear industry. The full line includes pants, shorts, vests, outerwear, and safety apparel all built to meet jobsite standards for quality and durability. Blaklader's North American headquarters are in Sarasota, FL.  
[www.blaklader.com](http://www.blaklader.com)

Site Assessment & Forecasting



**Global Weather Corporation**  
 Global Weather Corporation's SolarWX service proves forecasts of Global Horizontal Irradiance (GHI) and, when system characteristics are available, estimated power output, for any solar installation at any location in the world. SolarWX's accurate estimates of GHI enable applications such as solar energy generation, home and industrial energy use, and agriculture. Typical users include utilities, energy traders, smart home applications, photovoltaic monitoring systems, and agricultural information services. Forecasts can be displayed in their simple, intuitive, web-based display. Alternatively, forecast data feed can be integrated into any customer's system.  
[www.globalweathercorp.com](http://www.globalweathercorp.com)



**Meteadyn**  
 Meteadyn develops CFD based software to assess solar energy potential, study solar exposure, analyze site location, and suitable location for the panels. Meteadyn also provides consulting services.  
[www.meteodyn.com](http://www.meteodyn.com)





### Renewable NRG Systems

Renewable NRG Systems (RNRG) offers the SRA System, a complete measurement station for the prospecting and finance-grade resource assessment of utility-scale PV projects. Site-specific solar resource assessment (SRA) campaigns provide accurate context to correlate long-term satellite derived irradiance data. This combination provides the lowest resource-related uncertainty, which drives financial terms and, ultimately, project return-on-investment (ROI). RNRG's latest generation SRA System includes improvements to the tower, data logger, and pyranometer. With a choice of industry standard ISO 9060 pyranometers, the system provides accurate and repeatable measurements in any terrain.

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

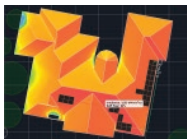


### WPred

WPred was founded in 2008 by a team of engineers and meteorologists with over 15 years of experience in renewable energy and specializes in custom technological solutions. Working with solar farms to predict weather and sun intensity, WPred assists in forecasting solar power production, planning maintenance calendars, and losses due to snowfall.

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

### Software Supplier



### Aurora Solar

Aurora Solar's one-stop software platform allows a user to quickly build complex 3D models, perform detailed shading analysis of a site, and automatically create full system designs in just a few clicks. Aurora easily generates NEC compliant designs and their associated electrical one-line diagrams. Inbuilt financial simulations produce a detailed cash flow model and investment summary. To tie everything together, Aurora's software can create fully customizable proposals, with uploaded logos, photos, and charts, as well as 2D and 3D viewports.

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



### geoAMPS

For development and operation of one or more solar panel fields, geoAMPS offers altAMPS, an efficient and configurable Web-based project- and asset-tracking system. The Web platform's dashboard-focused interface provides easy and secure access to the central database. Workers in the field can access and upload information on mobile devices. Detached/offline and sync-on-demand capability provides database access in areas lacking Internet connectivity. GIS is available. Gain automatic alerts of inspection and maintenance schedules. All project information, including landowners and infrastructure improvements, is securely stored in a single application.

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



### PVCComplete

PVCComplete is a comprehensive solar design software platform that is seamlessly integrated into the AutoCAD environment. PVCComplete automates the most time consuming tasks in solar design including module layout, performance model, shade analysis, performing NEC electrical calculations and generating bills of materials. PVCComplete makes it easy for even a novice designer to create a fast and accurate drawing set in AutoCAD, a detailed electrical report, a production estimate and a bill of materials.

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



### Sighten

Built by solar veterans for the unique needs of the industry, Sighten provides a comprehensive platform spanning the entire project lifecycle. With a single, consolidated platform, Sighten simplifies operations, cuts costs, and powers growth. Its reporting and analytics portal brings solar up to speed with mature asset classes with real-time access to data and analysis tools. Its pricing engine accommodates all solar financing structures and includes sophisticated asset pricing logic. Sighten's downstream toolset helps solar companies sell more effectively, and manage the entire financing workflow from lead to operating asset.

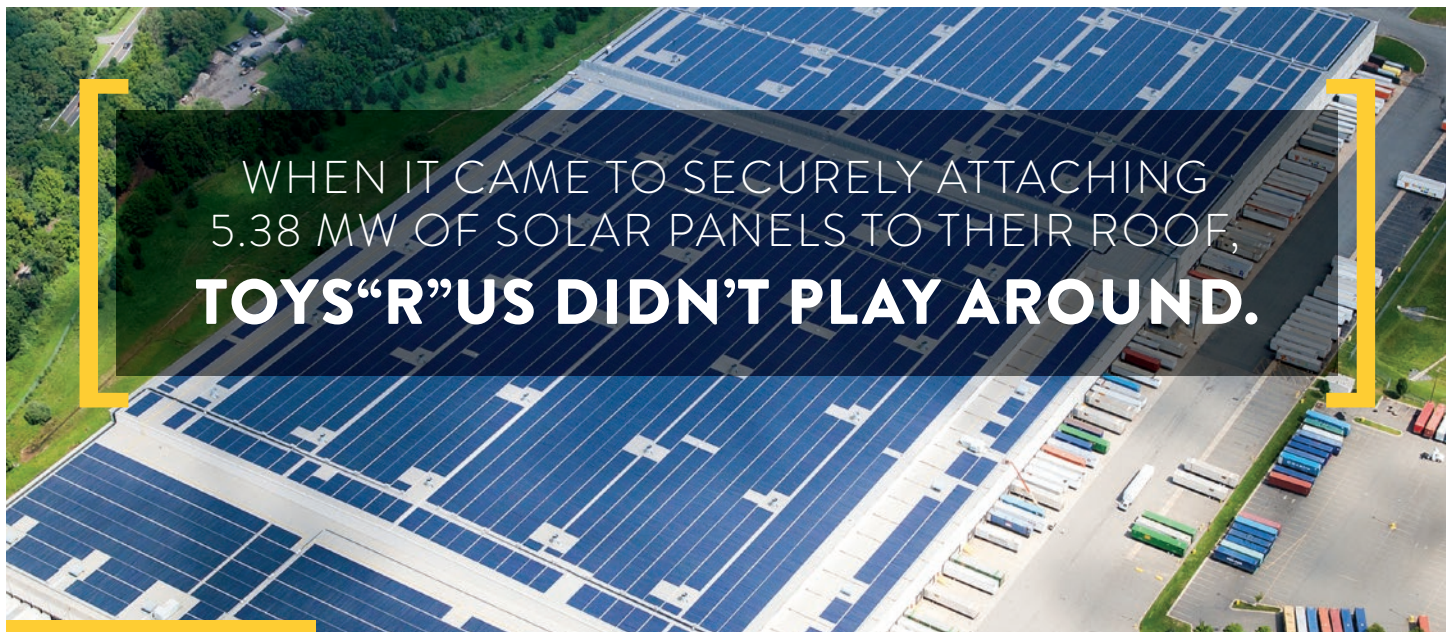
[www.sighten.io](http://www.sighten.io)



### SolarNexus, Inc.

SolarNexus is a robust software platform for independent sales and installation companies to manage a high volume of projects from lead through completion. SolarNexus combines sales, CRM, and project management features which are tailored for solar and energy efficiency businesses. Their core solution, combined with the larger eco-system of pre-integrated partner applications, simplifies information technology and enables companies to profitably operate and scale their business.

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

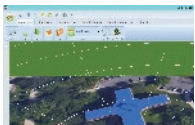


American made S-5-PV kits and clamps are the industry standard in metal roof mounting hardware. That's why the biggest names in business rely on our solar mounting solutions. They know that it's only secure, if it's S-5! secure.

Learn more at [www.S-5.com](http://www.S-5.com) or call 888-825-3432.







**Valentin Software, Inc.**

Valentin Software develops design, simulation, and yield calculation software, offering tools for solar electric (PV\*SOL), solar thermal (T\*SOL) and heat pump (GeoT\*SOL) systems. PV\*SOL premium's 3D analysis and shading visualization provides the basis for the precise calculation of system yields. PV\*SOL premium supports the design process by creating buildings and objects based on floor plan drawings, ground plans, and map screenshots. T\*SOL is Valentin Software's program for users to accurately calculate the yield of a solar thermal system dynamically over the annual cycle. With GeoT\*SOL users can design heat pump systems. [www.valentin-software.com](http://www.valentin-software.com)



**Velocify**

Velocify, a sales acceleration platform, helps sales teams and solar companies sell more by bringing speed and control to the entire sales process. Velocify helps solar sales professionals prospect with precision, quickly respond to new leads, and follow a proven sales workflow to find and convert more leads. [www.velocify.com](http://www.velocify.com)

**Solar Coatings**



**Sono-Tek Corporation**

Sono-Tek provides ultrasonic coating equipment for depositing active layers for CIGs, CdTe, Perovskite, and DSC solar manufacturing, as well as TCO spray pyrolysis deposition equipment. [www.sono-tek.com](http://www.sono-tek.com)

**Solar Fasteners**



**Marine Fasteners**

Marine Fasteners is a national supplier of stainless steel hardware in both imperial and metric. Their service offering provides expertise in mitigating unnecessary corrosion cost to their solar customers. [www.marfas.com](http://www.marfas.com)



**Mudge Fasteners**

The DURA-CON Power Lag showed no corrosion in tests to 1500 salt spray hours when used with aluminum components. The integrated washer head increases bearing surface, the serrated flange resists loosening due to vibration, and type 17 tip allows easy starts and quick drives. [www.solarfastenerexpert.com](http://www.solarfastenerexpert.com)



**Nine Fasteners, Inc.**

Nine Fasteners, Inc. designs, manufactures, and distributes stainless steel wire management products to the solar industry. They recently introduced a new addition to their line-up of standard wire management offerings, the NFI-1463. The NFI-1463 is designed to securely fasten a single Enphase Engage trunk cable to a module frame. The NFI-1463 is produced using 410-grade stainless steel, and is manufactured entirely in the US. Nine Fasteners has continued to use a rolled outer edge on this clip, as is standard across their entire product line. In addition to their standard products, Nine Fasteners offers custom design capabilities for application-specific products in both 300 series and 400 series stainless steel. [www.ninefasteners.com](http://www.ninefasteners.com)



**PMC Industries**

PMC Industries' AceClamp fasteners and solar kits now come with the UL Mark, having passed stringent testing for code requirements and performance. One of the easiest clamps to install, the patented, FM-Approved AceClamp ML can reduce installation time by as much as 25%. The AceClamp A2, with its dual push-pin design, has a built-in grounding wire groove and will not scratch the SSMR surface or damage applied roof coatings. Both clamps prevent torque back-out from high wind or seismic vibration. [www.aceclamp.com](http://www.aceclamp.com)

**Solar Glass | Encapsulation**



**Neenah Technical Materials**

Incorporating CraneGlas into the encapsulation/lamination process of conventional solar panels can lead to faster processing times, increased bond strength and uniformity, reduced shrinkage, and elimination air bubbles that can sometimes occur. [www.neenah.com](http://www.neenah.com)

**Solar Hot Water Distributors**



**UMA Solar**

UMA Solar distributes products including: Solar Pool Heating, Solar Hot Water, Solar Electric, and Chlorine Generators. The patented Helical Solar Pool Heater utilizes an advanced mounting technology with maximized efficiency and is hurricane resistant. The Helical Solar Pool Heater comes with a 12-year warranty. UMA Solar also offers support in marketing, sales training, engineering, and financing. [www.umasolar.com](http://www.umasolar.com)

**Solar Integration**



**Pfister Energy, Inc.**

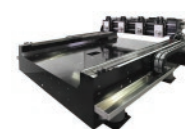
Pfister Energy specializes in the design and construction of renewable energy solutions for commercial, industrial, and institutional facilities with an emphasis on building-integrated applications, and energy supply services. The company implements the latest GREEN technologies including; photovoltaics, daylighting, energy efficiency, wind turbines, solar lighting, solar thermal systems, fuel cells, rainwater harvesting, geothermal systems, and green roofing. [www.pfisterenergy.com](http://www.pfisterenergy.com)



**Sullivan Solar Power**

Sullivan Solar Power is a turnkey solar system provider delivering solar electric projects from concept to completion. The company has installed over 30 megawatts of solar power ranging from small-scale residential to large-scale commercial and municipal systems. [www.sullivansolarpower.com](http://www.sullivansolarpower.com)

**Solar Scribing & Motion Control**



**SCHNEEBERGER, Inc.**

SCHNEEBERGER is a manufacturer of high precision linear bearings and components: ball, needle, and cross roller bearings, miniature linear bearings, ball and roller Monorail linear guideways, and spur and helical gear racks. Available options include anti-cage creep solutions, integrated magneto-resistive, or optical linear encoder. SCHNEEBERGER also distributes precision linear ball bearings, linear motors, ball screws with a diameter and pitch product range from 4mm x 0.5mm to 160mm x 80mm. SCHNEEBERGER designs and manufactures single to multi-axis linear motion systems, and is a supplier to the solar, semiconductor, life science, metrology, electronics, and automation industries. [www.schneeberger.com](http://www.schneeberger.com)



## Solar Support Structures & Carport Systems



### Baja Construction Co., Inc.

Baja Construction Co. specializes in the turnkey development of high-tensile, light-gauge steel structures that serve as the mainframe for solar energy projects, generating both power and revenue as well as providing shade and protection. With their team of in-house engineers, they are able to design, engineer, supply, and install any structural project, including ground-mounts, carports, and RV and boat storage facilities. Baja Construction's Solar Support Systems are integrated into projects nationwide ranging from school campuses, train stations, sports complexes, shopping malls, medical facilities, and office buildings.

