VOLUME 12 | ISSUE 3

North American Clean Energy

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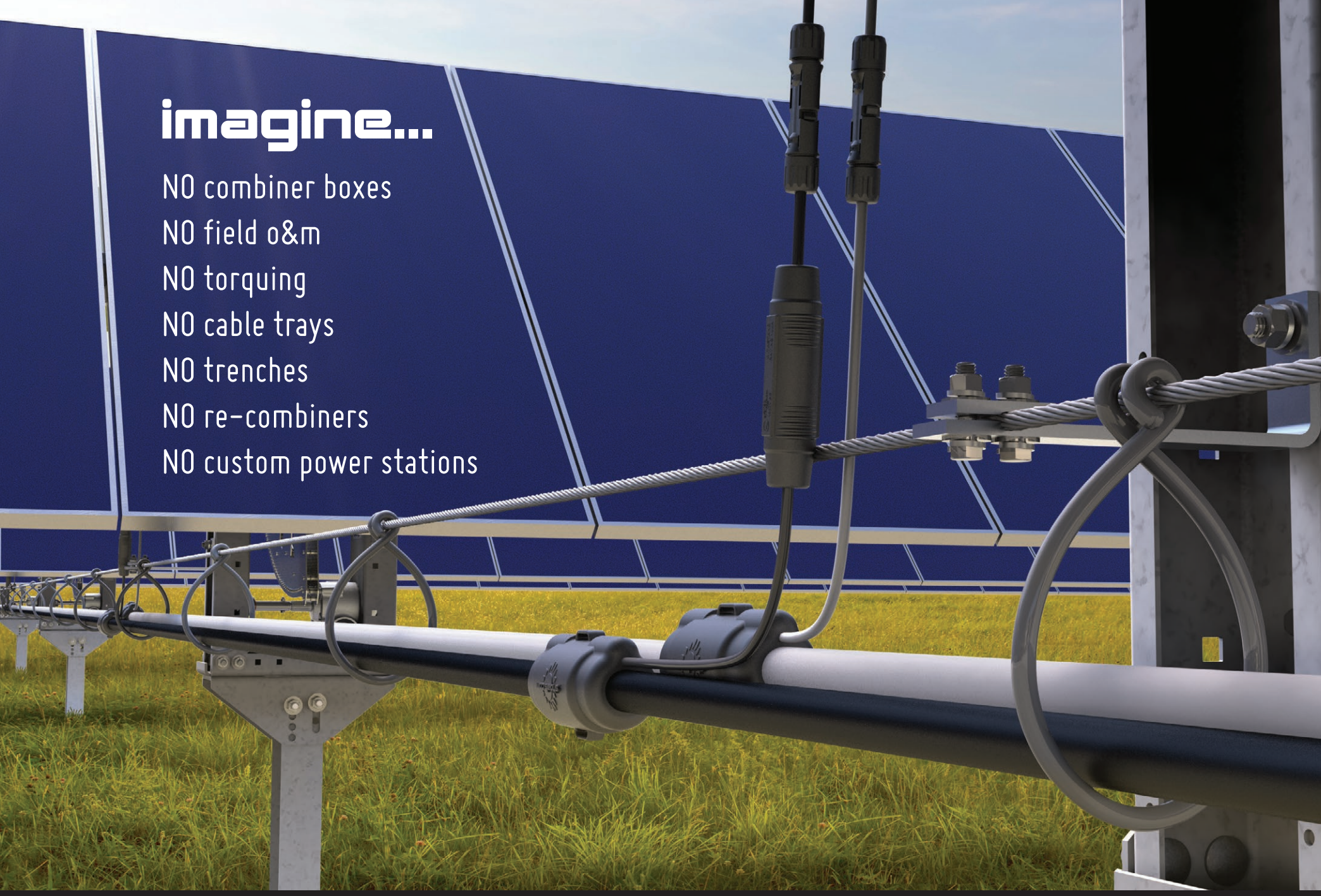
EXTREME WEATHER EDITION

Swinging from a Wind Turbine in an Earthquake

Cost-Effective PV in Northern Climates

Getting it done right from the start

Wind Solutions Overcome Challenges in Hazardous Conditions



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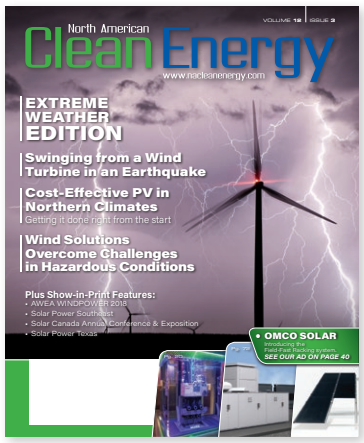

On our cover...

DTN helps the wind industry operate safely and efficiently, all the way from keeping technicians safe from lightning strikes to improved maintenance planning. DTN provides highly accurate, real-time business intelligence. They customize information to provide actionable insights to help wind farms grow and remain efficient while becoming a major source of modern power.

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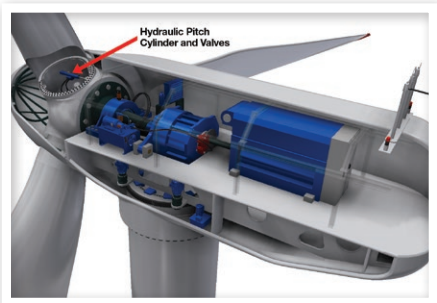

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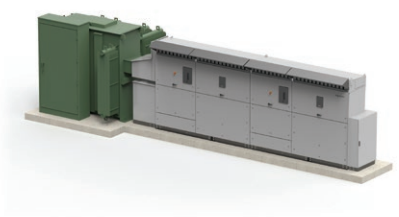

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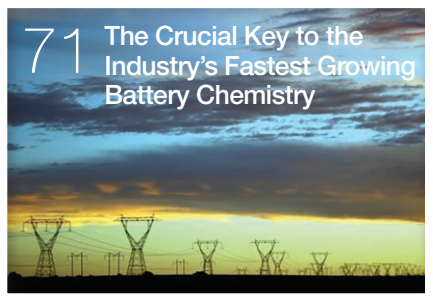

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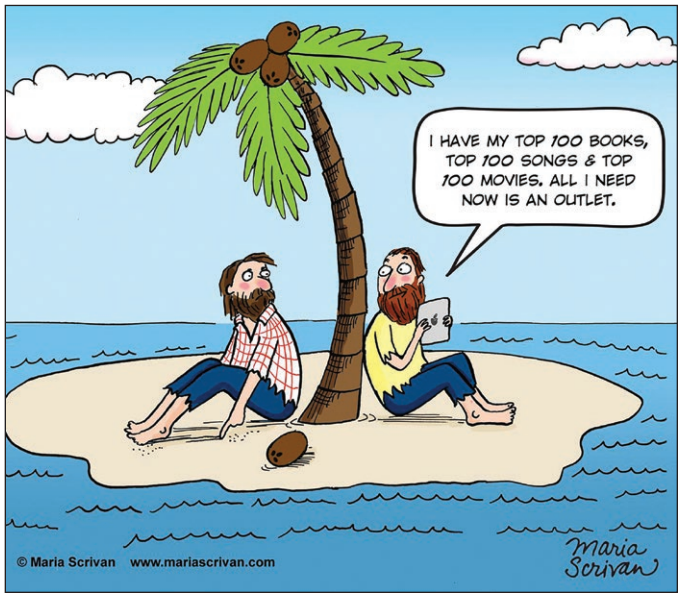
EVER SINCE I WAS A KID, I'VE BEEN FASCINATED BY WEATHER phenomena and natural disasters. I couldn't get enough of tornados, avalanches, tidal waves – any time the news highlighted our earth's natural destructive power, I was mesmerized. I'm still amazed by crazy weather, but now that I'm an adult, what really inspires me is human resilience in the face of such destruction. Scenes of people boating around their flooded neighborhoods made me shake my head in disbelief, unable to really grasp the magnitude of what I was seeing. I tried to imagine having my entire life turned upside down just because I happened to live in the path of an uncontrollable disaster. And yet, these people just keep on going, determined to rebuild their lives from the ruins leftover by the storm.

You may have noticed a similar resolve in the achievements of your colleagues in clean energy. No matter the obstacle, you will invariably find someone – engineer, executive, intern – who has figured out a way to get around it. Not only with weather, but also when it comes to reaching out to the global community. Existing solar and wind installments already occupy the best (most easily-accessible and buildable) real estate on the planet. If companies want to grow, they need to push the boundaries of technology to exploit what's left. Retrofitting only goes so far; remote islands, frozen wastelands, scorched plains, and places inhospitable to people and animals, are the hottest untapped real estate markets for new energy.

Location is everything. It's a familiar real estate trope, and one that's particularly prescient in today's renewable energy industry. You may have the greatest idea for exploiting natural and renewable energy sources, but if your idea needs a large open space that's unencumbered by obstructions or restrictions, it's worthless. Let's say you want to bring off-grid capabilities to people living where there's zero infrastructure, or you find that your "brownfield" is more suited for polar bears than PV, or you discover that you're just as likely to watch your windfarm towers sway from an air current as they do from an aftershock – these are just a few of the scenarios we explore in this issue.

As companies push further into territory that is less than desirable, they must adapt to the challenges of the terrain and environment. This past year's big storms have also have forced many people to think about contingencies, the reliability of clean energy, and grid stability. We are proud to feature examples of companies which are making use of unfriendly terrain, designing new equipment to better survive weather phenomena, and coming up with innovative technologies specifically engineered to withstand some of Mother Nature's toughest challenges.

Meg



Sustainable, natural swimming pools

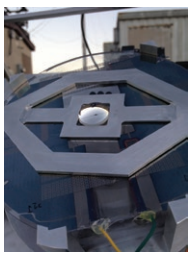
Considering the low carbon footprint and lower energy consumption, the construction of a Natural Swimming Pool (NSP) has been described as a personally responsible, sustainable consumer choice. NSPs are a complete reinvention of the chemical swimming pool: aquatic plants rooted hydroponically in gravel are used to clarify and purify the water, instead of using toxic, energy intensive mined chemicals. NSPs are sustainable and natural environments built using patented design techniques and energy efficient technology bring a safe, natural, and beautiful swimming experience. Natural Swimming Pools reduce exposure to harmful chemicals since the water is treated biologically. There are no chemicals (such as salt or chlorine) or devices (such as ozone generators or UV lights) used to disinfect or sterilize the water, thus preventing toxic chemicals from entering the watershed or our bodies. The movement of the water through the biological filter and regeneration zone, as well as the plants feeding hydroponically is how the water is cleaned. Existing sterile, energy consuming, chemically demanding, swimming pools can be converted into Natural Swimming Pools. In addition to the healthful swimming, the Regeneration Zones help support local wildlife such as honeybees, dragonflies, and other pollinators plus, they are a beautiful, unique landscape feature.

California Natural Pools | www.californiabionova.com

Automobiles with solar roofs

Audi and Alta Devices, a subsidiary of solar-cell specialist, Hanergy Thin Film Power, plan to work together to integrate solar cells into panoramic glass roofs of Audi models. With this cooperation, the partners aim to generate solar energy to increase the range of Audi electric vehicles. The first prototype will be developed by the end of 2017. As the first step, Audi and Alta Devices will integrate solar cells into a panoramic glass roof. In the future, because Alta's technology is uniquely flexible, thin, and efficient, almost the entire roof surface is to be covered with solar cells. The electricity generated from the cells will flow into the car's electric system and can supply, for example, the air-conditioning system and seat heaters, a gain in efficiency that has a direct positive impact on the range of an Audi electric vehicle. At a later stage, solar energy could directly charge the traction battery of Audi electric vehicles.The green electricity will be generated by Alta Devices' innovative solar cells. These solar cells are very thin and flexible, hold the world-record for efficiency, and perform extremely well in low light and high temperature environments.

Alta Devices | www.altadevices.com



Rooftop concentrating photovoltaics win big over silicon in outdoor testing

A concentrating photovoltaic system with embedded microtracking can produce over 50% more energy per day than standard silicon solar cells in a head-to-head competition, according to a team of engineers who field tested a prototype unit over two sunny days last fall. The researchers at Penn State developed a panel of tiny solar cells which tracks the sun with practically imperceptible movement. The researchers report their improved concentrating photovoltaic (CPV) system produced 54% more energy than the standard silicon cell over the course of one day. Their improved CPV system also reached 30% efficiency, in contrast to the 17% efficiency of the silicon cell.

Penn State University | www.psu.edu

Letter to the Editors:
We want to hear from you! Send your comments, concerns, and thoughts about what you're reading in North American Clean Energy to ***editor@nacleanenergy.com****.*

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Four Reasons Why Wind Farms Need Professional Weather Services

by Don Leick

Monitoring weather conditions at wind farms requires a unique and precise collection of meteorological intelligence. Many wind farms operate in the path of volatile and unpredictable weather patterns, which can make operations and maintenance challenging to manage. Wind farm operators have a duty to protect their assets, and employees, from weather related risks. Below are four main reasons why wind farms should prioritize their investment in professional weather insight.