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



Elevating the Future for Solar | By Doing What We Do Best



### DCE Solar

DCE Solar PV racking systems are easy to install and are engineered for reliable ground-mounting (including landfills) and rooftop-mounting solutions. Their ground-mounted Contour system is a topographically adaptable PV racking solution, while Cap-Rack is their solution for capped landfills. Their rooftop-mounted Eco-Top-HD features increased capacity with more wattage per square foot. DCE Solar works with utilities and EPCs on commercial and utility scale projects to deliver swift, efficient project completion.

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



### Falcon Steel Company

Falcon Steel provides custom metal fabrication products, produced from recycled material. They provide solutions for residential, commercial, or utility-scale solar projects. Whether it be support structures, solar pedestals, or land access gates, Falcon Steel's engineering department provides custom tailored solar solutions. Falcon Steel has been designing and fabricating steel structures and custom products for over 52 years.

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



### Florian Solar Products, LLC

Florian Solar offers integrated solar power structures designed for everything from carports and canopies, to awnings and greenhouses. Their latest product line provides a way to use solar within a living space or as a home addition. The Sierra F-200 PV Module is an insulated, frameless, and bifacial module designed to be integrated within Florian's proprietary framing systems. The Sierra PV Module is used within Florian's line of solariums, greenhouses, conservatories, and skylights.

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



Smarter PV mounting solutions from top of roof to bottom line®



### Roof Tech, Inc.

Roof Tech's compact and versatile rail-less PV mounting system, RT-[E] Mount attaches to rafters or anywhere else on roof decking. Once panels are fastened, the array is electrically bonded. RT-[E] Mount comes complete with watertight and durable RT Butyl flashing. Power electronics mounting is available for the RT-[E] Mount Air, as are PE stamped certification letters; UL 2703, ICC ESR-3575, ASTM 2140.

[www.roof-tech.us](http://www.roof-tech.us)



### Skyline Solar

Skyline Solar is a design-build construction firm of solar support structures, specializing in carport structures, covering parking lots, and top of parking garages. From their engineers to their field installation crews, Skyline Solar designs, engineers, and installs solar structures to fit the location requirements and the customer's needs. They approach every project with a focus on quality, safety, aesthetics, functionality, cost, and structural integrity, with the resources to keep projects on schedule. Skyline performs all work with their own equipment and employees, so they can offer lower costs and better quality control.

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

# SOLAR CLIPS



### NFI-1306-V90

90° oriented clip intended to secure two USE-2 wires, up to .20" diameter, to standard module frame.

### DCS-1306

Designed to secure two USE-2 wires, up to .20" diameter, to module frame.



### DCS-1307

Designed to secure two PV wires, up to .30" diameter, to module frame.

### NFI-1461

Designed to secure two Enphase trunk cables to module frame.



### NFI-1462

90° oriented clip designed to secure two Enphase trunk cables to module frame.

### NFI-1463

NEWLY designed clip to secure a single Enphase trunk cable to module frame.



### DCX-2452A

Designed to secure two Enphase trunk cables on to most rail/racking systems.

For FREE product samples, please reach out to Vin Marino  
[vin@ninefasteners.com](mailto:vin@ninefasteners.com) or 800.539.3939



233A South Street | Hopkinton, MA 01748 | 800.539.3939

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





**ZinCo Canada, Inc.**

With its Solar Base, ZinCo incorporates solar energy into green roofs and creates synergies, whether it is for generating electricity (photovoltaic), or for heating and hot water applications (solar thermal). The efficiency of photovoltaic modules depends on their temperature. Green Roofs will retain moderate temperature and improve the efficiency of PV modules permanently. The green roof build-up provides the load necessary for preventing wind suction with the solar energy system, avoiding the need for complicated roof penetrations and preventing load concentration.

[www.zinco.ca](http://www.zinco.ca)

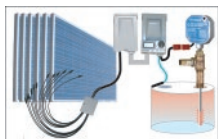
**Solar Thermal Manufacturing & Equipment**



**Beijing Sunda Solar Energy Technology Co., Ltd.**

Sunda's product families include their SEIDO series heat pipe vacuum tube and collectors, direct flow vacuum tube and collectors, storage type vacuum tube and collectors, receiver tube and parabolic trough collectors. Sunda's SEIDO series collector are applied in water heating systems, industry process heating, space heating systems, solar air-conditioning systems, and other applications. Sunda reinforces research and development to realize the quick industrialization of their high temperature evacuated tube, which Sunda provides for CSP power plants in mass production.

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



**Butler Sun Solutions, Inc.**

Butler Sun Solutions' new SRCC OG-300 certified PV Wand heats any standard tank using DC power from PV panels (up to 1500 Watts). For closed loop solar thermal systems, the Solar Wand heat exchanger converts any tank to a solar water heater (components and balance of system available), and is also SRCC OG-300 certified. Both systems are off-grid, and either system also can heat spas.

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



**Innosolar Energy Co., Ltd.**

Innosolar Energy supplies flat collector with aluminum and copper absorbers. Their flat collectors are SRCC, Solar Keymark, WaterMark, and SABS approved. Innosolar also offers accessories including tanks, mounting, waterproof roof units, and connectors.

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



**Vermeer**

The Vermeer PD10 pile driver was designed to assist with installation of solar panel configurations. This freestanding machine utilizes an inclinometer with auto-plumb and laser-controlled post-depth-control feature to help ensure every post is installed to exacting specifications. The PD10 features an optional laser receiver integrated into the control system and a GPS-ready design to help improve productivity. It also has an integrated control system, which offers the operator a variety of machine information, including pile angle and height.

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

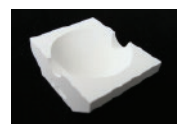


**Viessmann Manufacturing Company**

Viessmann manufactures solar thermal components and systems that achieve high standards of performance and quality for every application including pool heating, domestic hot water heating, and commercial process heating. Built with corrosion-resistant and UV-stabilized materials, Viessmann solar thermal collectors are SRCC Certified to the OG 100 standard and provide performance over a lifespan of 20+ years.

[www.viessmann-us.com](http://www.viessmann-us.com)

**Solar Thermal Systems**



**Accuratus Corporation**

Accuflect light reflecting ceramic is being incorporated into a wide range of renewable energy applications from solar cell processing furnaces to utility scale solar thermal plants. Accuflect reflects 95% to 99% of incident light from 450 nm to 2500 nm. Accuflect material is fabricated with high purity metal oxides free of transition metals and their compounds, and is available in two product types; the B6 material has the virgin ceramic surface produced during manufacture, and the G6 material has a clear glaze applied to seal the surface porosity of the virgin material to allow for easy cleaning and provide a non-contaminating surface where it is exposed to atmosphere or liquid environments.

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



**California Sunlight Corporation**

California Sunlight Corporation offers cost-effective, small-scale, portable solar energy systems. Products include: solar-powered BBQs, ovens, and stoves; solar food dehydrators; solar water heaters; active daylighting; and micro-CPV systems. Their latest product is a solar balloon cooker. At only two ounces, it can fit into a small pocket. The solar balloon cooker can be used for cooking, heating, water pasteurization, and even for increasing the power output of a PV panel. It's a solution for everything from camping to emergency responses, and serves well for water, cooking, and heating needs in developing countries.

[www.california-sunlight.com](http://www.california-sunlight.com)



**Next Generation Energy**

Sun Bandit by Next Generation Energy is a revolutionary new way in which solar PV technology is used to heat water. Sun Bandit eliminates the need for complex solar mechanical water heating, replacing it with a simple solution that makes installation and operation easier than ever before. With advanced PV microgrid technology and water heater design, Sun Bandit doesn't require net metering or a grid-tie connection, and can deliver hot water even when the utility power goes out. Sun Bandit can be used as a standalone or as a pre-heat to existing systems. It's currently one of the simplest solar water heating solutions on the market, providing an easy-to-use and economical way to go solar.

[www.sunbandit.us](http://www.sunbandit.us)



**Solar Sun Air Conditioning**

Solar Sun's solar air conditioner and thermal heat pump system require no forced air duct work, and with DC motors which revert to AC power on demand, there is no need for a DC to AC inverter. These systems are certified AHRI, Energy Star, UL 1995, CSA 22.2, ETL, and California Energy Commission (CEC certified solar air conditioner). Battery storage power is available for 100% DC power.

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



**Solar UV Solutions**

Distributed by Solar UV Solutions, the SunQuest 250 solar thermal collector utilizes evacuated tube technology to convert UV rays into a renewable source of usable energy. One panel can create up to 30,000 BTUs per hour, or 300,000 BTUs per solar day, which can then be used in a number of commercial applications including high volume water heating, domestic hot water, radiant floor heating, and steam applications. The SunQuest 250 seamlessly integrates with existing heating systems, becoming the primary heat source during the day, displacing fossil fuels, and reducing greenhouse gas emissions.

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



**Solar Wave Energy, Inc.**

Solar Wave Energy provides solar thermal monitoring products and services so users can remotely manage solar heating and cooling systems. Thermal-Grid monitoring provides web-based tools to commissions and fine-tune controller settings. Monitoring options range from simple temperature and run-time assessments to full measurement of solar production, contributions, back-up contribution, and displaced energy. Tools include performance checks, alarm messaging to technicians for components or performance problems, and a monthly health report shows owners the value their system provides. Thermal-grid products are approved by the California Solar Initiative for heat metering and Solar Wave is a CSI data provider.

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





### Stiebel Eltron

Stiebel Eltron manufactures the energy saving Tempra Plus tankless electric water heaters, Accelera heat pump water heaters, and solar thermal renewable energy systems. Tempra Plus tankless electric feature advanced flow control to automatically keep output temperature constant and provide an unlimited stream of hot water. Units are also ideal backups for solar thermal systems. Accelera 300 Heat Pump water heaters have an 80 gal capacity, low power input of 500 W in heat pump mode (2200 W including back-up element) and low power consumption of 1391 kWh/year, translating to \$167/yr based on 12 cents/kWh. Solar Thermal Systems hedge against fossil fuel price volatility. Federal tax credits, state, and local incentives cut the cost of an installed system up to 40% or more.

[www.stiebel-eltron-usa.com](http://www.stiebel-eltron-usa.com)

### Temperature Profiling

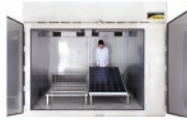


### Apogee Instruments

Errors in air temperature measurement up to 10°C (18°F) are common in naturally aspirated, multi-plate sensor shields in low wind, high solar load conditions. These errors are well outside the 1°C (1.8°F) recommended standard for PV monitoring. Apogee Instruments' TS-100 high-efficiency, fan-aspirated radiation shield solves this by providing constant internal aspiration using an IP55 rated 80 mA fan, which can operate as low as 28 mA using pulse width modulation. Built from rugged UV stable plastic, the unique Coandă inlet and internal Venturi contour shape optimize air-flow over the temperature sensor, consistently yielding accuracies of 0.1°C (0.18°F) when used with the recommended thermistor.

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

### Testing & Certification | Testing Chambers



### Atlas Material Testing Technology, LLC

With over 30 years of testing and measurement experience supporting the solar industry, Atlas provides weathering instruments, solar simulation chambers, testing services, and consulting solutions for the Photovoltaics, Concentrated Solar Power, Solar Thermal, and Building Integrated Photovoltaic markets. To address the unique needs of the photovoltaic industry, Atlas has developed a comprehensive durability testing program specifically for photovoltaic modules - Atlas 25+, a proprietary, multi-dimensional durability testing program designed to subject photovoltaic modules to the environmental degradation stresses which can be expected over long-term service.

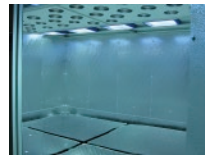
[www.atlas-mts.com](http://www.atlas-mts.com)



### Cincinnati Sub-Zero

CSZ provides solar panel test chambers designed to accommodate multiple solar panels for testing all three sections of the IEC temperature cycling, humidity freeze, and damp heat test specifications. CSZ also manufactures a full range of standard and custom-designed environmental chambers ranging from small benchtop chambers to full walk-in chambers, and rooms with conditions including: temperature, humidity, thermal shock, altitude, vibration, and more.

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



### Honle UV America

Honle UV America provides sun simulation and UV radiation measurement systems for testing in the solar industry including a class CCC Light soaking, CCB Hot Spot Test, and the IEC 60904-9 standard solar simulator for Honle SOL units. They can provide only lamp units with power supply, or complete manufactured systems including temperature control for the PV-module.

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



### IAPMO R&T

IAPMO R&T provides fast, flexible resources to accommodate their customers' product certification needs. Their range of certifications include: ANSI Accredited Solar Product Certification according to the Uniform Solar Energy and Hydronics Code, ENERGY STAR, ANSI/IAMPO Energy Production Rating of Solar Heating Collectors, SRCC Standard 100, SRCC Standard 150, SRCC Standard 300, and SRCC Standard 600.

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



### OAI

OAI manufactures a complete line of Solar Simulators and I-V Testers for production or R&D. Their solar simulators and I-V test systems meet the specifications for CPV, Multijunction, Single long pulse, and many other solar cells.

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



### Q-Lab Corporation

Q-Lab Corporation is a global provider of material durability testing products. They design and manufacture standard test substrates, as well as weathering, light stability, and corrosion testers. In addition, contract test services, which include accelerated laboratory testing, are available at various Q-Lab locations. Outdoor exposure testing for weathering, light-fastness, and corrosion are also available in the US.

[www.q-lab.com](http://www.q-lab.com)



## A highly secure safety system



### Greeneye Smart PV Switch

- Failsafe safety system
- Individual shutdown feature per PV module
- Protection for firefighters or PV installers and electricians

[ep.mersen.com](http://ep.mersen.com)







**UL, LLC**

UL is a global independent safety science company which has championed progress for 120 years. Its more than 10,000 professionals are guided by the UL mission to promote safe working and living environments for all people. UL uses research and standards to continually advance and meet ever-evolving safety needs. Uniquely designed and expertly delivered, UL's service portfolio is structured to fit the needs of the customer, covering virtually every aspect of the global PV value chain.

[www.ul.com/solar](http://www.ul.com/solar)

**Theft Protection**



**Bryce Fastener, Inc.**

Bryce Fastener provides tamper-resistant and custom keyed ground-mount security screws, nuts, and self-drill fasteners.

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



**Viasys Solar Secure, Inc.**

Viasys provides solar plant security with the Viasys Video Alarm System (VAS). VAS is a complete wireless or cabled perimeter security system using thermal imaging cameras and video analytic software to detect intruders day or night. A sequence of alarm images with a detection box around what caused the alarm is sent to the central station for verification and response deployment.

[www.viasys-iv.com](http://www.viasys-iv.com)

**Thin Film Materials**



**ProTech Materials, Inc.**

ProTech Materials offers turnkey sputtering solutions for the solar industry. This includes rotary and planar sputtering targets, backing plates, backing tubes, bonding services, and target recycling. The materials that ProTech Materials provides include: AZO; CdTe; CdS; CIG; Cu/Ga; In; ITO; Mo; Mo/Na; ZnO; ZnS; and ZnTe. ProTech Materials also specializes in custom engineered transparent conductive oxides used in PV manufacturing. ProTech Materials can supply small quantities for concept and feasibility studies with the ability to rapidly ramp to production quantities when needed.

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

**Tools**



**HT Instruments America**

The new I-V 400 W is a full-featured I-V curve tracer for use on PV panels and strings. Capable of measuring I-V curves up to 1000 Volts and 15 Amps, this curve tracer covers all IV measurement needs. The IV 400 is a self-contained unit, weighing 2.2 pounds, and can easily be carried to a jobsite. Standard with the IV 400 curve tracers are a protective hard case, all necessary leads, and a solar reference cell with attaching hardware. HT Instruments TopView software is standard and provides an excellent way to store, analyze measurements, setting up or updating the instruments as well as report generation. HT Instruments also provides over 50,000 panel specifications that can be downloaded into the instruments.

[www.ht-instruments.com](http://www.ht-instruments.com)



**HT Instruments America**

Solar I-V from is a combination instrument containing a full function I-V curve tracer (I-V 400 W) and a single-string to single-phase inverter efficiency measurement tool. The Solar I-V comes standard with HT Instruments patented Solar-02 remote unit, which aligns electrical measurements and environmental factors by remotely using aligned clocks. The Solar-02 unit eliminates the need for long wires, as well as risks with RF signal strength.

[www.ht-instruments.com](http://www.ht-instruments.com)



**HT Instruments America**

The HT 9022 Power Quality Clamp combines power quality analysis, phase sequence, conformity detection, as well as current and voltage meter in one device. The HT 9022 calculates power factor corrections, energy consumption, DC power, and harmonics to the 25th and more. It also connects via Bluetooth to android devices, and comes with the Top View software for documenting and storage.

[www.ht-instruments.com](http://www.ht-instruments.com)



**HT Instruments America**

PVCHECKS is a multi-function instrument that checks the safety, operating parameters, and performance of PV plants. PVCHECKS allows prompt and safe electrical checks required for PV systems (section DC), as well as the controls on working of modules and strings in accordance with IEC/EN62446 guidelines. The instrument successfully verifies the continuity of the protective conductors and associated connections, executing insulation-resistance measurements of the active conductors, without the need of short-circuiting the positive and negative terminals.

[www.ht-instruments.com](http://www.ht-instruments.com)



**Rennsteig Tools, Inc.**

Rennsteig designs and manufactures each line of their tools for maximum performance, ease of use, and long life. Their precision cutting, stripping, and crimping tools are engineered for the wires and terminals of the solar energy industry. They also offer custom designed tools for original equipment manufacturers (OEM), and have the knowledge to meet any customer specifications. Rennsteig's Professional Solar Crimp Kits allow customers to save money by fabricating their own customized PV-Cable.

[www.rennsteig.us](http://www.rennsteig.us)

**Tracking Systems**



**Array Technologies, Inc.**

Array Technologies, Inc. (ATI) unveils the latest evolution of its DuraTrack HZ solar tracking system for utility-scale power plants. DuraTrack HZ v3 offers features found nowhere else in the solar industry, including a single-bolt per module clamp and zero scheduled maintenance. This new version product delivers a variety of efficiencies allowing their customers to speed-up installation time, eliminate maintenance costs, and maximize power plant uptime to deliver the best levelized cost of electricity.

<http://arraytechinc.com>



**Dunkermotoren USA, Inc.**

Dunkermotor, an Ametek company, now introduces another Solar Tracker Motor (STM) product in addition to its STM with integrated programmable controlled BLDC GEN 3 motors. The GEN 4 STM is an integrated solar power motor unit, which embodies all the qualities and cost saving virtues of GEN 3 DC unit, and works with either 230v or 110v AC supply. There is no need for a switching cabinet, cabling, or wiring, as the integrated programmable BLDC motor is integrated with its own power supply.

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

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### Exosun

Exotrack HZ is an LCOE friendly single-axis solar tracker, increasing PV plant output up to 25%. Its design minimizes installation costs and time. Its linked-row architecture and grease-free, balanced structure make it a reliable solar tracker, reducing O&M actions to a minimum for 25 years. Exotrack's centralized control system pilots up to 10 MWp of trackers, allowing on-site or remote actions. With short rows, Exotrack HZ follows undulated topography, decreasing land grading works. Optimized DC wire management reduces wiring costs by 50%.

[www.exosun.net](http://www.exosun.net)



### Sedona Solar Technology

Sedona Solar Technology's new patented Intelli-Track SpeedRail Hybrid Dual Axis Solar Tracking System is a 5-panel modular frame, 21' in length, with adjustable elevation axis for strength and reliability. The quick and easy adjustment is made with a combination of telescoping 10,000lb Unistrut and 12000lb Ratchet Jack. Overall performance is approximately 35% better than optimized fixed panels, as per NRELS PVwatts. Solar tracking controls are provided by HelioTrack.

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



### Sun Action Trackers

Sun Action Trackers is a manufacturer of Solar Tracking and Racking systems. They offer services such as tracker installation complemented with in-house engineering services. Both their PST-2AL (Dual Axis Tracker) and their PST-1AX6 (Single Axis Tracker) utilize Sun Action Trackers' patented Real-Time Sensing Technology which is used to capture maximum production. Their steel is made from a revolutionary product known as Magnesium Alloy Coated Steel. This product, together with its self-healing properties, ensures that a project will be able to stand up to the rigors of the elements.

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

### TransPak

TransPak is a provider of solar logistics, packaging, and crating services. They have locations and partners around the world to streamline logistics from transportation, materials management, customs brokerage, and TSA screening.

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

### Utility Scale Solar | PV



**GP JOULE**  
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### GP JOULE USA, Inc.

GP JOULE is a diversified renewable project developer and EPC provider with a wide range of products and services. Products include: Phlegon Single Axis Tracker technology (heavy duty version and light version), PV carport (thin film/crystalline versions), Cultiveco PV Greenhouse. Their H-Tec Systems PEM electrolyser has an efficiency up to 75% percent and no hazardous chemicals emissions. GP JOULE also provides integrated co-generation solutions services including: turnkey EPC services, engineering/consulting services, O&M services, short and long term financing, and international project development.

[www.gp-joule.com](http://www.gp-joule.com)



### NEXTracker, Inc.

NEXTracker's Self-Powered Tracker has limited foundations and assembly points, which help mitigate geotechnical risk and accelerate project construction schedules. With independent rows and high slope tolerance, NEXTracker minimizes site preparation costs while providing the flexibility to install up to 30% more PV per site. The tracker is self-grounding, has a self-powered design, and it's wide rotational range provides a significant energy yield gain and enables PV systems to take full advantage of high irradiance environments. The SPT is also offered in numerous configurations, climates, and corrosion-proof models to accommodate US clients in the distributed generation and utility segments.

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



### Solar FlexRack

The TDP Turnkey Tracker offers a low total cost solution by providing a tracker that includes full design, installation, commissioning, and support services bundled in one contract. From a solar installation's preliminary layout and plans, through construction and life of system, the Solar FlexRack TDP Turnkey Tracker provides a reliable solution while reducing installation time and long-term maintenance. Solar FlexRack's TDP Tracker allows for close packing on odd-shaped lots, and maximizes land usage due to its distributed design.

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

### Transportation | Logistics



### Port of Longview

The Port of Longview is a full-service operating port with strategic transportation connections on the deep draft Columbia River. It is 5,000 miles and 20 days closer to Asia than gulf coast ports, 5 miles to Interstate-5, and located at Columbia River Mile 66. The Port maintains 2 Liebherr Mobile Harbor Cranes, 45 MTs Reach Stackers, multiple heavy-lift forklifts, and trailer options. There are 70 acres of open storage adjacent to berths, 25 acres of Foreign Trade Zone available, long-term storage options, and an available labor force. Served by Union Pacific and BNSF, and Industrial Rail Corridor for direct access off mainline and 1,500 contiguous feet of on-dock rail.