Caution: Lightning is Near

Crews performing maintenance at substantial turbine heights are at an increased danger to lightning strikes, and often need more lead time to seek shelter when a storm is rapidly approaching. Trying to ensure worker safety by relying on someone to listen for thunder, or watching local radar, doesn't cut it when compared to the significant advances made in weather technology. Free weather apps can pose an even bigger risk for wind farms; their weather alerts often don't give the complete picture of lightning hazard, which can put workers' lives in danger.

Wind farm operators need a reliable safety solution that includes real-time, location-specific lightning information. A professional weather partner can detect and forecast lightning strikes, as well as provide high-quality, timely mobile alerts for on-site maintenance crews. Together, these services have been shown to be highly effective in keeping workers safe.

Existing commercial solutions can setup alerts based on a fixed or GPS location on a smart phone. This is ideal for crew members working on a large wind farm with varied terrain, or those servicing multiple winds farms; these solutions can monitor strikes in real-time, as they approach. When strikes occur within a specific zone set by the wind farm, audio and visual alerts can be triggered. Each wind farm should develop their own alert thresholds, but we recommend three alerts to optimally ensure crew safety:

1. **Caution Alert** – When lightning is near crew location, up to 60 miles out
2. **Warning Alert** – When lightning becomes an imminent threat to crew position
3. **All-Clear Alert** – When no lightning has been observed in 30 minutes, and work can be resumed

New technology allows wind farms to include actionable alerts, rather than simply stating when and where a lightning strike occurred. This reinforces the action that crew members need to take based on the wind farm's established safety protocol. If an alert is distributed when a lightning strike is 60 miles away, the actionable alert could be, "Get prepared to do an evacuation. If you're already down tower, do not go uptower."

There are inexpensive applications that provide lightning alerts, but these are usually run by backyard hobbyists with unidentified sources, rather than professional meteorologists. To protect workers from harm, wind farms need multi-range alerts, as crew members need a warning long before severe weather affects their location. Thus, it is increasingly important to invest in reliable weather intelligence.

Proactively Inspect Blades

Commercial solutions also provide blade inspection technology that identifies turbines affected by lightning. Maintenance crews can use this information to inspect and repair blade damage before it matures, reducing the likelihood of generation loss due to turbine shutdown. Global lightning detection networks can generate daily reports, providing operational insight so wind farms strategically inspect only the assets affected. Pertinent details about each lightning strike include distance, amperage, polarity, time, and location; this helps determine whether a wind farm should restart turbines after a fault, or inspect them first.

Achieve Optimal Efficiency

High winds interrupt and delay maintenance on a turbine, threatening both the operation of equipment and safety of the maintenance crew. This results in unproductive downtime. To operate at peak efficiency, wind farms must utilize hub height wind forecasts that identify when each turbine will surpass normal operational thresholds. Understanding when turbines are most at risk of high winds — and being able to predict this as early as a week in advance — enables operators and maintenance crews to strategically schedule both internal and outside maintenance. Operators can then hire expensive outside resources such as a crane, lift, or rope crew, without worrying if weather will delay their efforts.

Winds at hub height can significantly differ from surface level. Using a free app will provide forecasts at ground level, but it leaves the wind farm operator to estimate how that translates to hub height. Additionally, forecasts should be gathered at the wind farm itself, where winds can be significantly higher than at the nearest weather station. Utilizing hub height and gust forecasts will help turbines perform at optimal efficiency.

Managing Ice

Although ice only affects turbines in certain parts of the country, it will always impact production. Freezing rain and fog are two of the biggest culprits that cause moving objects to accumulate ice, and blades are no exception. In fact, blades operating during an ice storm will accumulate even more ice than if they were stationary. If too much ice builds up on the blades, operating the turbine could damage the structure, causing maintenance workers to slow or shut down the turbine completely. The ice itself is also a danger to workers, as blades can throw accumulated ice glaze, sending fragments of ice and snow into the surrounding area. Without a pre-installed ice-prevention or de-icing system, operators require reliable weather intelligence to indicate when ice is no longer a threat, and regular maintenance can resume.

It All Starts with Professional Weather Insight

Volatile weather will continue to threaten crew safety and assets. In order to be readily prepared for severe weather, wind farms are turning more to timely, accurate weather information that is specifically designed for the wind energy industry. These solutions are simple to implement, cost-effective, and significantly improve productivity, reliability, and employee safety.

Don Leick is Senior Product Manager for DTN's weather business. Don leads the future direction and enhancement of online, mobile, and alerting products. He's been the product manager for the WeatherSentry product for most of his 13 years with the company. Don has extensive experience working with many of DTN's customer segments including utilities, wind farms, sports, and winter road maintenance.

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Swinging from a Wind Turbine in an Earthquake

by Narciso Lozano

On September 19, 2017, a 7.1 magnitude earthquake struck the central region of Mexico. Blade technician Ewa Pilch and engineer Narciso Lozano happened to be uptower during the 20 seconds the ground heaved beneath them. The company in charge of maintaining the Oaxacan region wind farm was immediately alerted, and scrambled to make sure their workers were safe.

A deadly earthquake measuring 8.2 on the Richter scale had affected Mexico's southern coastal area twelve days earlier, followed by numerous aftershocks. Nonetheless, we did not anticipate any major obstacles to completing the assignment. We arrived on location a couple of days before starting work, and were staying in a local town, when we found ourselves near the earthquake's epicenter. The power of the tremor inflicted severe damage; in a region of nearly 3,000 wind turbines, it disabled a key power transformer. Wind energy production across the region came to a screeching halt.

A safe foundation

Even in the best conditions, ascending a wind tower to do your job, while dangling over 200 feet above the ground, is not for the faint of heart. The higher you go, the more you feel the movement around you. There were numerous aftershocks in the week following our arrival. With no guarantee of being able to safely complete the work, we were unable to conduct any inspections on the turbines, and were told to stand down.

Before we could finally begin inspections, checks were conducted on the tower foundations for all turbines at the site, to ensure they were both safe to operate, and safe to ascend. Even after the site was deemed safe for working, there was an additional obstacle to overcome - lack of power. With the transformer offline, and generators in high demand for humanitarian needs, we ultimately had to source an adequate generator from a neighboring state. The back-up generator provided enough power to work the tower lift, but not enough to help yaw the turbine, or pitch the blade.

A moving tower

Tuesday, September 19th, brought wind speeds between 15 and 17 m/s. Despite such strong winds at the site (and already hindered by the extra delay) we, and the client, were anxious to begin up-tower operations. While I stood on the nacelle, Ewa descended on a rope to inspect the first of the turbine blades.

The strong winds were heavily swaying the tower when the 7.1 earthquake hit; on the nacelle, no immediate change in the movement of the turbine tower was noticeable. Down on the ropes, however, Ewa knew right away that something was wrong: the rocking effect of the earthquake was distinctly different, compared to the normal effects of the wind.

As soon as the substation team confirmed the tremor, we immediately descended from the turbine. Ewa was able to lower herself down to the ground. But from the nacelle, we had to climb down the tower using the ladder, in case the earthquake had caused damage to the lift. Given the scale of the earthquake, the day's remaining operations were cancelled.

A final call

Following the completion of additional safety checks on the foundations, it was deemed safe to return to the site. However, with no power to the turbines, and the blades feathered into the wind to protect them, we had to wait for the wind to blow in the right direction in order to spin the rotor so we could lock it in the right position, and inspect the blade. Half a day's worth of inspections ended up taking two weeks. Additionally, due to the challenges of orienting the blades, inspections could only be completed on a single turbine.

It was hoped power could be restored to the wind farm so we could more easily move the blades into position and complete the work. However, when the town was hit by yet another earthquake, we were forced to abandon the area, including our hotel.

As the low-wind season approaches in Mexico, we hope to return soon to complete the inspections – hopefully under less turbulent conditions.

Narciso Lozano is a rotor blade engineer at Altitec, where he analyzes blade inspection and damage reports, and advises clients on repair and maintenance programs for blade composites. Altitec is an independently operated, specialist rope access blade inspection and repair business, headquartered in London and Berlin. Since 2010, Altitec technicians have provided regular inspections on more than 5,000 blades and 1,500 turbines throughout the UK, Europe and emerging wind markets around the world. Altitec provides a full range of blade inspection, repair and maintenance services, as well as an industry certified training program, the Altitec Academy. Altitec holds distribution rights for the Actsafe Ascender in the UK, Baltics, and Ireland.

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RENEWABLE ENERGY

Keeping Wind Turbines Turning in Harsh Environments Starts with Lubrication

by Gary Hennigan

WIND ENERGY IS A PROMISING SOURCE OF RENEWABLE ENERGY, but harnessing this resource often requires wind turbine equipment to be located in remote or harsh environments. Unexpected places where you will find wind farms include the fierce North Sea, the frigid Alaskan tundra, and the hot California desert, just to name a few.

This equipment often experiences severe weather; gale-force winds, extreme temperatures ranging from -30 to 50 degrees Celsius, and heavy exposure to contaminants such as dust or corrosive salt water, make it no easy task to keep these turbines spinning.

However, it's vital that these turbines operate reliably over long maintenance service intervals. Any required servicing carries an increased level of risk, effort, and cost, when compared to turbines located in more easily accessible areas. Most importantly, going uptower in such a remote environment also poses an increased safety risk to personnel.

This context begs the question – what should operators do to make sure that their equipment is as productive and reliable as possible, with minimal unscheduled downtime?

It all starts with lubrication.

Lubrication is the first line of defense

Lubrication is the lifeblood of any industrial machine – it's what keeps parts clean, protected against wear, and running smoothly. For equipment that operates under extreme conditions, like those found in the wind industry, proper lubrication is absolutely paramount.

A best-in-class wind turbine lubrication program is built around three key facets: using advanced lubricants, conducting routine monitoring via used oil analysis, and choosing when to change out your lubricants.

Advanced lubricants

Wind turbines require the use of both advanced gear oils and greases. Advanced gear oils protect components in the gear box, which is the "engine" of any wind turbine. Using the right gear oils is critical to ensuring proper equipment reliability, as gear box failures are one of the leading causes of unscheduled downtime – and a costly one at that. One study showed that a single gearbox failure can result in a 52 percent loss in annual energy production, and a 55 percent increase in unscheduled turbine downtime.

Today, almost all operators use a synthetic gear oil. Despite a common misconception, however, not all synthetic products are the same. In fact, formulation varies significantly, even for synthetic lubricants. Operators should look for products formulated with the right mix of advanced base oils and additives, enabling them to deliver long oil life. These products should be able to:

- Perform in extreme temperatures (150 degrees Celsius or more).
- Deliver enhanced oxidation and water resistance.
- Provide superb protection against wear and micropitting.
- Exhibit foam control and trouble-free wet filterability.
- Claim a metal-free formulation that does not contribute to White Etching Cracks (WEC), a common cause of gear box bearing failure.

Using an advanced gear oil that meets all these criteria can help operators potentially double oil drain intervals, a particularly appealing option for turbines located in harsh, remote environments.

Typical wind turbine gear oils have an oil drain interval of 36 months. Advanced synthetic lubricants are proven to extend intervals up to seven-plus years. This means that an operator could, hypothetically, eliminate one

Gary Hennigan is a Wind Lubricants Technical Advisor at ExxonMobil Fuels & Lubricants, focused on supporting the wind sector. With more than 20 years of experience in the wind industry, Gary has worked with operators across the U.S. to develop tailored lubrication and equipment maintenance programs.

ExxonMobil | www.mobil.com

oil change over 20 years, significantly reducing costs. Moreover, mitigation methods like additive top treating (which involves "topping off" the oil with an additive package after some years in service) won't deliver the same long-term performance as oil originally designed to deliver long oil life.

Operators should also look to use advanced greases to help protect important bearing components, including the main shaft, pitch, and yaw bearings. Greases should be able to deliver:

- Good performance in severe low-temperature conditions (to ensure sufficient flow and facilitate start-up).
- Robust water tolerance.
- Enhanced equipment protection from wear, rust, and corrosion.
- Long lubrication intervals.

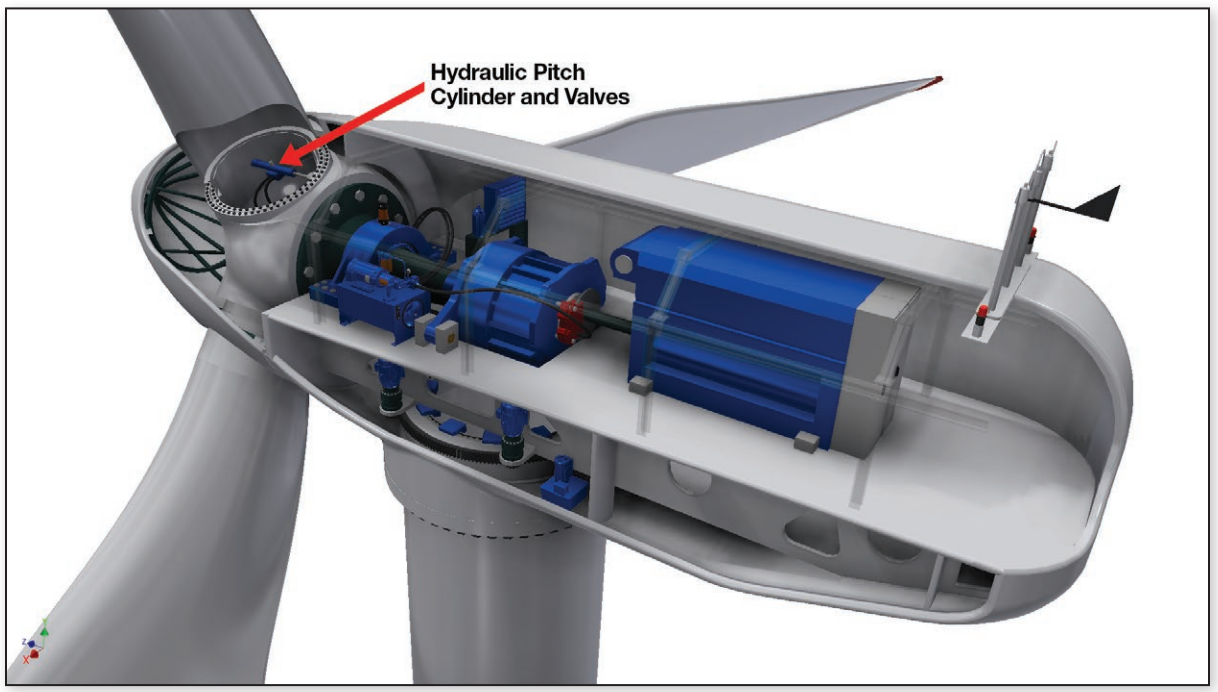
Routine monitoring to deliver real-time performance insights

Conducting regular used oil analysis (UOA) is an important tool that can help operators optimize the performance of advanced lubricants. UOA is the only way to identify turbine reliability issues, such as lubricant degradation and component wear, prior to critical failure. It's also relatively easy to implement, with a valuable pay-off in the long-term.

Oil analysis results can deliver insights on equipment condition, lubricant condition, and contamination. The results will indicate metal wear and component metallurgy, pinpoint any abnormal conditions in a lubricant, and assess presence of contaminants. Any issues flagged by the results can then be addressed before they result in equipment failure, saving operators time and money.

A low-hanging opportunity with significant pay-off potential

Lubrication is typically only a small part of a wind operator's budget, so it may seem like only a small opportunity. But making small changes to a lubrication program can have significant impact on the bottom line. For operators with wind farms in remote or harsh locations, the benefits of a best-in-class lubrication program are amplified.



Space is very limited inside the hub, making it more difficult to do the troubleshooting of the pitch control system.

Extreme Weather Conditions vs. Proportional Pitch Control Valves

by Scott Smith

In many instances, performance of the hydraulic pitch control is scrutinized in suitable weather conditions. However, these control systems are exposed to a variety of extreme weather conditions that can greatly affect both pitch performance, and longevity of the control components.

As in any hydraulic system, hydraulic pitch control systems experience the typical performance issues related to fluid cleanliness, temperature, and viscosity. Wind turbines, however, are not your typical industrial or mobile application for these components. The majority of hydraulic pitch control turbines over 1mw have a proportional control valve manifold, hard-mounted to the pitch ram inside the hub. The hub, which rotates with the blades, has much higher exposure to the external weather conditions; its only protection is a fiberglass nose cone that is not sealed. It's not the easiest environment in which to function.

With turbines installed all over the world, in ever-changing climates, weather conditions can have a devastating effect on performance and life of the proportional pitch control valve and system. Four primary weather conditions have a profound effect on the life of the pitch control components: Extreme Cold, Heat, Humidity, and High Wind Speed.

Cold can cause loss of spool seal integrity, as well as increased spool wear due to low viscosity. Extreme cold can also affect control wiring and connections.

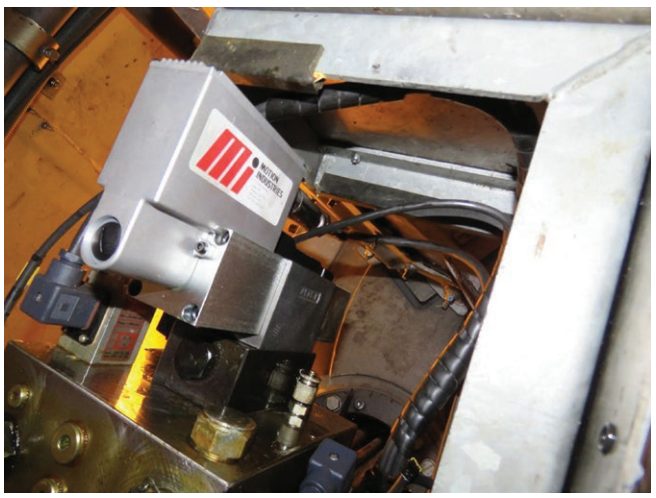
Heat creates low viscosity concerns, increasing wear, and reducing spool life. Varnishing can also result in spool sticking issues that can affect the proportional-integral-derivative (PID) control loop.

Humidity will cause corrosion in coil pin connections, or any type of electronic connection that is not well sealed. Ultimately, this will result in accuracy problems in the rotational PID loop, often causing a fault in the turbine control system.

High Wind Speed will create high levels of vibration in the pitch valve as it rotates in the hub of the turbine. The onboard electronics are susceptible to these rotational forces, subjecting the electronic driver card and enclosure to G-forces that loosen screws and wire connections; this results in loss of rotational position control of the blade.

Troubleshooting a fault or failure in wind turbines is not a quick and easy task. The tower climb and work process must be planned, and parts gathered; a climb safety meeting must be held before travel to the down turbine is even started. This controlled process can take many hours.

Once uptower and inside the nacelle – and especially the hub – space is very limited, making it more difficult to diagnose the problem. Changing a



This 50-liter pitch valve was designed with a more robust electronic package to decrease failure rates in harsh operating environments.

proportional pitch control valve in a turbine it can take 4-6 hours from start to finish, depending on the wind farm. Considering the maintenance costs, as well as lost production, the expense of constantly changing prematurely failing pitch valves can really add up.

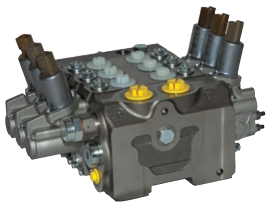
Many pitch control valve designs don't account for potential extreme weather conditions or tough operational environments. After examining hundreds of failed proportional pitch control valves, it was found that over 90 percent of the failures were related to electronic component failure or degradation, or mechanical failures of the driver card housing. Failures are seldom caused by wear or internal mechanical failure. These failures ultimately affect the PID pitch rotation control loop (which often requires a rotational accuracy of 1 percent). A proportional pitch valve problem or failure will create a fault, or error, in the pitch rotation system - ultimately shutting down the turbine.

Due to extreme weather exposure, the highest rates of failure are valves that do not have a robust electronic control package. Heavy-duty valve construction, coupled with a robust onboard electronic package, with rugged wire connections and seals, is paramount for a proportional hydraulic pitch control valve to perform well and survive in these extreme conditions. Focusing on the design of the electronics (the electronic driver card, the housing in which it must be mounted, and the electrical connections) results in an improved life cycle. The goal for proportional pitch control valves is a 3 to 5 year life – without failure.

Ultimately, the pitch valve must be constructed with the understanding that normal operating conditions will be exceeded. Valves are expected to perform in different wind and weather conditions around the globe. What performs well in Europe may not perform well in certain parts of North America. The valve manufacturer's original design must be analyzed and evaluated to determine if the valve can survive in the toughest wind and weather conditions.

Based in southern Oregon, Scott Smith (CFPHS) is a senior fluid power specialist at Motion Industries. He has 35 years of experience in the fluid power industry with distribution and manufacturing companies, and earned his Certified Fluid Power Hydraulic Specialist certification in 2001. Smith has been heavily involved in the wind energy market for Motion Industries, with a focus on hydraulic and lube systems.

Motion Industries
www.motionindustries.com



Post-compensated, sectional, load-sense valve

Muncie Power Products has expanded its valve line with a new post-compensated, sectional, load-sense valve – the L125. A 33 GPM nominal flow rate valve, the L125's inlet is capable of a maximum of 40 GPM and its work sections a maximum of 26.4 GPM. The L125 features good flow sharing parameters and multiple spool flow options. Electro-hydraulic and manual shift versions are available. Muncie Power's new L125 post-compensated, sectional, load-sense valve is suitable for the utility, agriculture, snow and ice and refuse markets in addition to specific applications such as truck-mounted cranes, forestry cranes, and plow and spreader functions.
Muncie Power Products, Inc. | www.munciepower.com

Bat Smart Curtailment Suitability Assessment and Modeling

by Christine Sutter

IN THE US, TWO MITIGATION METHODS HAVE PROVEN to reduce bat fatalities by wind turbines: standard curtailment (see Arnett et al. 2008) and smart curtailment (see Sutter et al. 2017). The rather discouraging results from recent deterrents tests (Table 1) suggest these may continue to be the only fatality minimization options for the foreseeable future.

Table 1: *Summary of results from three acoustic deterrent studies conducted during 2017*

Study Name and (state)	Summary
BWEC/DOE (OH)	Ineffective in reducing overall bat fatalities Ineffective in reducing fatalities for any single species Increased fatalities for eastern red bats
NRG/DUKE (TX)	Ineffective in reducing overall bat fatalities Effective in reducing fatalities for Brazilian free-tailed bats only Increased fatalities for eastern red bats
GE/INVERNEGY (IL)	Effective in reducing overall bat fatalities Effectiveness for individual species was not reported Increased fatalities for eastern red bats

Both curtailment strategies pitch out wind turbine blades to reduce rotation rates to ~2 rpm, and both are shown to be effective in reducing bat fatalities. Smart curtailment has the added benefit of being the only strategy that significantly reduces fatalities of Myotis species. The strategies differ in their effect on energy yield. Standard curtailment typically has a larger negative effect on energy yield because curtailment is determined solely by climatic conditions, and much of the curtailment (25 to 75 percent) occurs when no bats are present. In contrast, smart curtailment has a lesser negative effect on energy yield because turbines are curtailed only when bats are present in the rotor-swept zone (RSZ).

The optimal curtailment strategy at a wind farm may also be influenced by considerations such as the likelihood of the taking of a federally endangered species, state wildlife regulations, project economics, and the organizational culture of the wind farm proponent. There is no one-size-fits-all solution; instead, each site should seek an optimum solution based on all of these considerations.

Developing the optimum solution(s) starts with determining if smart curtailment is suitable for the site, then finding a scenario that balances the energy loss and the bat conservation benefit. Smart curtailment suitability and scenario modeling accomplishes both of these. The bat activity within the rotor-swept zone is analyzed to determine if the activity is spatiotemporally clustered. If so, then smart curtailment may be suitable at this site. Scenario modeling creates a variety of potentially optimum scenarios that can be judged based on all of the above optimizing factors. These scenarios estimate reductions in fatalities and reductions in energy yield (Table 2).

Table 2 contains a series of scenarios developed for a US wind farm. The inputs used were a single season (May to Oct) of bat exposure data from the rotor-swept zone, and meteorological data.

Table 2: *Standard and smart curtailment scenarios for a proposed US wind farm*

	Input Value	Results			
Scenario	Bat activity level to trigger smart curtailment	Expected bat conservation (% reduction in fatalities/facility)	Expected reduction in annual energy yield (MWh/ turbine)	Expected percent reduction in annual energy yield (%)	Expected reduction in annual revenue ($/turbine)
Wind speed ≤ 3.5 m/s					
1 (standard)	NA	16.7	0.73	0.0	$14
Wind speed ≤ 5.5 m/s					
2 (standard)	NA	43.7	38.2	0.3	$725
3 (smart)	1 or greater	43.7	19.7	0.2	$375
Wind speed ≤ 6.5 m/s					
4 (standard)	NA	55.9	92.1	0.8	$1,744
5 (smart)	1 or greater	55.9	47.5	0.4	$900
6 (smart)	2 or greater	54.5	38.0	0.3	$721
Wind speed ≤ 7.0 m/s					
7 (standard)	NA	61.3	143.4	1.2	$2,717
8 (smart)	1 or greater	61.3	69.2	0.6	$1,311
Wind speed ≤ 8.0 m/s					
9 (standard)	NA	71.2	322.8	2.7	$6,117
10 (smart)	1 or greater	71.2	149.4	1.3	$2,832

Summarizing the data presented in Table 2, the following has been observed for this site:

- The standard curtailment and the smart curtailment scenarios are expected to conserve roughly equal number of bats, but smart curtailment reduces the negative economic impact by nearly half of that observed under standard curtailment (e.g. compare scenario 4 to 5).
- Using smart curtailment, turbines can be curtailed at higher wind speeds (potentially conserving more bats) for the same economic cost of standard curtailment at a lower wind speed. (e.g. compare scenario 2 to 6).
- Four scenarios are expected to reduce bat fatalities by around 50% at a cost of less than 0.5% of annual energy production. Three of these are smart curtailment strategies - scenarios 3, 5, and 6.