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



### Parker Hannifin

Parker's "hybrid" actuators feature the controllability of electromechanical models combined with the power density, long life, and resistive force capabilities of traditional hydraulic systems. Designing this hybrid actuator into a pitch system allows designers to move more PV panels with fewer actuators and controls. All the internal wear items are permanently lubricated for extended life and the power density of HAS is typically three times that of a comparable EMA.

[www.parker.com/cylinder](http://www.parker.com/cylinder)



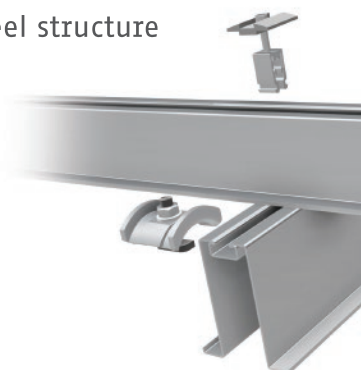
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**Greenwood Energy**

Greenwood Energy combines top-tier developers, financial professionals, and operational experts to create clean energy investment opportunities. They are currently focused on state-of-the-art energy solutions in solar and energy storage markets. Greenwood Energy's portfolio and expertise includes active investments in shovel-ready renewable energy projects, as well as taking on early stage developments meeting their selective investment criteria. Greenwood Energy has 400MW of experience in solar energy, with over 1GW of solar opportunities currently under development internationally.

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



**Solar Frontier Americas Development, LLC**

Solar Frontier Americas Development LLC, a subsidiary of Solar Frontier, develops and sells utility-scale photovoltaic plants in the United States and Latin America. Headquartered in San Francisco, California, the development team partners with leading solar system component suppliers, EPCs, and other developers to deliver optimized, high-yield solar plants that help meet the clean energy needs of today.

[www.solar-frontier.com](http://www.solar-frontier.com)



**Soltage, LLC**

Soltage offers solutions in the development, financing, and operation of solar power generation stations; providing electricity to commercial, industrial, educational, utility, and municipal customers across the United States under long-term contracts. Soltage has developed 35 solar energy projects with 85 megawatts total distributed generating capacity under management across eight states. Soltage is backed by a group of investors including leading independent power producer Tenaska and is headquartered in Jersey City, New Jersey.

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



**TMEIC**

TMEIC's Solar Ware Samurai Series of photovoltaic inverters is the first heat pipe air-cooled PV inverter. The Samurai is available in three power classes, 2500 kW – 2700 kVA (1500 V), 2300 kW – 2500 kVA (1500 V), and 1833 kW – 2000 kVA (1000 V). TMEIC's Solar Ware Main Site Control provides overall coordination and control of utility-scale PV plants, providing access to complete information about an entire plant's power production.

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



**Vis Solis, Inc.**

Vis Solis develops, finances, installs, and operates Utility Scale and Commercial Scale PV-Solar projects in the United States and the Philippines. They provide consultancy and advisory services in due diligence, project development, merger and acquisition, engineering, procurement, structuring, and financing.

[www.vis-solis.com](http://www.vis-solis.com)

**Weather Stations**



**Lufft USA Inc.**

Lufft offers a unique series of weather products to meet the meteorological monitoring requirements for utility and commercial-scale PV projects. The WS Family of weather stations offers the WS501, WS502, WS503, WS510, and WS504 with solar radiation, as well as the WS601/WS600 with an added rainfall option. Rainfall measurements can help to gauge variance in performance due to panel soiling. The flexibility of each station allows for ease of integration and possible measurement of wind speed, wind direction, plane of array solar radiation, temperature, relative humidity, barometric pressure, and back of panel temperature. Turnkey or sensor-only packages are available from Lufft or a Lufft partner.

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

**Other Aerial Imagery & Measurements**



**EagleView Technologies**

EagleView Technologies offers Pictometry Intelligent Images and analytical tools for accurate pre-contract assessment. The high-resolution images provide top-down, as well as north, south, east, and west views, to easily identify shading and roof obstructions. With image libraries covering the United States and Canada, neighborhoods in any geographical area can be evaluated right from the desktop. After the sale, EagleView Solar Roof Reports use patented, 3D technology to deliver detailed measurements, including orientation, tilt, and total square footage. They also provide CAD files that can be imported into existing workflows for precise solar design and installation.

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

**Applied Light Spectrum**



**EYE IWASAKI / Applied Optix**

EYE Applied Optics / Iwasaki Electric develops light-applied system solutions. From full spectrum solar simulation, to unique UV durability test chambers, their goal is to employ light technology to create a more sustainable environment. Their light applied solutions provide uniformity, performance, and energy efficiency.

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

**Equipment Manufacturer**



**GRT Utilicorp, Inc.**

GRT Utilicorp manufactures post driving and pressure digging machines. They also provide sales of new and used machines, pneumatic rock drills, augers, driving equipment for smaller jobs, repair and replacement parts, and truck and track mounted machines for highway median, or solar panel post driving.

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

**Machine Vision**



**FSI Technologies, Inc.**

FSI Machine Vision provides a full range of automatic inspection systems and components, engineering, and training for demanding industrial environments and applications. They are partnered with NeuroCheck vision software, Eye Vision Software, Automation Technology 3D sensors, and are a ViDi Preferred Solution Provider. Their Assured Path to Success program has a 100% success rate on even the toughest machine vision applications.

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

**Microgrid Control Systems**



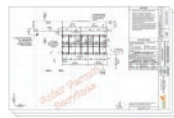
**Sustainable Power Systems, Inc.**

Sustainable Power Systems' Universal Microgrid Controller (UMC) is a drop-in control cabinet designed to reduce the cost and complexity of microgrid deployment. It is engineered to meet the needs of a wide spectrum of microgrid configurations, grid-tied or off-grid, eliminating the need for solar project developers to do controls integration and custom programming. In their new Simulation Mode, the UMC monitors and controls a virtual version of a proposed microgrid, allowing customers to experience the microgrid controller in action, before making a purchase decision.

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



## Permitting Services



### Advanced Solar Solutions

Advanced Solar Solutions offers a powerful, web-based service generating residential solar permits and interconnections. With its graphic interface and use of templates, the user/contractor can click through the submission process in 10 minutes or less. They offer a tablet based Advanced Site Survey Software which will interface with most solar proposal tools or CRM's the user currently has their existing site info stored in, making the process even faster. They send high resolution rooftop images from Pictometry/Eagle View so the rooftop layout can be quickly sketched.

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

## Printing/Metallization Equipment & Services



### ASM Alternative Energy

The ASM AE Eclipse metallization platform delivers a modular design, allowing manufacturers to scale up production with ease. Featuring a series of field-retrofitable process modules, Eclipse enables manufacturers to scale production from 1350-4000 wph, as demand dictates. The metallization line can be designed for a production ramp by inserting spacer process modules equipped with conveyors where future production modules will be added. Fast, but sensitive handling incorporates high speed and zero edge contact for negligible wafer breakage rates.

[www.asm-ae.com](http://www.asm-ae.com)

## Radiant Heating



### Electro Plastics, Inc./STEP Warmfloor

STEP Warmfloor heating elements are made of homogeneous, durable, and thin (1.2mm) PTC semi-conductive polymers. The system operates on 24 Volts AC or DC and can be connected to alternative energy sources. Because the elements are self-regulating, they cannot overheat and are very energy efficient. STEP Warmfloor is used in residential, commercial, and industrial applications, including for primary heat, floor warming, snow melt, and roof deicing applications.

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

## Remote Asset Management

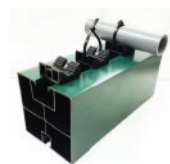


### WAGO

WAGO's line of terminal blocks and interface modules ensure safety and quality while providing cost-effective asset management. WAGO's Smart Grid offerings now include controllers supporting Distributed Network Protocol (DNP3). Widely used for communication between various types of data acquisition and control equipment, this protocol enables outstations to create a reliable link to a provider's SCADA system and other equipment. Featuring Scalable Smart Grid technology available in Ethernet 2.0 and WAGO-I/O-PRO configuration software, DNP3-enabled controllers from WAGO offer computing power for economical and efficient process management.

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

## Roof-Top Pipe Support



### A-Rise Pipe Support

A-Rise's 'Twisted System' is an integrated system consisting of a high-strength, patented, UL Listed ABS/AES Pipe Support which is sizable, durable, and lightweight coupled with a patented universal Conduit/Pipe Clamp that simply twists into place in the strut channel formed in the Pipe Support.

The single piece Pipe Support and the polycarbonate Twist Clamp cannot rust, corrode, or fall apart.

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

## Solar Solutions Provider



### Panasonic Eco Solutions Company

Panasonic Eco Solutions Company provides a streamlined process for going solar. Instead of moving from one third-party to the next, organizations now have access to a platform which serves as a one stop shop, providing executives with an end-to-end solar solution that includes everything from design and construction, to financing and long-term O&M.

[www.business.panasonic.com/solutions-energysolutions](http://www.business.panasonic.com/solutions-energysolutions)

## Vacuum Chambers & Components

### Nor-Cal Products



### Nor-Cal Products Inc.

Most PV solar cells are made using thin-film deposition techniques, similar to compound semiconductor processing or industrial coating. Nor-Cal is a key supplier of vacuum chambers, pressure control, isolation valves, fittings, and flanges to many existing solar cell manufacturers. They also offer products to start-up companies and those doing research and development (R&D) on next-generation, thin-film techniques for non-semiconductor substrates, such as steel. The goal is to bring the cost of solar energy within reach of existing electrical utilities and to reduce dependence on fossil fuels.

[www.n-c.com](http://www.n-c.com)

## Vacuum Valves



### Vacuum Research Corporation

Vacuum Research provides rectangular port, gate, and poppet valves for solar cell vacuum process equipment.

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

## Valves, Measurement & Control Systems



### Gemu Valves, Inc.

GEMU HP products and components for ultra pure applications are manufactured by GEMU in their clean-room facility in Emmen, Switzerland. The products are injection molded or machined, cleaned, assembled, tested, and packed using the very latest technology and processes. GEMU HP products are developed for process equipment, including ultra pure chemical and water supply systems.

[www.gemue.de](http://www.gemue.de)

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show in print

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

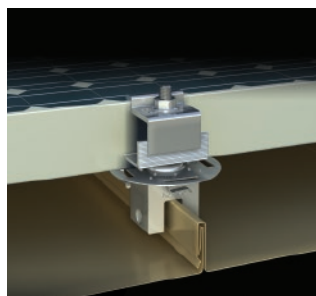


### Economic development

Rutland City, Vermont has become a green leader for the Northeast by embracing solar development, adopting policies and partnerships, and supporting energy based technologies which support and benefit the local economy. The City has recently seen investment from national players such as NRG Energy, Next Sun Energy, and groSolar and will continue to support this diverse and growing industry sector by leveraging a close collaboration with Green Mountain Power's new Energy Innovation Center. The shared goal is to become a regional technology hub by assisting pioneering companies working in the fields of energy innovation, renewable energy, and environmental technology to grow and succeed. To achieve this, the City has developed a Business Incentive and Assistance Program which includes grants, loans, free workspace, workforce training, even relocation assistance, to encourage growing companies to locate or expand in Rutland.

#### Rutland Redevelopment Authority

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



### PV mounting solution

The S-5! PV Kit is one of the first solar module mounting solutions to be listed to the new UL subject 2703, a standard that covers both bonding and mounting, and has gained an ETL listing to UL 1703. This non-penetrating, DirectAttach PV mounting solution for standing seam metal roofs fits the majority of solar panels on the market and can withstand the harshest weather conditions while maintaining electrical conductivity. S-5!'s new EdgeGrab is specifically designed to be used in conjunction with the patented S-5-PV Kit for solar array end conditions. The S-5! PV Kit reduces cost by eliminating the need for inter-module copper wires and lug bonding, and ultimately saves time and materials by providing the entire attachment system.

**s-5!** | [www.s5.com](http://www.s5.com)



### Balance-of-system solutions

SolarBOS' Rapid Shutdown Solutions represent low-cost and space-saving solutions for residential and commercial solar systems utilizing string inverters. 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, as required by NEC 690.12. SolarBOS also offers a wide range of Disconnect Combines, Arc Fault Circuit Interruption (AFCI) Combiners, Recombiners, and Wire Harness Solutions. All products are listed to UL-1741 and made in USA.