Smart curtailment scenario modeling can allow operators and regulators to identify and achieve win-win scenarios that reduce bat fatalities, in exchange for a reasonable reduction in energy yield.

The quantitative nature of the scenario modeling supports more nuanced stakeholder discussions on the costs and benefits of potential curtailment strategies. It also generates a cost estimate (in lost energy yield) that assigns a value to the minimization efforts. And it provides crucial information on the likely timing and duration of curtailment events, which can be incorporated into energy forecasts, and power purchase agreements (PPA).

Christine Sutter is Head of Environment at Natural Power North America. She provides advice and guidance on natural resource issues to clients in the wind and solar industries throughout the US and Canada.

Natural Power | www.naturalpower.com

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Wind Solutions Overcome Challenges in Hazardous Conditions

by Bill Cook

THE WIND INDUSTRY HAS GROWN TO THE POINT WHERE IT is now the fourth largest source of electrical power in North America, after natural gas, coal, and nuclear. Industry reports indicate that global electricity generation from wind energy reached 60 GW in 2016. The U.S. Department of Energy's Wind Vision report says the United States may be able to meet 10 percent of its electricity needs through wind power by 2020, 20 percent by 2030, and 35 percent by 2050. Further, according to the American Wind Energy Association (AWEA), there are now 13,759 MW under construction, and 15,875 MW in advanced development. The combined 29,634 MW represents a 27 percent year-over-year increase, the highest level reported since AWEA began tracking both categories at the beginning of 2016.

However, it takes power to make power, and the unpredictability of extreme weather conditions can cause disruptions to onshore and offshore construction projects. Against this backdrop, and to stay on schedule, many wind energy developers are turning to temporary power generation solutions that provide for a wider, more flexible, and durable power capability across each stage of the wind farm lifecycle.

Temporary power generation solutions can be deployed at various stages of a wind farm development project to maintain productivity from both an economical, and operational standpoint… regardless of the waves Mother Nature makes.

Planning

Compared to onshore wind energy projects, planning for offshore wind farms presents a new learning curve. Much of the testing can be done at the manufacturing facility on both high and low voltage systems, but additional onsite testing is required for all projects.

For example, in order to progress from the planning phase into the construction phase, a project needs a reliable power source for LIDAR. LIDAR ensures the collection of a constant stream of information on wind, birds, and other wildlife. In this phase, the operation cannot lose power, even when challenged by turbulent waves and extreme wind. Any temporary power generation equipment must be waterproof to keeping the planning stage on track.

Construction

A reliable source of power is also required throughout the construction phase. Temporary power for large and small loads can be supplied with a wide range of generators designed to withstand any climate condition.

Testing the high voltage (HV) cable and substation requires a temporary power source. Per offshore construction, an HV cable soak test is conducted for building the substation, so that the developer can test all the relays and transformers on the substation prior to floating out. This prevents potential failures that will be costly to rectify offshore. For onshore projects, the cable soak is the first step in the commissioning process for each circuit of a wind farm. When the circuit is energized, this is the first time that cable has received power. The developer then has the entire circuit inspected prior to energizing the transformers.

Commissioning

Offshore, generators are used to commission or condition the turbines. This often includes use of generators on the MAP that power the essential equipment, followed by a greater amount of power to pitch and yaw the turbines. Failure to provide this motion could result in damage to the turbine.

Novel offshore power solutions have been created for this requirement, with the operating environment in mind; generators that are lightweight, durable and can synch together work to minimize the load. LV and HV back feeding solutions can also be provided for the offshore substation (OSS), further minimizing cost for the developer.

The past 20 years have seen certain variability and induction problems with wind-farm projects, and continues to make connecting to the utility grid a major challenge. This is where temporary power suppliers have played a pivotal role. The average size of wind driven generators has increased from 0.5 MW in the mid-1990s, to 8-MW in the latest offshore models. Commissioning these systems into service is expedited with mini-grid solutions, which provides the capability to manage power from the turbines, along with an associated array of scalable generators and transformers.

Onshore, generators are used to commission turbines prior to grid interconnection. This is often required because the transmission line is not complete, or the interconnection will occur, leaving too short a timeline to commission all the turbines prior to the sites Commercial Operation Date (COD). To complete the function on a large scale, the power from the turbines must be absorbed and managed by technically-trained

personnel with the correct equipment.

The generators and load banks supplied to the industry enable turbines to be commissioned prior to connecting to the power grid; this benefits return on investment (ROI) by letting the developer begin production as soon as the project completes the wind farm's substation. Saving time with reliable power equipment is important, given the tax incentives and credits available once the wind energy system is fully operational.

Operations and maintenance phase

In the post-commissioning phase, low-voltage power generators at the base of each turbine can power ancillary equipment, such as lighting, and the hydraulic pumps to turn the rotor (to prevent bearing lock up). Alternatively, a central high voltage package can power the integrated system from one point of connection, keeping transformers and switchgear running, in addition to the turbines.

Maintenance typically uses temporary power from standard generators, while transformers are available for the higher voltages, such as 690V (the industry standard for many years). In fact, transformers have been supplied for multiple uses; to connect the circuits in the field, 480 V/34.5 transformers in the 2,500-to 5,000 kVa range are provided. To keep the system operational, power has been supplied to the field when the main transformer has failed, or the utility has to take the distribution system out of service. Whether it is a maintenance issue or an emergency situation, sometimes an entire wind farm must be taken offline. When this occurs, a temporary mini-grid solution can support the entire wind farm, providing enough power for all the turbines to pitch and yaw correctly, and protect all warranties associated.

Offering unique designs and reliable models that weather severe conditions, temporary power generators can significantly reduce the costs and risks of downtime across the lifecycle of a project. While Mother Nature never stops, the capabilities of such generators continue to expand, as the industry transitions into offshore projects in North America and elsewhere.

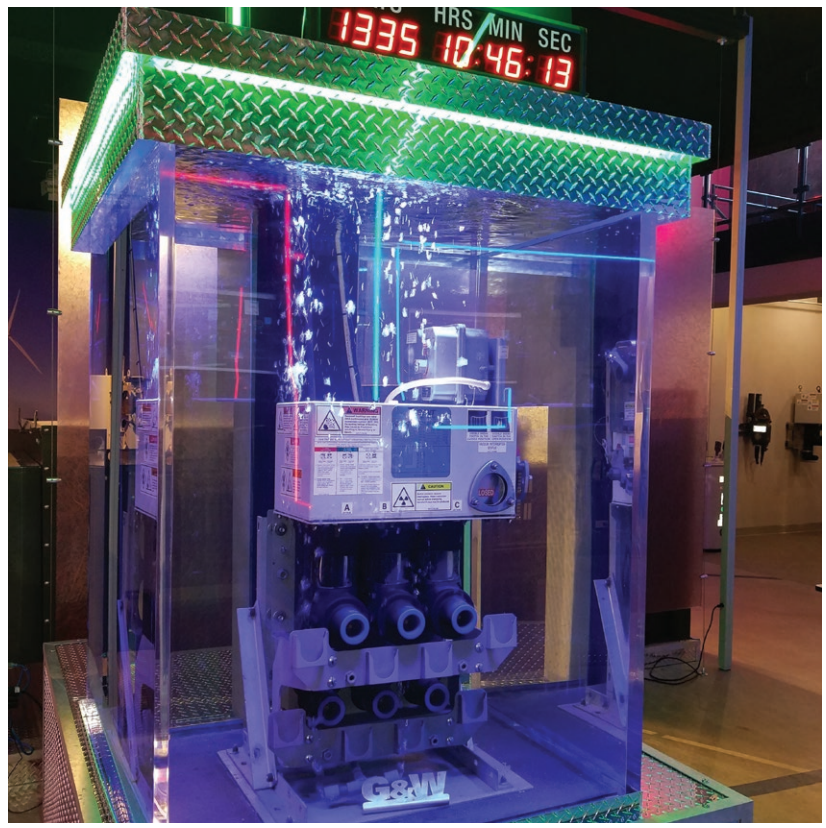
Bill Cook is a Renewable Energy Sector Manager for Aggreko, an international provider of power generation and temperature control solutions. In his role, Bill is focused on driving the company's business strategies and relationships within the renewables market. He has been leading Aggreko's business in the renewables sector for the last 12 years. Bill spends most of his time traveling and working with industry experts to develop solutions to their individual challenges. He lives in Chicago with his wife and four children.

Aggreko | www.aggreko.com

‘Switching’ It Up

Finding the right solution to make wind turbine technology safer

by Stephen Linn



According to the Bureau of Labor Statistics, a wind turbine technician is the fastest-growing occupation in the United States. With the rising societal mandate for clean energy and efficient technologies, this type of job will continue to be in high demand. Currently, the U.S. wind industry employs more than 100,000 people; employment of wind turbine service technicians is projected to grow 96 percent from 2016 to 2026, the second highest rate behind solar photovoltaic installers.

With rapid hiring comes the need for efficient and intensive job training – specifically when it comes to safety. Due to the dangerous job conditions, wind turbine technicians typically receive more than 12 months of on-the-job training. On any given day, technicians are faced with hazardous weather, working at extreme heights, and with high electrical voltages. Even with extensive training, a technician is always at risk.

Wind turbine manufacturers and energy suppliers also need to do everything in their power to protect employees from workplace hazards, and guarantee their safety. Choosing the right switchgear for wind turbines is critical to eliminating employee safety risks. Continued advancements target installation simplicity, maintenance, and safety, regardless of location.

Flourish in Harsh Conditions

When it comes to challenging conditions, it’s important to choose switchgear that’s not only designed to survive, but thrive in every environment. Switchgear should be independently rated and tested for harsh conditions, including snow, rain, wind, and dust.

Choosing switchgear that is rated with an IP68 certification is essential. This certification ensures that the switchgear is protected against any contamination from dust, dirt, sand and submersion. Because wind farms operate in some of the earth’s most unrelenting environments, such as along coastlines, many turbine components are exposed to salt water, sand, and flooding. Make sure the switchgear is rated for flooding; if flooding is a regular occurrence, consider selecting equipment that can be submersed indefinitely.

Switchgear that can handle wide fluctuations in temperature is also an important consideration. Look for products that have a temperature range from as low as -40°C, to as high as 65°C.

While consistent and strong wind is important for turbines, too much wind can damage their switchgear. Finding switchgears that can endure high winds is paramount. Additionally, look for systems with remote software that allows you to closely monitor wind speeds, and shut off the tower to prevent damage.

Switchgear should be able to withstand major earthquakes. In states like California, be sure to follow local codes. For example, all equipment inside the towers must meet OSHPD level 3 (2.5g) and pass ICCES-AC-156 testing, a seismic certification by shake-table testing of nonstructural components.

Safety Considerations for any Climate

No matter the weather or region, there are some basic considerations when specifying switchgear. To address safety concerns, products are being designed to keep technicians out of harm’s way. There are three major safety advantages when it comes to today’s switchgear.

1. Ground Position
   - A ground position is very important for the switchgear, as it removes residual energy from cables for maintenance.
   - Without the ground position, wind-turbine operators would have to remove elbows, or apply a grounding elbow, which can commonly lead to contamination and failure upon restarting.

- Any contamination could cause heat, and then cause a failure of the elbow. Not having to remove the elbow reduces the chances of contamination.

2. Visible Break
   - The visible break allows an operator to see the contacts (which are conducting energy) to be in either the open position or disconnected position, so the technicians can see that there is not a continuous circuit, and safely complete their work.
   - Having a visual break inside of the switch, without having to remove elbows, prevents contamination, making the job easier and faster.
3. Arc-Flash Resistance
   - According to OSHA, the majority of wind tower injuries and fatalities are related to arc-flash incidents.
   - The best way to keep a technician safe is with arc resistance. The most common type of arc resistance is a planned rupture and vent system.
   - When pressure builds to where it can no longer be contained, a rupture disk is designed to break and vent hot gases, indicating to the technician that there is a failure inside the switch.
   - Ultimately, it is designed to vent into an exhaust compartment, where it can be contained and directed away from the technician. However, it doesn't reduce the amount of energy in the arc-flash

There is also a less-common type of arc resistance that provides containment. In this design, instead of having a planned rupture point, the switch is designed to contain the pressure rise created by the fault and resulting arc flash for a prescribed period of time. This design further reduces the risk to the technician by preventing exposure to any hot gases.

Remote Operations:

- Many switchgear manufacturers offer the ability to add actuators as an orderable option to switchgear in the field.
- Actuators, when paired with a control package, can allow operators to get a safe distance away from equipment before issuing a command to open or close this switch. Increasing their distance from the switch reduces the risk of harm in case of an arc flash event.

To better understand how to utilize switchgear safety features and their advantages, onsite training is available for technicians. Ask your equipment provider for details, and whether or not they offer expert consultation and training.

Stephen Linn is a Field Application Engineer at G&W Electric Company, a global supplier of electric power equipment since 1905, including underground distribution switches, Lazer® Automation solutions, Viper® reclosers, distribution and transmission cable accessories, and current limiting system protection devices.