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

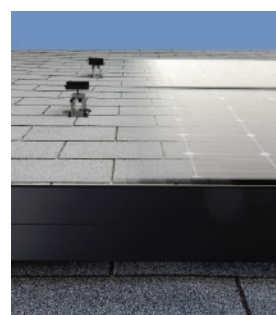


### Solar structures & carports

Baja Construction Co. Inc. specializes in the development of high-tensile, light-gauge solar support structures, an alternative to traditional rooftop applications. By executing a "turnkey" approach to their projects, Baja advances their clients through the design, engineering, supply, and installation process, delivering both high quality and cost-effective results, leading to a versatile asset for any business. Baja's projects are custom-designed and tailored to optimize their clients' specific structural objectives for commercial, municipal, and residential developments. These projects can include, Solar Ground-Mounts, Carports, Solar/EV Charging Stations, Mini Storage, or RV/Boat Storage.

#### Baja Construction Co, Inc.

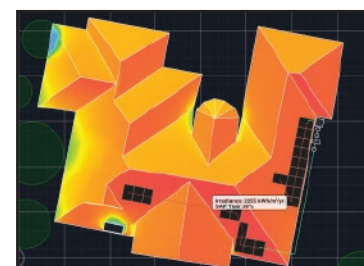
[www.bajacarports.com](http://www.bajacarports.com)



### Rail-less PV mounting system

Roof Tech's compact and versatile rail-less PV mounting system, RT-[E] Mount attaches to rafters or anywhere else on roof decking. Once panels are fastened, the array is electrically bonded. RT-[E] Mount comes complete with watertight and durable RT Butyl flashing. Power electronics mounting is available for the RT-[E] Mount Air, as are PE stamped certification letters; UL 2703, ICC ESR-3575, ASTM 2140.

**Roof Tech** | [www.roof-tech.us](http://www.roof-tech.us)



### Solar software platform

Aurora Solar's one-stop software platform allows a user to quickly build complex 3D models, perform detailed shading analysis of a site, and automatically create full system designs in just a few clicks. Aurora generates NEC compliant designs and their associated electrical one-line diagrams. Inbuilt financial simulations produce a detailed cash flow model and investment summary. Aurora's software can also generate fully customizable proposals, with uploaded logos, photos, and charts, as well as 2D and 3D viewports.

**Aurora Solar, Inc.** | [www.aurasolar.com](http://www.aurasolar.com)

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## V2G EV Charging

### The ground-breaking technology of today and the future

By Darren Hammell



**WHEN THE FIRST ELECTRIC VEHICLES (EV)** rolled out of factories in North America, the fascination of a car having to only run on electricity had great potential as gas prices sky rocketed. The promise of a lower carbon footprint enticed consumers as well as sparked the reduction of greenhouse gases. The electric vehicle industry is growing more every day. For instance, since the release of the Nissan LEAF in 2011, there are now over 200,000 on the road globally, making it the most popular EV ever. Many other auto companies have joined the movement by creating hybrid and electric vehicles for their consumers.

#### **A versatile battery on wheels**

In addition to contributing to the global clean energy movement, an electric vehicle battery can serve as a backup battery source for homes and buildings. This groundbreaking technology can even be used for renewable energy resource smoothing, and can increase efficiency and sustainability of an electric grid. However, with all these perks, consumers have had to pay a price, but not necessarily a dollar amount. As the EV Charging technology advances, consumers are dissatisfied with lengthy charging times from overnight to 24 hours. For example, the Nissan LEAF can achieve a full charge when connected to a standard wall plug for 24 hours, thereby only charging it a third of the way if left for eight hours overnight. Although there are faster charging stations available which can charge the EV's in eight hours, the need to reduce car charging time further is key to the owner experience. Is there a car charging technology out there which can charge in a shorter amount of time? The answer

is yes. Through a DC-DC conversion process in EV charging technology, the converters can provide up to 50 miles of range in less than 20 minutes.

#### **How does it charge in a short amount of time?**

The answer lies in how the technology utilizes DC power. The technology maximizes the DC power output from a solar array, and through a DC-DC converter provides DC fast-charging directly to the electric vehicle. The direct DC-DC conversion reduces losses associated with power conversion by over 50%, maximizing efficiency and reducing charging time. However, the charging technology is not just about powering up EVs; the system can also output power to the grid, or to the home when the grid is not available.

#### **Vehicle-to-grid in action**

This ground-breaking EV charging technology has been utilized at the Los Angeles Air Force Base in El Segundo, CA by the Department of Defense (DoD). Prior to the commissioning of the systems, the Pentagon established plans for initial vehicle-to-grid (V2G) tests at four military bases in the United States, L.A. Air Force Base being one of the more prominent ones. The DoD was searching for a cost-efficient and reliable EV charging solution which could be utilized at the base. As a result, the first fleet of bi-directional electric vehicle charging stations were installed. The technology provided to the military base was set to charge an electric vehicle directly from the local utility grid, enabling L.A. Air Force Base personnel to utilize the electric





### Grid-scale flow battery

ViZn Energy Systems Inc. (ViZn), announced it has built upon its proprietary flow battery technology to enhance the capabilities, reliability, and lifetime of all next generation flow battery systems for multi-megawatt energy storage applications. The Vanguard II battery stack further expands the operating range of ViZn's systems, strengthening their long-duration energy services by enhancing the fast switching and high power cycling capabilities required for many applications, further maximizing ROI and providing industry-leading payback periods. The Vanguard II battery stack has demonstrated 20% greater capacity and is immune to cycle life degradation, providing more headroom to handle spikes in power requirements for demanding and unpredictable applications on both sides of the meter. All ViZn flow batteries incorporate the new Vanguard II stack control technology which eliminates life-limiting issues such as dendrite growth, simplifies cell balancing, and removes thermal and electrolyte breakdown issues associated with high frequency power switching. This unique multi-use capability is necessary for frequency regulation and other high power applications while adding value to longer duration storage. All of ViZn's systems are highly scalable, adding value for even the largest utility requirements. By interconnecting multiple units, both power and energy capabilities can be increased to offer utilities, as well as commercial & industrial customers the optimal fit for any size project. ViZn's current flow battery systems can be seamlessly upgraded with the Vanguard II battery stacks, increasing the capabilities and application flexibility of customers' current assets and making existing systems even more efficient across the remaining life of the battery.

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

vehicles as transportation within the base. When called upon, and when connected to the electric vehicle, the bi-directional charging stations were to switch power flow directions quickly in order to support the V2G energy request. This was done by discharging the electric vehicle's on-board battery. In addition to supporting the reliable operation of the transmission and distribution system by providing frequency regulation, discharging the battery can also support demand response, VAR support, and other operating modes of the military base.



The project included the installation of V2G plug-in electric vehicle charging stations in support of the Air Force Research laboratory. The scope of supply delivered to L.A. Air Force Base consisted of thirteen 15 kVA bi-directional charging stations with CHAdeMO DC fast-charge option, capable of exporting power from the car to the grid. Today, the output of the stations are monitored and controlled by a site controller having built in frequency regulation, demand response, and other grid-support features.

### Charging the future

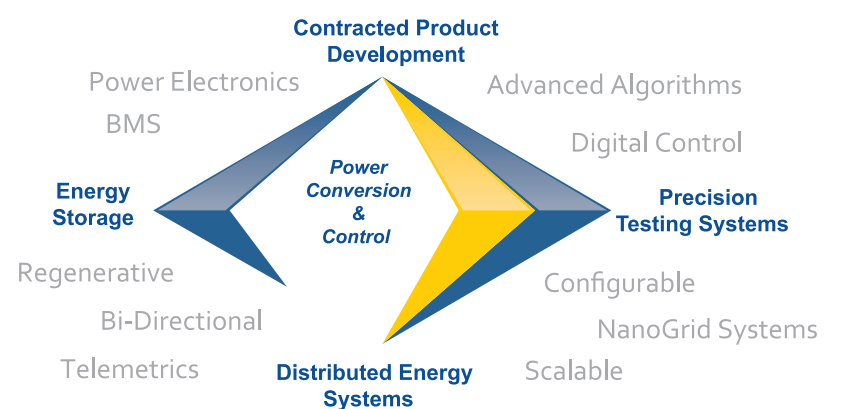
Military deployments, such as L.A. Air Force Base, and commercial deployments of EV charging technology are just the beginning. Imagine the possibilities as the technology becomes more efficient and faster. In the beginning, these EV charging systems were utilized solely for charging electric vehicles. Today, they are still used for that purpose, but are also used to distribute clean, reliable energy when the power goes out. As natural disasters continue to strike, and in areas where the grid is not reliable, V2G charging is the solution for power outages and the sustainability of the electric grid to keep homes and businesses up and running.



*Darren Hammell is the co-founder and chief strategy officer of Princeton Power Systems.*

**Princeton Power** | [www.princetonpower.com](http://www.princetonpower.com)

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# From Cost to Value

## The economics of battery energy storage

By Jesse Morris and Garrett Fitzgerald

**LAST YEAR, IN MANY WAYS, PROVED THE “YEAR OF THE BATTERY.”** After the U.S. installed ~44 and ~62MW of energy storage capacity in 2013 and 2014, respectively, through just Q3 2015 some 108MW had already been deployed, according to GTM Research and the Energy Storage Association. Tesla’s long-anticipated Powerwall and Powerpack batteries made their debut to much excitement. Stem bid aggregated, customer-sited batteries into California’s real-time electricity market as a demand response resource for the first time in September. And investment bank Lazard released its first-ever in-depth analysis of the leveled cost of storage in November.

To date, much attention has been focused on battery cost, and especially how comparatively cheap (relative to recent historical prices) batteries have gotten and how rapidly they’ve come down the cost curve. But the energy storage conversation is now shifting to crucially add in the second half of the economics equation: value and revenue.

So far most energy storage capacity in the country has been front-of-the-meter installations with utility-scale batteries. And even when they’re installed behind the meter, they’re usually deployed for a single, primary use, whether demand-charge reduction or backup power for a commercial customer or frequency regulation in places such as PJM’s wholesale electricity market. But this approach underutilizes and undervalues the battery, especially relative to its cost. It’s akin to buying a Swiss Army knife multi-tool and using only the blade.

A battery is capable of delivering many services with the same device, yet that’s not how they’re being used today. Batteries deployed to reduce demand charges, for example, might only be used 5-50% of their useful life. Enabling batteries to deliver a stack of additional services during that balance of time they’re sitting “idle” could unlock more value, and thus greatly enhance battery storage economics.

The report *The Economics of Battery Energy Storage\** asked several fundamental questions:

- What services can batteries provide?
- Where on the grid can they deliver each service?
- How much value can they generate when highly utilized and services are stacked?
- What barriers—especially regulatory—stand in the way?

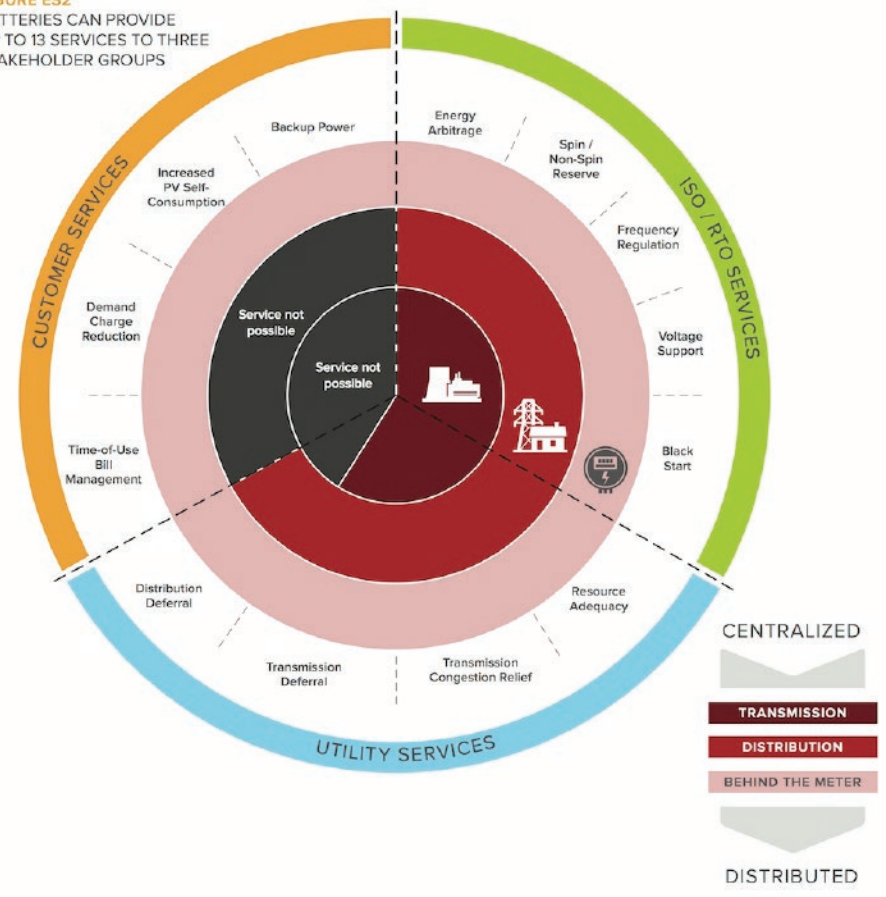
The research indicated that batteries, when placed behind the meters of residential, commercial, or industrial customers, can deliver 13 services to the electricity system at large (see Figure 1). Batteries deployed further downstream in the electricity system (behind the meter) can technically deliver the maximum number of services to the grid.

### Batteries deployed behind the meter can be cost effective today

This finding, though important, doesn’t tell how much net value batteries can deliver to the electricity system. To estimate this, an energy storage dispatch model was developed to understand the economics of energy storage in four potential real-world scenarios. The results were surprising. Batteries deployed behind the meter are “in the money” right now, under prevailing cost structures, without subsidy. This finding comes with two major caveats:

- Batteries must be well utilized and deliver multiple services to customers and the grid in order to be cost effective.
- The modeling results assume no regulatory barriers to aggregated, behind-the-meter market participation or revenue generation.

**FIGURE ES2**  
BATTERIES CAN PROVIDE UP TO 13 SERVICES TO THREE STAKEHOLDER GROUPS



**Figure 1**

### The economics are promising, but regulations must evolve

Every one of the revenue-generating services in this example is being delivered by some behind-the-meter energy storage systems in operation today. But very few projects are simultaneously providing this full stack of services (or other combinations thereof) with a single device or fleet of devices. A number of regulatory prohibitions currently prevent batteries deployed behind the meter from delivering and getting paid for many of these services.

This is because energy storage—and other distributed energy resources (DERs) like smart controls, energy efficiency, and rooftop solar PV—has matured faster than the rates, regulations, and utility business models needed to support them as core components of the future grid. That needs to change, and regulators, utilities, and battery and other distributed energy resource (DER) developers can all play a role.

Battery-based energy storage is a powerful resource capable of reducing grid costs and customer bills, increasing the resilience of the grid, and supporting a largely renewable electricity system. And even though the economics of storage look good today, they’re only going to get better as costs come down further. It’s time for utility business models to evolve, and for regulations to change in order for the benefits offered by behind-the-meter, battery-based storage to be captured across the U.S.

*Jesse Morris is a manager and Garrett Fitzgerald is a senior associate in the electricity practice at Rocky Mountain Institute, an independent nonprofit focused on market-based energy efficiency and renewable energy solutions.*

**Rocky Mountain Institute** | [www.rmi.org](http://www.rmi.org)

*\*The Economics of Battery Energy Storage: How Multi-Use, Customer-Sited Batteries Deliver the Most Services and Value to Customers and the Grid; released by Rocky Mountain Institute in October 2015.*



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# Energy Storage Systems

## Finding the optimum size

by Michael Lippert

Energy storage systems (ESS) based on high technology Li-ion batteries are fast becoming an essential tool for wind and solar plants. Not only do they help overcome the unpredictability of renewable energy due to changing weather conditions, they also help grid operators combat infrastructure congestion at times of peak supply. The challenge is how to achieve the best match between the size of the ESS and the renewable energy installation?

### Ramp rate control and smoothing

The output of solar and wind farms can change suddenly in reaction to changes in wind or cloud coverage, causing a sudden ramp up or down. By controlling the ramp rate, the ESS acts as a buffer and the power injected into the grid is smoothed out. This ensures production remains within the grid operator's limits, maximizing the amount of power that is accepted onto the grid.

Typically, a battery system for ramp rate control or power smoothing will experience many small charge and discharge cycles as it controls many steps in output. While the average Depth of Discharge (DOD) is around 5% for each step in output, the cumulated "energy throughput" of the battery can represent up to two or three times its total capacity in a 24 hour period.

Power smoothing is similar as it keeps production within a given forecast window, with the ESS compensating for short-term power sags and therefore experiencing many small to medium charge and discharge cycles.

### Power shaping

The technique of power shaping uses energy storage to achieve a consistent, predictable flow of energy. The ESS will deliver a daily DOD of 70% or higher. It is charged during the peak daylight hours in the middle of the day before discharging in the afternoon, overnight, and in the morning before the sun's energy is able to achieve the desired output.

### Peak shaving

For peak shaving, the ESS will help reduce the load on the grid at periods of peak demand. Equally, wind and solar farms are often limited to supplying power up to a maximum value permitted by the grid operator. So when production is at a peak, the plant operator can store energy, ensuring that they do not experience curtailment and achieve the maximum revenue from the energy they produce.

### Frequency regulation

An increasingly important function of energy storage is frequency regulation, for which the ESS absorbs and releases active power onto the grid to keep the grid frequency within its operating limits. Frequency regulation can help the grid accommodate more renewable energy generators. It has traditionally been a service provided by power plants coming online at short notice, but ESSs are now able to perform this role.

While local grid conditions can vary widely, an ESS used for frequency regulation is likely to experience many small charge and discharge operations of 3-4% DOD throughout the day but with energy throughput of up to six times the battery's energy storage capacity.

### Drawing on experience

Practical experience from more than 80MW large-scale Li-ion ESSs deployed worldwide shows that an ESS should be considered as an integral part of the overall scheme, rather than as a standalone installation.

As part of the optimization of an ESS it is vital to consider the Total Cost of Ownership (TCO). This takes account of the initial capital cost, maintenance and operational costs, as well as the cost of curtailments or outages.

Varying the size and specification of a battery changes its cost profile. A smaller ESS will have a lower capital cost but could lead to lower revenues, more penalties, lower compliance with the grid code, or more curtailment losses. It will also alter the system's calendar life.

To find the optimum ESS an Energy Management Strategy (EMS) must form the basis of a model. It calls for three inputs from the customer. The first of these is knowledge of the legislative environment, including limitations of the electricity grid and local legislation.

Secondly, the operator must survey the actual solar or wind profile from the site. Site-specific measurements take account of local variables and mean that the EMS will be more accurate, improving return on investment.

Lastly, the customer must set its objectives in terms of power output.

The EMS is completed with knowledge of energy storage technology. This includes energy, charge and discharge power capacities, and the effect of aging on the electrochemistry.





## Energy storage for critical projects

Utilizing earth-abundant iron, salt and water for its electrolyte, and simple materials for battery components, make the Iron Flow Battery (IFB) from ESS Inc. a durable, environmentally-safe, long-duration storage solution ideally suited for: time-shifting renewable energy on a daily basis, managing a facility's demand charges, and smoothing the intermittency of renewables on a constrained grid. Over a lifespan exceeding 10,000 cycles, maintenance requirements are low, and with an energy capacity of over 6 hours, the IFB matches well with the requirements of 25-year lifecycle solar and wind projects, supporting those applications' low levelized cost of energy (LCOE) requirements. Concurrent with serving these applications, the IFB's inherent quick-response power electronics can perform ancillary services such as voltage and frequency support on microgrids and utility-scale applications.

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

### Modelling

A set of algorithms can then be used to model the performance of an ESS over its lifetime for any given size of ESS.

By running the model iteratively with different sizes of ESS, the model will identify the sweet spot where the operator will find the best balance between whole life cost and revenue.

### Puerto Rico

At a 10MW Puerto Rico PV plant, an ESS has been installed to limit ramp rates and support grid frequency by up to 5%. Modeling identified the optimum size of ESS had a 1.3MWh capacity and 5MW power rating. This balanced the requirements of peak power and the customer's minimum technical requirements. It also took account of the likely drop in power over the lifetime of the ESS due to aging in order to ensure maximum returns throughout the plant's lifecycle.

### La Réunion

One of the largest Li-ion ESS to date is located at a 9MWp PV plant at Bardzour on La Réunion in the Indian Ocean. Used for power shaping, the ESS ensures power is injected into the grid at a constant 40% of the plant's peak power capacity. It also provides primary reserve for 15 minutes and voltage support.

Modeling identified the optimum size of the ESS as 9MWh energy storage capacity. While a larger system would have had the benefit of higher energy efficiency and a longer lifetime, the capital cost would have been higher. Finding the optimum size for the installation enabled the delivery of the most cost-effective lifetime solution.

*Michael Lippert is the marketing and business development manager for energy storage for Saft.*

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# Fears the Export Pellet Industry Harms Forests Unfounded

by Tracy Leslie

2014 US South Forest Inventory and Removal Data (million tons) (Sources: USFS FIA Database, Forest2Market Delivered Wood Raw Material Database)			
End Use	Total Removals	Total Forest Inventory	Removals as a % of All Forest Inventory
Non-pellet Sawtimber	92.9	7,616.73	1.22%
Non-pellet Pulpwood	151.3		1.99%
Pellet Pulpwood	6.0		0.08%
<b>Total</b>	<b>250.2</b>		<b>3.3%</b>

Table 1

**IN 2014, INDUSTRIAL GRADE PELLET PRODUCERS SHIPPED** roughly 3.6 million tons of wood pellets to the EU. To manufacture those pellets, mills in the US South consumed 6 million short green tons of pulpwood. That 6 million tons of pulpwood represents:

- Less than 4% of all the pulpwood harvested in the region
- Less than 2.5% of all the timber harvested in the region

Though these numbers are small, the export pellet industry has come under fire as environmental organizations criticized the industry on the grounds that it will decimate forests. A new study commissioned by the US Endowment for Forestry and Communities, US Industrial Pellet Association and National Alliance of Forest Owners, Wood Supply Market Trends: 1995-2015, indicates the real impacts of the pellet industry in the South are minimal.

The only credible way to measure the effect the export pellet industry is having on forests in the US South is to compare the amount of forest inventory that is removed every year for pellet production to the total inventory in the forest.

As Table 1 shows, 250 million tons were harvested to supply all wood consuming industries in 2014; these removals represented just 3.3% of total forest inventory. The bulk of this total was consumed by pulp/paper and Oriented Strand Board (OSB) manufacturers; they consumed 151.3 million tons of pulpwood, which represents 1.99% of total forest inventory. Lumber and plywood manufacturers consumed 92.9 million tons, or 1.22% of forest inventory.

Pellet manufacturers consumed 6 million tons or 0.08% of total forest inventory. Compared to other wood consuming industries, the amount of wood fiber consumed by the export pellet industry is minimal. The industry, it turns out, is not the voracious consumer of US South forest resources that many would have the public and policy makers believe.

In fact, a deeper look at forest inventory data suggests that not only is the export pellet market not a threat to US South forests, but the entire forest products industry consumes wood in a way that ensures both our forests and forest products industries (pellets included) are sustainable.

Table 2 shows annual inventory growth in 2014 exceeded harvest levels by 143.6 million tons. In effect, forests accumulated an additional 393.8 million tons of new growth in 2014, 250.2 million tons of which was harvested, leaving a net increase of 143.6 million tons of forest inventory for the year. In fact, since 2000, US South forests have accumu-

lated an average of 85 million tons of additional inventory (after harvests) every year.