G&W Electric Company
www.gwelec.com

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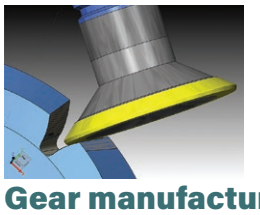


Gear manufacturing software

Sandvik Coromant has extended the functionality of its InvoMilling software. The latest version of this user-friendly CAD/CAM solution for fast and simple NC programming offers even more possibilities when manufacturing gears on universal five-axis machining centers. The software will also enable customers to produce straight bevel gears and herringbone gears. InvoMilling exploits machine tool kinetics for the effective and flexible manufacturing of high-quality gears and splines in quality level 6 or better (according to DIN 3962). After entering the required gear data, the intuitive CAD/CAM software defines the optimum machining strategies and generates a CNC program that allows the production of different gear profiles using just a few standard precision tools. The software also offers graphics as well as features to create and simulate milling paths. As well as upcoming options for herringbone, double helical (with and without gap), and straight bevel gears, an additional new function available in the latest version of InvoMilling is flank correction. This applies to tip relief and crowning in both the flank and profile directions as well as helix and pressure angle corrections. Numerous improvements have also been made to the tools. For instance, adapted tools have been introduced to the tool library.

Sandvik Coromant | www.sandvik.coromant.com

Predictive maintenance for wind turbine owners and operators

Global lubricant manufacturer, Castrol, and Romax Technology (Romax), a provider of software, analysis, and services for rotating machinery, have launched ONYX InSight, a new predictive maintenance brand offering wind energy asset owners and operators clarity and control over technological risks and operational expenditure; complete visibility of what goes wrong, when and where, before enabling them to act on this analysis to refine maintenance programs, maximize long-term performance, and minimize OPEX costs. These benefits are realized via a unique combination of specialist engineering consultancy and an integrated platform of proven hardware and cloud-based software. This includes ecoCMS, a condition monitoring system, FieldPro, a mobile solution for equipment inspection and reporting, and Fleet Monitor, an advanced web-based data analytics tool which brings all critical monitoring, inspection, and maintenance data into one place.

ONYX InSight | www.onyxinsight.com

Premium low wattage power supplies

Phoenix Contact has added compact AC/DC power supplies ranging from 30W to 100W to the premium QUINT POWER family. With these new low wattage additions, control engineers can select a more precise power supply for their low-power applications, while still getting advanced QUINT POWER features, such as preventative monitoring and power reserve. All of the new low wattage additions feature QUINT POWER's power boost of up to 200 percent the nominal current. This allows inductive loads to start without disrupting the output voltage. The power boost provides additional power to an application, which eliminates the need to install an oversized power supply. The new QUINT POWER low wattage additions are the first small power supplies with configurable alarming.
The new QUINT POWER low wattage products are available with either push-in or screw connection technology for easy installation. They are also NEC Class 2 classified.
Phoenix Contact | www.phoenixcontact.com

Asset optimization software to support digital transformation

ABB launched its new ABB Ability Ellipse software solution delivering a cross-enterprise approach to connected asset lifecycle management. The comprehensive solution suite enables electric power utilities to optimize asset utilization, drive down maintenance costs, and reduce equipment failures and system outages. The ABB Ability Ellipse solution offers utilities a proactive approach for predictive maintenance that combines an asset management system with collection and analysis of performance data and a comprehensive workforce management solution for dispatching crews and maintaining critical assets. Specifically, the solution unifies the functionality of ABB's world-class solutions for Enterprise Asset Management (EAM), Workforce Management (WFM), and Asset Performance Management (APM). ABB Ability Ellipse is the latest offering in the ABB Ability family. The solution embeds industry best-practices and business processes and leverages real-time equipment data and the Industrial Internet of Things to connect predictive analytics and asset management systems to the mobile worker in the field. It is available either as an 'on-premise' or 'Software as a Service' solution for electric utilities and other asset-intensive sectors like renewables, transport and mining.
ABB | www.abb.com

Rugged tablet PC

Endress+Hauser's Field Xpert SMT70 is a rugged tablet PC for commissioning and maintenance staff to manage field instruments and document the work progress. The tablet comes preinstalled with DeviceCare device configuration software and device library.
The Field Xpert SMT70 supports HART, PROFIBUS DP/PA, FOUNDATION Fieldbus, Modbus, CDI, and Endress+Hauser service interfaces. It can connect to field instrumentation devices directly via a USB or Bluetooth wireless modem, or via a gateway, remote I/O, or multiplexer to a bus system. The Field Xpert device library has more than 2,700 pre-installed device and communication drivers, allowing it to work with many different instruments from a wide variety of vendors. The drivers can be used to communicate with virtually all HART and FOUNDATION Fieldbus devices, and additional device drivers (DTMs) can be easily installed if required. Generic HART DTM and PROFIBUS profile DTMs also enable communication with field devices using these protocols. The tablet also supports Endress+Hauser Heartbeat Technology and FieldCare instrument diagnostic and monitoring functions. The tablet PC has Windows 10 Pro software installed. It comes with an 11.6" Multitouch HD display, a 5MP auto focus camera, a 2MP front facing camera, and up to 256 GB storage. Communication ports and supported networks include USB, Ethernet, HDMI, Wi-Fi, and Bluetooth, with 4G LTE and GPS available as an option. The battery runtime is 14 hours. The tablet comes in a general purpose configuration as well hazardous area configuration for Class 1, Division 2 Groups A,B,C,D, T4 and Class 1, Zone 2, Groups IIC, T4.
Endress+Hauser | www.us.endress.com/SMT70

Rescue stretcher

The new SKYLOTEC CONREST RESCUE STRETCHER is designed for rescue from difficult confined areas. Features include: Rated Frontal Chest D-Ring for easy hoisting and no need to put a harness on the victim, large Pelvic Strap for victim stabilization, arm loops, head stabilizer, and foot rest for victim comfort, solid and durable flat back plate for easy movement in confined spaces and over edges, curved top and bottom plate for smooth operation, four side handles for easy manual lifting, and user friendly color-coded straps for quickly securing the accident victim.
SKYLOTEC | www.skylotec.com

Quiet power take-off

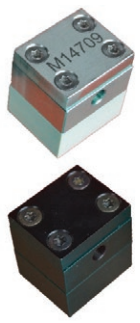
The FR6Q features the latest in noise abatement technology. With the FR6Q's patent-pending spring-loaded rocker mechanism, virtually all gear rattle noise is eliminated for a quiet power take-off. Muncie Power's FR6Q fits 4X2 and 4X4 Ford Super Duty trucks, F-350 to F-550, with the Ford 6R140 transmission, but may also be used on F-650 and F-750 trucks. The FR6Q has a one-piece installation with rocker. It has up to 200lbs/ft of torque capability. The FR6Q boasts a preconfigured wiring harness, is solenoid activated and available with direct mount pump drives or round shaft output options. The FR6Q operates in stationary and mobile modes. It is suited for the tow and recovery, dump, utility, and snow and ice markets as well as applications such as cranes, compressors, and vacuum tanks.
Muncie Power Products, Inc.
www.munciepower.com

Multi-stage telescopic hydraulic cylinders

Enerpac introduces its new series of multi-stage telescopic hydraulic cylinders designed for long cylinder strokes in confined spaces. The telescopic cylinders feature a multi-stage rod built from a series of nested steel tubes of progressively small diameter. The long stroke, multi-stage telescopic cylinder is particularly suited for extended lift heights when clearance is limited. The nitrocarburized surface treatment inside and out provides side load resistance and corrosion protection for safe use in harsh conditions. Other features include: three percent side load for full capacity, double- or triple-wear bearing support lifting stages, tilting saddles with five degrees of maximum tilt, lifting eyes for safe handling and positioning, and steel cylinder base for maximum strength. Enerpac's telescopic cylinders are available with two or three pistons, have 15 to 35-ton capacity and can lift loads up to 24 inches in a single movement.
Enerpac | www.enerpac.com

Connector to resist harsh conditions

HARTING's new M12 INOX connectors are made of high grade stainless steel to provide superior corrosion resistance in extreme, harsh environments, indoor or outdoor. HARTING tested especially durable materials in developing the M12 INOX. It settled on superior V4A grade stainless steel and adapted its manufacturing processes to suit the raw material. The connectors are made with V4A that's free of flaws to ensure that the connectors meet the IEC 60068-2-52 severity 4 standard. The M12 INOX is designed for an ambient temperature range of 40°F to 185°F (-40°C to 85°C), and up to 500 mating cycles, rated for up to 4A and 250V with crimp termination. HARAX termination (IDC technology) also is supported. The M12 INOX is available in A (5 pole male), B (5 pole male and female), and D codes.
The HARTING Technology Group
www.harting.com



Wireless lubrication monitoring

The WLubeMon monitors that the right amount of lubricant is fed in the right time to the bearing – the fundamental criteria for reliable lubrication system. The system works completely independently and is capable to monitor all types of grease lubrication systems including manual lubrication. The meter (LubeMon) has been available with cable transmission which includes the high cost of cable installation as well as risk of cable damages. The WLubeMon comprises a precision grease meter that measures the amount of lubricant fed into the lubrication point. The meter communicates on a regular basis wirelessly with a Control unit. The system provides alarms for both too high and too low volume as well as statistics and log functions. The Control unit can monitor up to 20 individual meters and has a normal carriage of 75 meters. The condition for each meter is shown clearly on the user-friendly Control unit's color display. The battery lasts at least 15 years.
Assalub AB | www.assalub.se

2-in-1 impact sockets

Hi-Line Utility Supply announces Klein Tools has introduced their two new 2-in-1 Impact Sockets. These new 2-in-1 Impact Sockets will save time and reduce tool drops, plus will eliminate the need for multiple size tools for the job. The 12-point design is easy to position and works with square fasteners, while the 6-point design contacts flat sides of hex fasteners, reducing round-off. Both flexible impacts are designed for high-torque. Both versions offer a new solution to utilizing multiple tools by providing a two coaxial spring-loaded sockets, for automatic switching between socket sizes. Users can quickly move between various size projects without flipping, removing, or adjusting the tool. Socket sizes are 3⁄4" and 9/16", and feature a deep socket with a 1⁄2" drive for pole hardware installation and removal.
Hi-Line Utility Supply
www.hilineco.com

Free diagnostic mobile app

Manitowoc Cranes has announced a new smartphone app that will help customers quickly diagnose technical issues on their cranes. The free app is available on iOS and Android devices, and enables users to understand the numeric diagnostic codes generated by their on-board control systems, allowing the to begin working on solutions immediately, boosting their uptime. The first version of the app will address diagnostic codes on all Grove- and Manitowoc-branded cranes that run on Manitowoc's Crane Control System (CCS), as well as all-terrain (GMK) models that have ECOS 1 or ECOS 2 installed. National Crane boom truck functionality will follow in a future update.
Manitowoc Cranes
www.manitowoc.com

Turbines

Wind turbines convert the kinetic energy in the wind into mechanical power and are generally divided into categories based on their rated capacity. Large wind turbines range in size from 100 kilowatts to as large as several megawatts. Small turbines, below 100 kilowatts, are used for homes, telecommunications dishes, or water pumping. Here we focus on some of the small and large wind turbines available today.

Goldwind Americas

Product: GW 136/4S MW

Capacity: Scalable: 4.0MW and 4.2MW

Rotor diameter: 136m (446ft)

Hub height: 80m, 100m, and 110m (262ft, 328ft, and 360ft, respectively)

Swept area: 14,711 m^2

Rated power: 4000 and 4200kW

Cut-in wind speed: 2.5 m/s

Rated wind speed: 11 m/s

Cut-out wind speed: 25 m/s

www.goldwindamericas.com

SEE AD ON PAGE 11

Siemens Gamesa Renewable Energy

Product: SG 2.7-129

Capacity: 2.75MW

Blade length: 63.5m (208ft)

Hub height: 87m (285ft)

Swept area: 13,080 m^2

Rotor Speed: 12.5rpm

Nominal Power: 2750kW

Cut-in wind speed: 3 m/s

Nominal wind speed: 12 m/s

Cut-out wind speed: 23 m/s

Key Features:

- Aeroelastic tailored blades with 129-m rotor diameter;
- IntegralBlade technology, DinoTails Next Generation, Vortex Generators, and optimized cross-sections (airfoils) design;
- Adaptive yaw system for optimized performance;
- Gearbox with two planetary stages and one helical for increased capacity;
- Efficient direct cooling system.

www.siemensgamesa.com

SEE AD ON PAGE 17

Nordex USA Inc.