By comparing these statistics to the same ones from 2005 (the height of the market between 2000 and 2015), an even clearer story of the health and sustainability of US South forests emerges. In 2005, 278.1 million tons of timber were harvested, or just over 4% of forest inventory. After removals, annual inventory growth totaled 50.5 million tons in 2005. By 2014, that number had nearly tripled. In fact, annual inventory growth after removals increased by 184% between 2005 and 2014. Even though part of that increase can be explained by the lower harvest levels, it should be noted that if 2014 removals had been equivalent to harvest levels in 2005, annual inventory growth would have been 129% higher than 2005 levels.

As for the overall sustainability of the forest, even after 10 years of annual removals that ranged from 220 to 278 million tons, forest inventory in the US South increased by 15% or 972.8 million tons.

To understand how these same numbers might look in the future, it is necessary to make some educated guesses.

**The Housing Market:** If housing starts once again reach the 2 million mark, something that most industry analysts think improbable, harvest levels will likely approach 2005's 278 million tons.

**Export Pellet Market Expansion:** In 2014, the European Union's 28 countries consumed roughly 9 million metric tons of industrial wood pellets. The US South exported 3.6 million metric tons to these countries, which is a market share of 40%.

US South Forest Inventory Comparison (million tons) (Sources: USFS FIA Database, Forest2Market Wood Raw Material Database)			
Year	Annual Removals	Annual Inventory Growth after Removals	Total Inventory
2005	278.1	50.5	6,643.9
2014	250.2	143.6	7,616.7
Difference	-27.84	93.1	972.8
% Difference	-10%	184%	15%

Table 2



The majority of current and near-term incremental EU demand will be supplied from existing and under-construction pellet mills, which have a production capacity of 7.4 million metric tons. Beyond that, growth in demand is likely to come from three UK projects—Drax Unit #3, RWE Lynemouth, and MGT Teesside—which have been awarded Investment Contracts under the Contract for Difference support scheme and will require 5 million metric tons of pellets. If the demand from the Netherlands rises to the government-imposed cap on biomass co-firing, 3.5 million metric tons of additional production capacity will be required.

When the current market share rate of 40% is applied to this additional 8.5 million metric tons of demand (5 million from the UK and 3.5 million from the Netherlands), an additional 3.4 million metric tons of pellets could potentially be sourced from the US South. To meet the US South share of EU demand for wood pellets in the future—7.4 million metric tons of current production plus 3.4 million metric tons of future production, for a total of 10.8 million metric tons—a total of 25 million short green tons of wood fiber would need to be harvested, an increase of 19 million tons over 2014's rate.

In total, to support rising demand for an improving housing market, increased global demand for containerboard, fluff pulp and performance fibers, and additional coal-to-biomass conversions, total removals for all wood consuming industries would be less than 300 million tons. Using the 2014 inventory growth rate, roughly 100 million tons of annual growth would still accumulate in forests in the US South annually, even after removals.

Examining inventory, inventory growth, and harvest data is the only fact-based methodology for proving or disproving claims the export pellet industry, even forest products industries as a whole, are not endangering US South forests. The data definitively proves they are not.



*Tracy Leslie is the director of Forest2Market's Biomaterials and Sustainability Practice. With a background in renewable energy project development, Leslie provides decision support services to biofuels and biochemicals producers during project development and operations.*

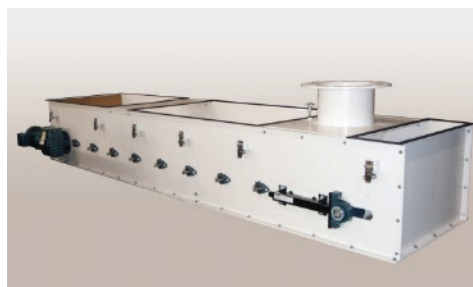
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### Custom packaged scrubber system

Bionomic Industries, Inc. has announced release of their new ScrubPac Custom Skid-Mounted Scrubber System. ScrubPac is a cost effective, packaged system engineered to meet the demands of a customer's process emission control application. All necessary components—recirculation pumps, piping and valve networks, exchangers, instrumentation, controls, and any other essential items needed to satisfy customer application requirements are included in the system. Systems are available for batch or continuous operation, semi or fully automatic operation, along with pretreatment options (high temperature gas quenchers, VOC condensers, super saturators for fine particulate capture), standard or customer specified instruments, controls and mechanical components, local or remote system control/monitoring, and special spill containment skids and modularized, skid-mounted assemblies for large system hard to fit spaces. Factory assembled, run tested and operational when they arrive on site, the systems require only process and utility connections and are available for gas capacities from 100 through 150,000 acfm.

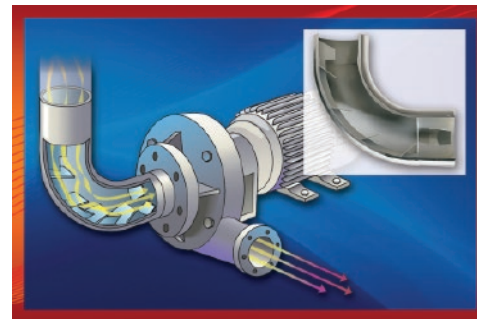
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### Volumetric belt feeder

Metalfab, Inc., has announced availability of their new APB Volumetric Belt Feeder. Designed for highly accurate +/- 1 to 1 1/2% metering of all types of powders, pellets, and agglomerates, the APB is exceptionally well suited for feeding of abrasive or friable materials and materials that have a tendency to smear or compress when being fed by a volumetric source feeder. Available in 12", 24", 36", or 48" belt widths and 36", 72", 108", and 144" lengths (extended lengths available), the APB features a ruggedly built, sliding belt assembly and offers feed rates up to 5,800 cu. ft./hr. Standard belt material is neoprene and HYCAR, Nordel, and Viton are also available. Construction materials include carbon steel, carbon steel with special coatings, 304 or 316 stainless steel, and drive choices include constant speed motors and AC motors with variable frequency control. Other standard features include bearings that are sealed and located outboard to prevent contamination; skirt boards and adjustable belt tensioners; belt scrapers to prevent material buildup on the belt surface and ensure complete discharge of material from the belt; and an AC Variable Frequency motor. Other motor options are available.

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The Vortab Elbow Flow Conditioner eliminates the turbulent fluid flows resulting in pump cavitation. The pre-conditioned flow stream achieved with the Vortab Elbow Flow Conditioner mimics the straight run needed for efficient pump operation, and removes asymmetric velocity flow profiles. In addition to conditioning the flow stream, the 90° angle tab-type Vortab Elbow Flow Conditioner eliminates the straight pipe run cost and installation technician labor. Ball valves, gate valves, out-of-plane and in-plane elbows, and swirl generators were installed at the immediate inlet of the Vortab elbow and tested in the company's gas and liquid calibration facilities. The Vortab Elbow Flow Conditioner isolates the flow irregularities and conditions the flow stream into a swirl-free and symmetrical velocity profile. Vortab's anti-swirl and inclined vortex generating profile correction tabs, projecting from the inside pipe surface, generate vortices that accelerate these natural pipe effects to create a uniform, non swirling, symmetrical flow profile in a much shorter section of pipe. The simple, flexible designs of the Vortab Elbow, the Vortab Insertion Panel (VIP), and the Vortab Insert Sleeve, Short Run, Meter Run, and Field Kit configurations provide a cost effective solution to crowded installations for flow meters and other critical process equipment. Vortab flow conditioners can be made from carbon steel, 316L stainless steel, or Hastelloy C-276. A variety of process connections are also available--ANSI flanges, male NPT threads, butt welded preps, or retaining wafers. Custom configurations are also available.

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# A Call for Net Zero Energy

by Alden Hathaway, P.E. CEM



Completed residential Net Zero project. The solar installation will provide power to the home, with enough left over to charge an electric car.

**ACCORDING TO THE UNION OF CONCERNED SCIENTISTS**, sea level rise is the very predictable outcome of rising carbon concentrations in the atmosphere. They confirm the technology is already available for solutions to prevent global warming, and they point out the following key measures among several;

- Expand the use of renewable energy; and
- Build a clean energy economy by investing in efficient energy technologies.

At the COP21 Conference Talks in Paris, the World Resources Institute stated if the world were to hold mean global temperature change to two degrees or less it must embrace Net Zero Energy by 2050; less than 35 years from now.

## Voluntary program background

Beginning in 1991, the Environmental Protection Agency (EPA) launched a series of voluntary energy efficiency programs, Green Lights, and Energy Star Buildings, encouraging companies to invest in energy efficiency. In 2001, the EPA followed with the Green Power Partnership; promoting renewable energy to the same companies who participated in Energy Star.

These programs were successful in moving energy efficiency and renewable energy, but their separateness failed to uncover the natural synergies existing when integrating energy efficiency and renewable energy together.

Consider solar roofs shading buildings undergoing HVAC upgrades. The shading can be used to downsize the A/C equipment, improving payback economics. These, and other interactive effects have been documented through valuable research at the US Department of Energy (DoE) and the National Renewable Energy Laboratory's (NREL) Net Zero Energy Programs. Although these programs have demonstrated Net Zero Energy Buildings are now possible and more economical than ever, there isn't a national voluntary effort directed to entice organizations to pledge progress toward achieving Net Zero Energy.

## Why zero energy now?

Early in the 1990's, environmental policy officers at major corporations recognized the value of a voluntary partnership with the federal government supporting energy efficiency. Each time a new voluntary energy program came along, these officers pledged

their companies to the next goal from Energy Star to Green Power Partnership to Climate Leaders. Unfortunately, after fourteen years, many of these business leaders are retiring, and some fear the new crop of leaders, who are less familiar with the success of voluntary programs, may not be as willing to participate as their predecessors. And while waiting with no Net Zero Energy partnerships, opportunities to develop Net Zero Energy buildings are missed.

But there is still another very important reason why a Net Zero Energy Building Partnership is needed. The EPA is asking states to implement programs to reduce greenhouse gases under the proposed Clean Power Plan, and allows innovative voluntary efforts to count. A new national program could help the states receive credit in the plans they must submit to the EPA later this year.

Although recent emphasis at the EPA is on strengthening energy and environmental regulations, it should not be forgotten that voluntary programs have been equally successful at attaining environmental goals. If the EPA allows states to use voluntary programs to help achieve their Clean Power Plan compliance, it is important to have many new recipes for achieving an integrated energy approach guiding the states. The momentum brought

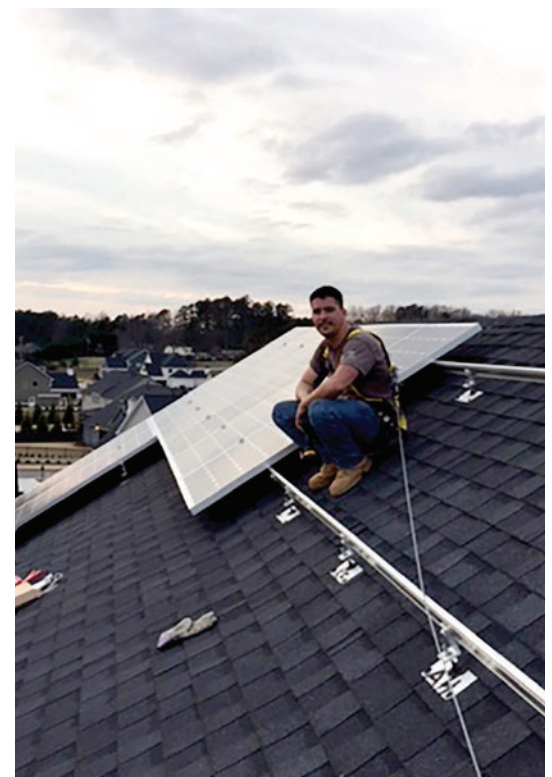






Photo credit: Sean R. Compton

US Route 80 was submerged during high tide October 27, 2015 and stranded Tybee Island, GA for several hours.

on by earlier voluntary programs should be continued and capitalized upon to get Net Zero Energy into the mainstream now, especially as technology is rapidly helping make it all possible.

Finally, Net Zero Energy Buildings are being developed in other countries, separating the United States, which has the most invested in clean technology, from active policy where climate leadership is directing the deployment of clean technology, such as Indonesia, where the 99 story Pertamina Energy Building is billed as the world's first Net Zero energy skyscraper. And his Royal Highness, the Prince of Wales' Corporate Leaders Group has 16 EU companies committed to the idea of Net Zero Buildings. Given the stakes, America cannot afford to give up energy and environmental leadership to other countries, whose own clean tech industries will benefit at her expense.

#### **New technologies, lower costs for net zero**

Solar energy's lowering costs, combined with new LED lighting technology, variable refrigerant flow HVAC, controls, and energy dashboards have set up a recipe of opportunity for economical zero energy facilities at unprecedented levels. These technologies have reduced the cost per watt by more than half to achieve zero energy. In 2001, it cost approximately \$5-\$6 per watt for the necessary energy efficiency and solar investment to ensure a zero energy building. Now, due to tax credits and lowering costs of solar, one can achieve enough solar alone to offset energy use at a rate that is closer to \$2.10 - \$2.40 per watt. And, with new LED lighting, HVAC technologies, controls, and insulation, the costs are less than \$2 per watt overall, a reduction of up to 65% compared with 2001.

This means taking a balanced approach to both energy efficiency and solar technologies. If solar costs were \$2.20 per watt on a project, it wouldn't be practical to invest in energy efficiency costing more than \$2.20 per watt saved. Instead, simply adding more solar would be the most cost-effective solution, even though other energy efficiency choices are eliminated. Likewise, if the

solar investment tax credit (ITC) is eliminated in 2017, the cost of solar will be closer to \$3 per watt, then the solution would be to invest in energy efficiency up to the \$3 per watt saved range.

But clearly, energy efficient technologies which help reduce overall costs, such as LED lamps (\$0.20 - \$1.00 per watt saved), should be pursued relentlessly, as well as some envelope measures such as window films and improved insulation. New variable refrigerant flow HVAC can make the cut if downsized from heat load reductions benefitted from lighting and envelope measures. Finally, energy dashboards, which regularly prove to save 10-20% energy because of their real-time reporting, provide returns almost as fast as LED lighting.

#### **Zero energy voluntary program call**

The Federal EPA's focus on flexibility in implementing the Clean Air Plan suggests states and cities are in the best position to move in this direction. By calling for a joint partnership to achieve Net Zero Energy Buildings, US states and cities can take bold leadership, not only helping them achieve aggressive energy efficiency and renewable goals, but rewarding American clean tech businesses as well.

Since the COP21 meetings in Paris, the world is asking questions and taking action on Net Zero Energy Buildings. Isn't it time America did as well? Tybee Island and the southeastern coast can no longer wait.

*Alden Hathaway is SVP for Sterling Energy Assets, a renewable energy development company. Under his guidance, the company is developing 13 zero-energy solar homes in North Fulton County, Georgia. Sterling Energy Assets is part of the Sterling Planet family of companies that promote renewable energy, energy efficiency, and carbon products for energy consumers seeking to reduce their environmental footprint.*

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### **Consoles with communicating controls**

WaterFurnace International, Inc., is pleased to announce that the Envision Console and Envision Low Sill Console are now available with communicating Aurora controls.

Aurora controls offer full two way communication between components, advanced operating logic and robust troubleshooting capabilities. The Aurora Base Control (ABC) features a microprocessor control to sequence all components during operation for optimum performance. In addition, the ABC provides easy-to-use troubleshooting features, including fault lights, onboard diagnostics and a handheld Aurora Interface Diagnostic (AID) tool.

Also available in console units is the Aurora Universal Protocol Converter (UPC). Designed to incorporate the advanced features, performance and controls of WaterFurnace Aurora-based heat pumps into commercial building automation systems, the Aurora UPC seamlessly communicates with Aurora boards and converts the Modbus protocol to BACnet MS/TP, LON or OpenN2 protocol. The module provides access to unit sensors, relay operations and faults and allows individual unit configuration – all without the need to manually access the heat pump. A portable touch-screen interface gives a technician full access to equipment status, parameter values, temperatures and humidity sensing, as well as access to alarm and trend history.

**WaterFurnace International, Inc.**

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





## Energy Innovation in the Factory of the Digital Age

By Jason Ferrara

**AS WORLD LEADERS CONVERGED ON PARIS** in December to talk about the climate, Bill Gates did something that made many professionals stand up and cheer.

On Day 1 of the 21st session of the Conference of the Parties (COP21), Gates announced the largest public-private partnership in history to tackle climate change by funding research and development of clean energy technologies. Gates said he was surprised that research and development (R&D) had not been on the agenda during the previous 20 climate talks. He certainly put it there.

The public component of the partnership is known as Mission Innovation. Twenty countries, including the United States, vowed to work toward doubling public investments over the next five years to a total of \$20 billion to support clean energy research.

The private component is the Breakthrough Energy Coalition, a group of 28 private investors from 10 countries, including Gates, Facebook's Mark Zuckerberg, Virgin Group's Richard Branson, and Amazon's Jeff Bezos. These investors have pledged \$2 billion of their own money to help spark a "new economic revolution" based around clean energy, and they're hoping to get others to pitch in more.

### A new economic revolution

"It's like throwing billions at Silicon Valley," said John Picard, a building efficiency and sustainability expert. The money, from the private investors and participating governments, will be fuel to jumpstart clean energy innovation in Silicon Valley and beyond. And it won't just be for the greater good of the planet. Saving the world, getting the climate in balance, has to also grow the economy. It's been proven innovation can generate tremendous economic returns, and that is the goal here, as well as to get the Earth's climate back in balance.

### Energy innovation in the factory of the digital age

The data center is the factory of the modern economy; to make a lasting difference in energy efficiency broadly, it's necessary to find ways to be reliable and efficient in a digital world.

One example of innovative thinking is the data center services provider who plans to build an 8MW colocation data center on a floating barge. The data center will use seawater for cooling, which would eliminate water waste. The Silicon Valley company has already completed a proof of concept with several organizations and says its floating data center will use half as much energy as a comparably sized land-based facility.<sup>1</sup>

Then there are the innovative companies putting the IT equipment itself in liquid. One such immersion system employs a two-phased liquid cooling approach. The IT hardware is immersed in a bath of non-conductive, non-corrosive liquid engineered with a boiling point of about 120°F. The heat generated by the IT gear actually boils the liquid; the vapor carries the heat away.<sup>2</sup>

### Measuring data center efficiency

The most commonly cited measure of data center efficiency is Power Usage Effectiveness (PUE), which is the total power used by the data center divided by the power that goes just to the IT equipment. The average PUE for a colocation data center is 1.7, according to the Uptime Institute. That means for every 1kW of energy used by the IT equipment, another 0.7kW is used for cooling and things other than powering the IT gear.

Energy innovation in the data center has focused largely on reducing PUE, that is, on improving efficiency. One example of such innovation is the data center services provider relying on a conductive cooling system which uses 80-90% less energy. The cooling system manufacturer was named one of the world's ten most innovative companies in energy by Fast Company.<sup>3</sup>

A heat sink removes heat directly at the rack or aisle. It draws the hot air from the servers, passes it across coils made cold by refrigerant, and returns the cool air to the server inlets at the front of the enclosure, removing massive amounts of data center heat using just a fraction of the energy of conventional cooling systems. The refrigerant is pumped by a cooling distribution unit (CDU) that routes heat outside. In contrast to traditional chillers, the patented cycle of this CDU uses passive (free) cooling most of the time, even in hot climates, so it's ultra-efficient.<sup>4</sup>

These represent just a few examples of companies innovating the data center. They're doing essential work because without significant gains in data center efficiency, our planet simply won't support the kind of compute capacity needed for cloud, big data, and IoT.

Added to the fact that some companies are already innovating the data center, Gates' Mission Innovation and Breakthrough Energy Coalition give reason for hope. As John Picard said, "I think we've begun turning a corner. We've gone from having an awareness of the issues to finding real solutions that will give the world a better future."

*Jason Ferrara is chief marketing officer at Aligned Data Centers, the first pay-for-use data center provider to offer consumption-based pricing for organizations that require greater control of their data center.*

**Aligned Data Centers** | [www.aligneddatacenters.com](http://www.aligneddatacenters.com)

<sup>1</sup>Tom Coughlin, "Awash in a sea of data." *Forbes*. <http://onforb.es/1N57E5I>

<sup>2</sup>Stephen J. Bigelow. "Liquid immersion cooling relief for ultra-dense data centers." *SearchDataCenter*. <http://bit.ly/1Z35uaO>

<sup>3</sup>Fast Company. "The World's Top 10 Most Innovative Companies of 2015 in Energy." <http://bit.ly/1uvlQOa>

<sup>4</sup>Rich Miller. "Aligned Data Centers Seeks to Solve the Capacity Challenge." *Data Center Frontier*. <http://bit.ly/1AvH2q>



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- 25-27 **9th Annual Storage Week**  
Wyndham San Diego Bayside – San Diego, CA; [www.infocastinc.com/events/storage-week](http://www.infocastinc.com/events/storage-week)
- 25-27 **ASHRAE 2016 Winter Conference & AHR Expo**  
Orange County Convention Center – Orlando, FL; [www.ashrae.org/orlando](http://www.ashrae.org/orlando)

**FEBRUARY**

- 09-11 **Wind Power Finance & Investment Summit 2016**  
Rancho Bernardo Inn Resort – San Diego, CA;  
[www.informationforecastnet.com/events/wind-finance-investment](http://www.informationforecastnet.com/events/wind-finance-investment)
- 23 **GreenBiz 16**  
JW Marriott Camelback Inn Resort & Spa - Phoenix, AZ; [www.greenbiz.com](http://www.greenbiz.com)
- 24-25 **Solar Power PV Conference & Expo – Boston (formerly PV America)**  
Boston, MA; [www.events.solar/pvconferenceexpo](http://www.events.solar/pvconferenceexpo)

**MARCH**

- 02-04 **GLOBE 2016**  
Vancouver Convention Centre – Vancouver, BC; [www.globeseries.com](http://www.globeseries.com)
- 14-16 **3rd Annual Wind Farm Data Management & Analysis Forum**  
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- 16-17 **2016 ACORE National Renewable Energy Policy Forum**  
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- 17 **International Geothermal Energy Showcase**  
Ronald Regan Building & International Trade Center – Washington, DC; [www.geo-energy.org](http://www.geo-energy.org)
- 22-23 **AWEA Wind Project Siting and Environmental Compliance Conference**  
Francis Marion Hotel – Charleston, SC; [www.awea.org/siting](http://www.awea.org/siting)
- 24 **Intersolar Summit USA East**  
Brooklyn, NY; [www.intersolar-summit.com](http://www.intersolar-summit.com)
- 30-01 **2016 Northeast Biomass Heating Expo**  
Burlington, VT; [www.nebiomassheat.com](http://www.nebiomassheat.com)

**APRIL**

- 17-20 **5th Annual NABCEP Continuing Education Conference**  
Paradise Point Resort & Spa – San Diego, CA; [www.nabcep.org](http://www.nabcep.org)
- 17-20 **2016 World Congress on Industrial Biotechnology**  
San Diego Convention Center – San Diego, CA; [www.bio.org/worldcongress](http://www.bio.org/worldcongress)

**MAY**

- 15-18 **Strive for Sustainability**  
The Sagamore, Bolton Landing – New York, NY; [www.nyfederation.org](http://www.nyfederation.org)
- 23-26 **WINDPOWER**  
New Orleans, LA; [www.windpowerexpo.org](http://www.windpowerexpo.org)
- 25-26 **Solar Power Southeast**  
Atlanta, GA; [www.events.solar/southeast](http://www.events.solar/southeast)

**JUNE**

- 14-15 **National Geothermal Summit**  
Reno, NV; [www.geo-energy.org/events.aspx](http://www.geo-energy.org/events.aspx)
- 21-22 **REFF Wall Street Renewable Energy Finance Forum**  
The Grand Hyatt – New York, NY; [www.reffwallstreet.com](http://www.reffwallstreet.com)
- 26-29 **50th US Rock Mechanics/Geomechanics Symposium**  
Houston, TX; [armasyposium.org](http://armasyposium.org)

**JULY**

- 12-14 **Intersolar North America 2016**  
Moscone Center – San Francisco, CA; [www.intersolar.us](http://www.intersolar.us)
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- 14-15 **Solar Power International**  
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**OCTOBER**

- 04-06 **Energy Storage North America 2106**  
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