Product: AW125/3000

Capacity: 3000kW

Blade length: 61.2m (200.78ft)

Hub height: 87.5m to 120m (287ft to 393.7ft)

Swept area: 12,305m^2

Rotor speed: 86.5 m/s

Nominal power: 3000kW

Cut-in wind speed: 3.5 m/s

Nominal wind speed: 10.5 m/s

Cut-out wind speed: 25 m/s

Key Features:

- Ideal for higher wind projects in the Central Plains and Texas;
- Optimized design for the US market;
- Financed by top lenders.

www.nordex-online.com

Suzlon Wind Energy Corporation

Product: S128

Capacity: 2700kW

Blade length: 64m (210ft)

Hub height: 86m to 120m (282ft to 394ft)

Swept area: 13,000m^2

Rotor speed: 7.3 rpm to 12.1 rpm

Nominal power: 2700kw

Cut-in wind speed: 3 m/s

Nominal wind speed: 9.5 m/s

Cut-out wind speed: 20 m/s

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Figure 1: *PV system installed at Rivière-au-Renard (Canada)*

Solar PV Challenges in Cold-Climate Regions

by Sergio Gualteros, Pierre Beaudoin, and Matthew Wadham-Gagnon

SOLAR PV SYSTEMS SUBJECT TO EXTREME COLD-WEATHER CONDITIONS face particular challenges, from the planning stage, to operation and maintenance. Low temperatures, heavy snowfall, freezing rain, and short periods of sunlight are some of the phenomena that may affect solar PV performance. Due to an ongoing misconception that solar PV systems are not suitable for such conditions, its deployment in colder North American regions remains considerably low.

However, solar PV is the fastest growing renewable energy source worldwide, with an extraordinary 50 percent growth rate in 2016. This unprecedented growth has also facilitated the development of measures to adapt PV systems to harsh environments. Regarding PV systems in cold climates, such measures can be separated into two main groups: (i) design and technologies and (ii) O&M strategies.

Design and Technologies

During planning and design stages, on-site extreme weather conditions must be considered. Snow accumulations on the PV modules can be minimized by using higher tilt angles, and frameless modules, which helps snow to slide off easily. Along with the aforementioned configuration, portrait-oriented PV module installation is an advantage; a longer sliding surface will facilitate snow shedding. If high tilt angles and frameless PV modules cannot be used, landscape orientation is preferred, as snow accumulation at the bottom of the covered modules will tend to cover a single PV cell string, minimizing energy losses. For ground-mounted arrays, if high snow accumulations are expected on site, elevated frames are needed.

Even a light coverage of snow on the module surface can have a large impact on energy yield. Bypass diodes are used to bypass covered PV modules, thus minimizing related losses. Thanks to recent engineering development, bypass diodes are also included inside the PV modules so that covered PV cell strings can be also bypassed. Proper string/row design can also help reduce coverage losses; the electric connection of a string over two physical rows will produce an undesired combination of covered and uncovered modules, and should be avoided.

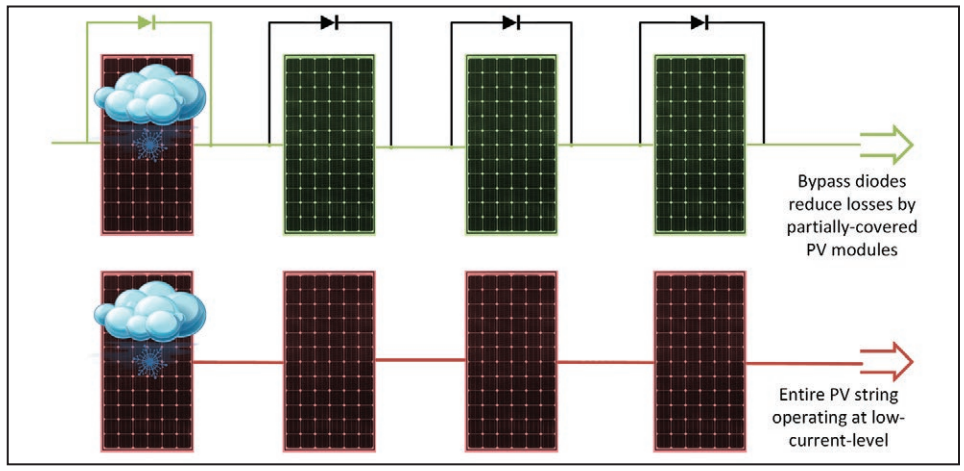


Figure 2: *Bypass diodes can reduce energy losses caused by partially-covered PV modules*

Microinverter-based architectures are superior to string inverters in cold climates. The increased granularity of this architecture leads to better performance monitoring, which reduces the single-point-of-failure challenge, and minimizes the impact of partially snow-covered PV modules.

O&M Strategies

PV systems installed in cold and isolated regions are subject to logistical constraints for O&M, which considerably increases operational expenditures. Reducing system complexity helps minimize required O&M interventions. For example, sun tracking systems, which comprise sensitive equipment and moving parts, are likely to fail due to extreme low temperatures or high wind speeds.

In order to avoid false-alarm situations, the adverse effect of freezing temperatures on electronic equipment must also be considered. In fact, electronics are highly impacted by ambient temperature; voltage, current, and temperature readings can drift when sensitive equipment functions outside its operating temperature range. Utilizing hermetic, temperature-controlled enclosures for electronics, or using military-grade electronics, can help reduce this drift in systems with high precision requirements. To avoid false-alarm conditions in small-scale systems, an overall uncertainty estimation is recommended.

One of the most common concerns in cold weather is removing snow accumulations from PV modules. In an effort to reduce O&M interventions, self snow-shedding and de-icing must be evaluated at each particular site. Snow cover on a PV module can eventually allow some solar radiation to pass through; even partially covered modules can produce electricity and heat, and promote self snow-shedding. Experience and observations gleaned from the first winter of PV operations should provide sufficient information to operators. Cleaning tools for de-icing and snow removal must be carefully chosen in order to avoid damaging PV modules.

Advantages of Solar PV Systems in Cold-Climate Regions

Nevertheless, cold-climate regions show an exceptional set of favorable conditions for PV. Silicon-based PV modules perform considerably better in colder temperatures. Module efficiency at 0°C can be up to 12.5 percent higher; snow accumulations surrounding the PV modules can act as a mirror, increasing both the solar radiation reaching the modules and the energy yield. Similarly, because copper resistance decreases at lower temperatures, electric losses in the conductors are reduced. In fact, ideal conditions for PV modules include high solar radiation, low temperatures, and high ground reflectivity.

In standard conditions, the main cause of PV module degradation is the heat generated by the incident solar irradiation. Since cold weather helps keep module temperature low, PV systems in cold climates are expected to have longer service lives. In fact, PV systems installed in northern Canadian locations have been operating for more than 35 years with lower degradation rates than expected, and almost no O&M issues reported.

Some cutting-edge technologies remain to be tested in northern locations. Such is the case for bifacial PV modules, which may profit from high snow reflectivity, therefore increasing energy yield and promoting faster snow and ice melting. Passive and active melting technologies can also be tested in PV systems. One example of passive technology is the ice-phobic coatings that impede rime or glaze from forming on the PV modules, while reverse flow-current through the modules to generate heat is an active melting technique already used in some European PV systems.

Despite existing restrictions, cold-climate regions represent a beneficial environment for solar energy systems. PV modules are easy to install and operate, have no moving parts, and perform particularly well in cold climates. Indeed, overcast locations are less favorable to solar PV deployment than cold, snowy sites. Furthermore, by combining PV with wind energy in higher latitudes, operators can take advantage of regions where lower solar radiation seasons often coincide with higher winds. With the proper design, solar PV can become a mainstream energy source for northern isolated locations, replacing polluting diesel generators, and improving energy source diversification and availability.

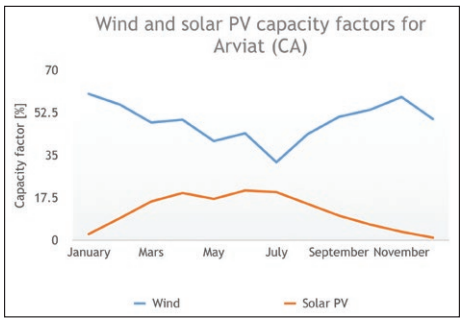


Figure 3: *Capacity factors for wind and solar PV in Arviat, Canada (N 61° 6.4984′, W 94° 3.5971′)*

Sergio C. Gualteros is an Analyst of Research and Innovation at Nergica. Drawing on his expertise in integrating renewables into electric systems, his projects foster the development of innovative solutions for energy efficiency and the transition to cleaner energies.

Pierre Beaudoin is a Project Manager of Research and Innovation at Nergica. He is a specialist in the integration of off-grid renewables, and has been working in the field for over 25 years.

Matthew Wadham-Gagnon is a Business Development Manager at Nergica. With more than 10 years of engineering experience as project manager, coordinator, and guest speaker, he has acquired leading-edge expertise in his field of activity.

Nergica is a centre of applied research that stimulates innovation in the renewable energy industry through research, technical assistance, technology transfer, and technical support for businesses and communities. Known until recently as the TechnoCentre éolien, Nergica has been active for nearly 20 years in the field of renewables, and is an official college centre for technology transfer (CCTT) affiliated with the Cégep de la Gaspésie et des Îles.

Nergica | www.nergica.com

Northern Exposure

Ground mount solar for anywhere the ground freezes

by Jono Stevens

The sun may be shining brightly, but the ground is frozen—perhaps permanently. Frozen ground presents two challenges for traditional ground mount solar foundations. One is year-round, and involves the need to go deep below the frost line, to avoid problems caused by heaving as the soil freezes and thaws. The other is seasonal, and involves being able to install steel piles or screws in the frozen ground, without damaging them or the installation equipment. The former can make ground mount systems cost-prohibitive; the latter can put solar companies out of business for several months every year.

Both challenges are addressed by the earth anchor foundation system, a recent innovation in the ground mount solar industry. Earth anchors have long been used for a variety of applications, including by electric utilities for securing the guy-wires that tether power poles. The operating characteristics that enable earth anchors to function well - even in the most difficult of soil conditions, from desert hard pan to sand - also make them viable in frozen ground. Before understanding how earth anchors work through freeze/thaw cycles and in permafrost, it is necessary to first understand some basics about their use.

Earth Anchor Basics

The advantages afforded by earth anchors derive mainly from their shape: bullet-like and typically about 5” long by 1.5” in diameter; penetrating “teeth” at one end; a hole for inserting the drive rod at the other end; and an “eye” in the center for attaching a stainless-steel cable or galvanized rod. Some anchors are more like wedges that are narrower and wider, but either shape gets its rather extraordinary holding strength from the “inverted cone” of soil above. An anchor set 48” deep, for example, is secured by over 26 cubic feet of contributing soil, for a holding capacity of over 2,000 pounds, under most conditions.

Its relatively narrow profile and aggressive teeth make the earth anchor substantially easier to install, compared to driven or augered piles or screws. An electric or pneumatic rotary hammer drill, powered by a portable generator or air compressor, and equipped first with a bit (for drilling a pilot hole) and then with a special drive rod, are the only tools needed to set the earth anchors. After the drive rod is removed, and uplift force is applied to the attached cable or rod, the underground anchor rotates into its final, horizontal, and locked position.

This installation process affords another major advantage: The ability to conduct simple, inexpensive, real-time field load tests to measure the actual (vs. calculated) holding strength of every earth anchor. Such verification eliminates the need for geotechnical reports and related inspections, and virtually guarantees being able to meet the required engineering and design specifications, easily and cost-effectively. It is important to note that, should any test fail to reach the specified load, the earth anchor can simply be removed and reinstalled at a different angle and/or depth. If necessary, a second anchor can also be set, with the load test performed again on the pair.

Below Ground Below Zero

The advantages of earth anchor foundation systems are already proving applicable in frozen soils, making ground mount solar projects viable in some of the worst locations.

Depending on the soil composition, the basic “warm climate” installation is modified by adjusting the depth of the earth anchor and, optionally, using springs to accommodate ground movement, and limit the cyclical forces being applied to the anchors. The easiest case is permafrost where, with no seasonal ground movement, the earth anchors can normally be installed to a depth 36-48", just as they would be at Southern latitudes.

of the earth anchor, and its cable or rod, overcome all of the problems that plague traditional foundations. Fewer problems means lower costs. The earth anchor foundation system is opening new markets and creating new opportunities, by making ground mount solar viable wherever and whenever the ground freezes.

Jono Stevens is the co-founder and Executive Vice President of Products at Nuance Energy Group, Inc. He is a solar industry veteran with more than 20 years of experience in photovoltaic energy and construction management, where he has helped develop over 50 MW of solar capacity across more than 1000 systems in residential, commercial and utility-scale projects. Prior to co-founding Nuance Energy, Jono held senior leadership positions at SunWize Technologies, GreenVolts and Cobalt Power Systems.

Nuance Energy | www.nuanceenergy.com

Where freezing is seasonal, it is necessary to accommodate movement of the ground during freeze/thaw cycles. Ground begins freezing at the surface; the resulting expansion or heaving has the effect of applying additional upward force on the foundation. Specialized compression springs in the anchor system allow the foundation to rise slightly as the ground freezes, and settle as it thaws, all while maintaining adequate tension in the anchor's cable or rod. Engineering analysis can determine the optimal tension of the spring, and depth of the anchor. Both variables depend on the soil properties, specified depth of the frost line, and other environmental factors.

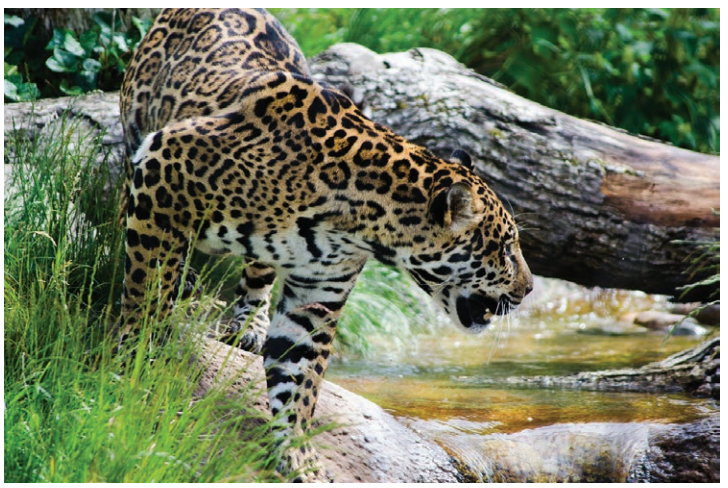
Earth anchor foundation systems offer important advantages over traditional ground mount solar foundations. During installation, there is no need for an excavator, pile driver, auger, or other heavy equipment, or for any costly admixtures for pouring concrete in freezing conditions. Earth anchors readily overcome the resistance to penetration caused by hard, frozen soil.

Heaving ground also applies uplift forces to vertical surfaces. In order to prevent freezing soils from adhering to the metal or concrete of traditional foundations, it helps to replace the surrounding native soils with gravel, or install a PVC collar down to the frost line. This also prevents so-called frost-jacking, where the pile or pier rises during freeze cycles, but fails to settle when the ground thaws. The opposite problem occurs during warmer months in permafrost, where the high thermal mass of steel piles or screws, or concrete piers, can cause the surrounding ground to melt, resulting in the array sinking or settling, likely in an uneven and permanent manner.

The narrow profile, low surface area, and virtually negligible thermal mass

Off-Grid Solar in the Rainforest

by Thomas Beindorf



THE QUALITY OF HUMAN COHABITATION STRONGLY DEPENDS ON A reliable access to energy. This can be a feat for any large, metropolitan city; a small community in an isolated or off-grid location faces an enormous challenge when establishing a sound and affordable power supply. Remote communities often meet this challenge by utilizing fuel-based energy generating technologies, such as diesel generators. However, this kind of power supply represents a heavy burden, since fuel prices are unstable, the generators require extensive maintenance, the logistics of diesel is expensive and time-consuming and, of course, the emissions cause serious pollution and harm to the natural environment. To overcome the dependence on fossil fuels, more and more remote communities are choosing to install off-grid, renewable energy systems.

Thanks to its flexible application and low maintenance requirements, solar technology represents an ideal opportunity for remote areas to ensure a consistent energy supply, while attending to the challenges of climate change. As one of the clean energy pioneers in the Caribbean, the government of Guyana strives towards a 100 percent renewable energy supply in the country by 2025, and aims to equip even remote rainforest communities with solar energy installations. Associated with the Ministry of Public Infrastructure of Guyana, the government-run Hinterland Electrification Company is implementing solar projects in remote areas, to help reduce their dependence on polluting diesel generators.

In the remote Mabaruma Region, in the very North of the country, an international company has stepped in to install a 400 kWp off-grid solar solution, together with an energy management and energy storage capacity of 400 kWh. After a thorough planning and logistical stage, this project has been recently completed and implemented. Given the challenges of a remote solar power project, special consideration was taken with each step in the process. This project was a far cry from most solar projects in densely populated and interconnected areas.

Overcoming logistic hurdles through diligent preparation

The small, remote community of Mabaruma is located close to the Venezuelan border, surrounded by dense rainforest vegetation. Since there is no major seaport near the community, the delivery of the materials needed for the solar systems represented the first major challenge. Ensuring the timely and safe delivery of the modules, substructure, batteries, and inverters, required diligent and accurate planning and preparation. Unlike other solar projects, the components for the solar systems in Mabaruma could not be delivered directly to the construction site via containers and trucks. Instead, the parts were first delivered to the international seaport in Georgetown, the capital of Guyana, then moved out of the containers, loaded onto smaller boats, and finally delivered by small local trucks to the power plant. Every step of this transport chain had to be carefully orchestrated to ensure a smooth and safe transport of the materials.

Wildlife conditions required additional planning. While realizing a solar energy project in the rainforest, it is especially important to take into account the environmental aspects around the installations. Besides generating solar power, the renewable energy systems also represent an opportunity to increase the biodiversity value of a site. The rainforest of Guyana is characterized by a high biological diversity with a unique flora, and represents a rich habitat for endangered species such as the Tepui swift, the jaguar, and more than 850 species of birds.

To maintain this exceptional environment, natural habitats like field margins were preserved. Even self-seeding plants and security fences promoted diversity during the construction process. As some animals may represent a threat to solar plants and their smooth operation – such as small rodents cutting cables - the security fences not only protect the installations, but also the animals. At the same time, they offer a surface for growing climbers and the resulting nectar sources.

Apart from the logistical challenges arising from the remote location of the Mabaruma community, the conditions around a site in the middle of the rainforest needed special and highly customized preparation. Due the difficulty in accessing such a remote location, all necessary components and materials had

to be procured in advance; it's almost impossible to purchase any of these parts locally. Careful preparation and extraordinary attention to detail allowed the local teams to properly execute each construction stage, according to the design and schedule.

Continuous monitoring and surveillance of the site was essential during the construction phase; the project site was prepared and cleaned, and a fence was erected. To further protect the components during the installation process, local security guards were hired to monitor the area 24/7.

While supervisors coordinated the implementation of the project, the installation itself used labor from a local workforce. After training on site, the workers were able to provide the necessary support to the technical team, and complete installation. In addition to creating jobs and adding to the local infrastructure, the project helped residents gain a new understanding of nature and wildlife conditions, which will help ensure the success of this exceptional venture.

Establishing off-grid solar in such remote areas as rainforests represents a major challenge. Above all, it requires accurate and diligent planning and preparation of all project stages. It may not be easy, but the extra effort definitely pays off – not only for stakeholders, but also for the local communities that are no longer dependent on fossil fuels, able to benefit instead from reliable and sustainable solar energy.

Thomas Beindorf is the Chief Technical Officer of The meeco Group. He is an experienced mining engineer with 30 years of experience working on the development and management of technical installations, the supervision of respective teams of engineers and workers, and the installation of facilities worldwide.

The meeco Group
www.meeco.net

Mounting platform for exposed fastener panels

The new SolarFoot from S-5! for exposed fastener metal roofing, has four points of attachment, providing a mounting platform to attach the L-Foot of a rail-mounted solar system or other ancillaries to the roof. The SolarFoot ensures a durable weathertight solution for the life of the solar system and the roof. Each piece contains two reservoirs of a factory-applied butyl co-polymeric sealant, allowing a water-tested seal. Simply peel the release paper from the butyl sealant and fasten through the predrilled holes in the base of the SolarFoot.
S-5! | www.s-5.com

Wire management gone bad. An unidentified supplier's UV rated cable ties, passed through a module hole, failed and significant rework was needed.

Avoid Wire Management Disasters in Three Easy Steps

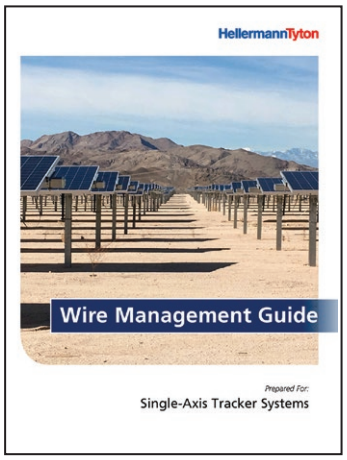
by Nick Korth

Just like the weather, poor wire management application and lack of strategy can be catastrophic. Unlike storms and natural disasters, however, wire management failure on solar installations is not only predictable, but also easily preventable.

If you want to reduce risk and added costs, consider the following three-step process:

The first step is **education**. NEC 2017 prescribes a number of requirements dictating proper wire management – unfortunately, they tend to be open to interpretation.

According to NEC 110.12, "Electrical equipment shall be installed in a neat and workmanlike manner." NEC 338.24 refers to "insufficient support of conductors and stress on junction box and plug connections."



These codes provide a baseline for evaluation and inspection, but they don't guarantee a long-lasting installation. Seeking out best practices, and adopting quality assurance programs, will go a long way to ensure that installers learn and practice proven installation procedures.

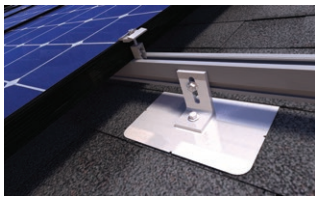
For example, one site actually had a plastic-coated metal cable tie routed through a module hole. The tie was so tight that, due to wind and thermos-cycling, it had sliced through the wire jacket and caused a fault. This is a profit killer; any time you have to repair a serious fault, you drastically reduce your profit margins.

Another example was damage to a cable jacket because of poor application of metal clips. It's not uncommon to see workers pounding on poorly designed, cheap metal clips, with the back of a side cutter or screwdriver. Not only does this distort the actual clip, which affects performance, it can cause damage to the module itself. The solution is to use better metal clips that are designed to go on easily, and hold incredibly well.

The second step in having a good wire management plan **is specifying the correct materials, and having the correct product for the application**. Plastic products often get a bad reputation in the solar industry, and are frequently seen as a poor alternative to metal. But, like all products, quality is often relative; you get what you pay for. Not all plastic wire management products are created equal. Plastic cable ties get a bad rap. Like everything else on the market, there are varying levels of quality; don't let the reputation of inferior plastic products scare you away from seeking out and using a stronger, well-made, and lasting plastic cable tie.

One particular site happened to be in a desert environment, but had cheap, "UV rated" cable ties looped through solar module mounting holes. After three replacements in four years, the owner of this single axis tracker installation decided enough was enough; he specified and was able to find a product to match the hazards of constant heat, thermo-cycling, wind, and sun.

But think about this: four laborers for five days, at $20 per hour, adds up to $3,200 a year. Over the course of five years, a site owner could spend $16,000 on labor for replacing cheap cable ties alone, significantly adding to the operations costs. That's in addition to the multiple faults and connector failures, and the added risk of junction box failure due to strain on the lead wires.



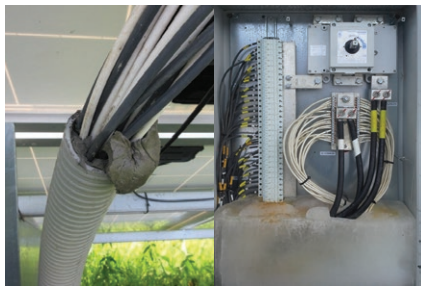
Fully integrated mounting and racking solution

Quick Mount PV introduces the QRail rooftop racking system, a comprehensive, cost-effective single-source solution for solar installation on all roof types. Combined with the company's waterproof mounts, Quick Mount PV now offers a complete, fully integrated racking and mounting solution for installing solar PV modules on any roof. QRail features patented QClick and QSplice technologies to streamline the installation process. Mid- and end-clamps with QClick technology simply snap into place and remain in an upright position, ready to accept the module. QRail's QSplice is a tool free, bonded structural splice that installs in seconds with no tools or extra hardware required. External splices are also available. QRail is designed and engineered for strength and versatility. The aluminum rails come in three sizes, Heavy, Standard and Light and are available in 168" and 208" lengths, in mill and black finishes. The QRail Series is compatible with virtually all PV modules and L-foot attachments. Modules can be mounted in portrait or landscape, in either standard or shared rail configurations.

QRail also comes with QDesign, a free online design tool to enable quick and easy design of solar arrays, as well as produce detailed bills of material and all necessary engineering reports.

Quick Mount PV | www.quickmountpv.com

Here's where **UV stabilized** fasteners truly shine. Designed with a mounting base or a cable tie buckle, these products will last five to seven times longer than a UV rated cable tie through a module mounting hole. Parts made from UV stabilized plastic, along with other modifiers, can drastically increase the life expectancy of these products in the elements. In fact, some plastic compounds can last even longer, around 15 to 25 years. Choosing engineered plastics designed to perform in the elements will consistently deliver rewards.



Lastly, come up with a sound **O&M strategy**. Consider the combiner box shown above. The wire entry was sealed with a compound, but one that was not rated for outdoor use. As the compound flaked away, water seeped into the conduit and flowed down to the combiner box. A more routine maintenance schedule could have caught this issue before leading to expensive fixes. Unfortunately, in this case, a complete combiner box replacement was required.

Focus on these three steps to successfully master solar installation costs and risks. Effective wire management can help save money at installation, reduce installation times and maintenance visits, and continue delivering over the long term.

Nick Korth is the Product Marketing Manager – Energies at HellermannTyton North America. The manufacturer provides solar solutions that connect, fasten, route, protect, and identify. HellermannTyton demonstrates an ongoing commitment to industry education and safety.

HellermannTyton
www.hellermanntyton.us

Cost-Effective PV in Northern Climates

Getting it done right from the start

by David Pichard, Rob Souliere and Eugene Koval

2.7MW Project in Lake Waconia

This fixed-tilt system in Minnesota was constructed during winter 2017. Winter construction poses many challenges, including poor irradiance, cold temperatures, snow load on the modules, low PV production, and impaired road access to the site. Ideally, all civil work should be concluded before the seasonal ground freeze.

What works in the desert won't last on the northern prairie. As utility-scale PV grows beyond its traditional sun-soaked environments, developers and EPCs have faced a steep learning curve. Experience gained in the desert doesn't necessarily translate into designing for the geotechnical and environmental challenges of northern frost, snow loads, and strong winds. What is accepted as cost-effective in traditional settings, can prove disastrous under extreme conditions.

The right engineering

Making the numbers work is one thing, but making sure you're using the *right* numbers is something else entirely. Use the standard engineering ASCE 7 guidelines, but research local standards carefully. In areas where PV development is new, engineers need to consider regional building codes for other types of projects, to help them learn about local snow loads, wind shear, and frost heave potential.

Foundation designs in particular must take geotechnical forces into account. When water freezes and expands in subsurface soils, it can create ice lenses that shift and push upward, carrying solar rack foundations along with them. Unfortunately, the rate of this frost heave is dynamic and can occur at over an inch per day, depending on local conditions, including the soil's moisture depths. Heaving foundations can flex structures, crack modules, and cause catastrophic damage to conductors and grounding.

Check what historical records show for the depth of subsurface frost. Designs that stipulate a range of three to nine feet, for example, are not specific enough to counter frost heave. Pile lengths must be long enough to meet the deepest frost numbers. How much snow accumulates in the region? Different foundations and designs can accommodate varying weights. What are the region's maximum wind speeds? Mounting designs can handle the stresses if local data are taken into account.

Key design features and decisions should include:

- Install as much pile material as necessary (size, depth) after running a proper pre-production test program. Reduce frost heave risk by installing accurately engineered helical piles, which minimizes the true cost per kWh produced, without compromising on the ground anchoring of the PV system and increasing maintenance costs. Driven piles aren't suited to areas with deep subsurface frost.
- Reduce mechanical connections. Avoid systems that require lubrication, and use bearings, which can fail during the natural expansion and contraction cycles in areas with extreme temperature ranges.
- Select enclosures, cabling, conduits, wire management etc. adequately rated for a wide range of temperature variance and exposure to harsh conditions - which most people do. But also ensure the installation and placement of BOS fully takes advantage of the higher spec products: installed right with easy access, wherever preventative or curative maintenance is needed.
- Limit cut-and-fill operations to preserve existing grades. Precipitation and wide temperature swings destabilize disturbed soil more readily than untouched ground. Look for state-of-the-art top of pile engineering, combined with advanced racking, that adapts to challenging topography.

The right products

Resist the temptation to go with the least costly options; seek out quality components that have withstood a range of third-party testing and certification processes. Choose parts built to tolerate the maximum stresses recorded in the region. Wind tunnel checks, accelerated life-cycle testing, and cyclic corrosion studies show proof of quality.

Temperature range studies are a vital tool. Inverters, cabling, and mounts should show both lab-based and in-situ performance measures. Panel stringing components and designs should take both snow load and temperature extremes into consideration.

Select racking structures or trackers with the right corrosion resistance, from galvanizing applied to the steel components. For single axis trackers, specifications should include how well the system holds up in sustained winds in any operating position (ideally over 40 kilometers per hour) and in stow position (a base design rate over 140 kilometers

Fixed Tilt System in Snow

This photo is typical for Canadian snow accumulation. Leading edge ground clearance for fixed tilt and tracking systems in the north must take snow accumulation into account.Typically, minimum required clearances are one meter, but that is not always sufficient for heavier snow loads.

per hour works well). Trackers also need to hold up against heavy snow loads - 50 psf is ideal.

Push back against any suggested use of I-beam or C-channel foundations in place of helical piles. While cheaper than deep-set helical piles, these foundations have a history of failing in northern soils.

The right execution

EPCs who know the region can work through the winter without compromising quality. For example, the north's construction season usually coincides with the rainy season, making trenching tough, expensive, and harmful to the environment, if not planned well. Ideally, trenches should be dug up and back-filled during dry, storm-free periods. During the spring thaw, special attention must be paid to sediment and erosion control measures.

Don't overlook the working environment. In one case, the construction trailers used throughout a cold winter had no source of heat; with no way to warm up, on-site crews ended up making mistakes they likely wouldn't have in better working conditions.

Local building codes in emerging markets, where standards are still being developed, are frequently older, and ill equipped to accommodate solar. In the case of one 10-megawatt solar farm, the original pile contract was $1.6 million for materials and installation, with a six-to-eight-week installation schedule. To save money, however, the contractor put pilings in only to the minimum required depth. By the time spring rolled around, frost heave had displaced nearly every piling. Remediation costs climbed to nearly $8 million -- more than four times the cost of the original contract -- and stalled the facility's operational date for six months.

Seek out an EPC who schedules time for documentation, training, O&M preparation and QA/QC processes, long before the finish line is in sight.

The right partner

An EPC partner familiar with the region, particularly in newer markets like those in the Midwest, Northeast, or Canada, can offer designs and products suited to snow, wind, fluctuating temperatures, and uncertain topology. These regions may not yet have solar-specific building codes, leaving data open to interpretation. Don't look for the lowest short-term costs. Instead, do careful total cost analysis from start to finish. Experienced partners know that a project's true cost requires factoring in the lowest mean time between failure, and avoiding remediation costs for issues that should be addressed during installation.

Trench, MN

This open trench in Canada flooded during heavy rains and required 24 straight hours of pumping before the cables lying next to it could be placed. Flooding like this is common during spring and autumn, particularly during thaws.

Choosing the most bankable partner helps establish the best possible backbone to support a plant's 20-year lifespan. EPCs with an integrated PV solution, combining proprietary products with a turn-key installation package, can offer substantial advantages over a piecemeal approach.

David Pichard is Vice President and COO, Rob Souliere is Director of the Product Division, and Eugene Koval if Director of Engineering – EPC Division at GP JOULE. GP JOULE is a global renewable energy company with an extensive track record developing, engineering, constructing, operating, and financing commercial and utility-scale photovoltaic ground mount installations. GP JOULE provides a full range of PV products and services with complete in-house and local execution that includes civil, mechanical, and electrical expertise. Globally, GP JOULE has installed over 500 MWs of PV projects and manages 600 MWs of assets across Germany, France, Italy, Canada, and the United States.

GP JOULE | www.gp-joule.com

New benefits and installation certification

Fronius is expanding its Fronius Solutions Provider (FSP) program, a network of solar installers who are certified and trained directly from the manufacturer. Formerly known as Fronius Service Providers, the renamed loyalty and training program offers solar installers the ability to provide quality service to their customers in both installation and service. The Fronius Solutions Provider trainings now also include design and installation aspects of Fronius solutions in the residential and commercial segment. With this qualification, FSPs are able to provide their customers with high-quality solar solutions and can support them seamlessly over the lifetime of a system. The unique O&M solution of the FSP program eliminates the need for inverter exchanges, which typically causes wait times for the new unit and potential re-wiring and re-inspection. Qualified installers can service inverters directly on site, with only one truck-roll, guaranteeing maximum system uptime as well as satisfied system owners. In addition to providing better solutions to their customers, FSP certified installers receive a multitude of benefits, including higher reimbursements for warranty work, a direct phone line to Fronius technicians, regular visits from the Fronius team, continuing education, and opportunities for beta testing of upcoming products. Fronius also supports FSPs with joint marketing activities and sales trainings.

Fronius USA LLC | www.fronius.com

Solar wire management products

Advanced Cable Ties, Inc.'s NYLON 12 Cable Ties are molecularly designed to withstand the harsh rays of the sun and corrosive outdoor elements. The unique properties of Nylon 12 make it a solution for engineers designing for solar and wind power applications as well as other extreme climate environments. Nylon 12 Cable Ties resist temperature fluctuations, are chemical resistant, and insensitive to stress cracking. The smooth edges eliminate abrasion damage and won't cut into panel cables. Low water absorption and high density maintains the stability of the cable tie providing ultra-long lasting performance for solar panel systems. Advanced Cable Ties produces a complete range of sizes from 5" up to a 14" heavy duty in convenient contractor packaging of 100 per bag and 1,000 per case, made in their Gardner, MA facility.

Advanced Cable Ties, Inc.
www.advancedcableties.com

Setting the Standard

PRC-024-2 & LVRT requirements – differentiation between internal and external faults in wind and solar farms

by Augusto Morando

THE FEDERAL ENERGY REGULATORY COMMISSION (FERC) APPROVED

Reliability Standard PRC-024-2; this standard requires power plants to set their relays so that the plant remains connected during power spikes. PRC-024-2 ensures that plant owners set their generator protective relays so that generating units remain connected during defined voltage excursions, including the operation for 9 cycles (150 ms) at zero voltage, measured at POI (Point Of Interconnection). In other words, protection relays must not trip the generators within the "no trip zone" for faults happening at POI, or beyond the wind or solar plant. (Figure 1)

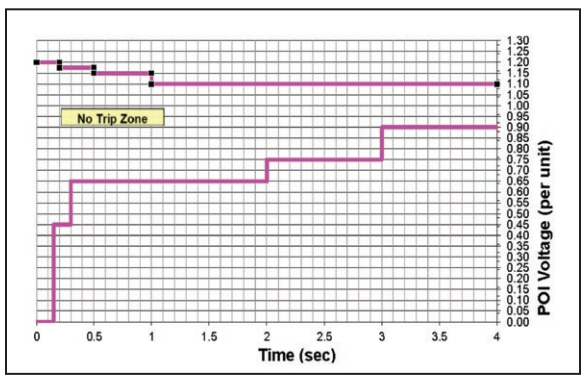


Figure 1: *Voltage Ride-Through Time Duration Curve.*

POI means the transmission side starting on the high voltage side of the substation main transformer of a wind or solar power plant substation.

In order to comply with the standard, power generation asset owners have been resetting their protection relay of their wind and solar power plants. But faults also happen inside the wind or solar farm, so there is a need for differentiation between internal and external faults, and that is what VDH/GSMI provides.

In order to study the FERC PRC-024-2 requirement effectively, a PSCAD tool was used to simulate how the voltage would behave at the mains of the Generator in a farm equipped with VDH/GSMI – first, in the presence of an External Fault, and second, in the presence of an Internal Fault. (Figure 2)

For our External Fault simulation, we will consider that voltage will drop instantaneously to zero at POI for a period of 150 ms. (Figure 3)

When an External Fault happens, there is voltage drop at the terminals of the Generators (in our PSCAD model, that drop was 83%). After 150 ms the fault disappears. Although 83% is a huge drop, it is not as robust as the voltage drop caused by the combined circuit breaker and high-speed grounding switch (VDH/GSMI) tripped during an Internal Fault.

Simulating an Internal Fault, the combined circuit breaker and high-speed grounding switch (VDH/GSMI) trips, opens the feeder circuit, clears the fault, and, in less than a cycle, makes a balanced three-phases short to ground on the collection circuit. This causes a robust voltage drop at the terminals of each generator unit. (Figure 4)

In case of an Internal Fault, in our PSCAD modeled farm, the voltage measured at the terminals of the Generators dropped more than 90%.

The difference in voltage drops between Internal and External faults is given by the impedance of the main plant power transformer. In both cases the system is in presence of zero volt; in one case said zero volt is outside the farm (External Fault), and on the other case on the collection circuit (Internal Fault).

Figures 5 and 6 show voltage drop on a per-unit basis. In Figure 5, the voltage drop is measured at the terminals of the Generator, caused by a voltage drop to zero for a period of 150 ms at POI (External Fault). In Figure 6, the voltage drop is caused by the action of VDH/GSMI after clearing the Internal Fault. Figure 7 is an overlap of figures 5 and 6, showing the difference of voltage drop at the terminals of the Generators. At near full power for the wind or solar power plant, the delta in voltage between the two fault locations is 8%, a clear signal for the Generators to stay online, or shut down.

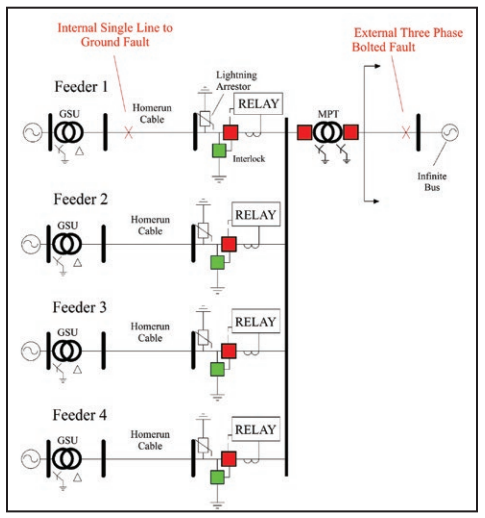


Figure 2: *Faults locations for PSCAD simulations in a Wind or Solar Power plant using VDH/GSMI.*

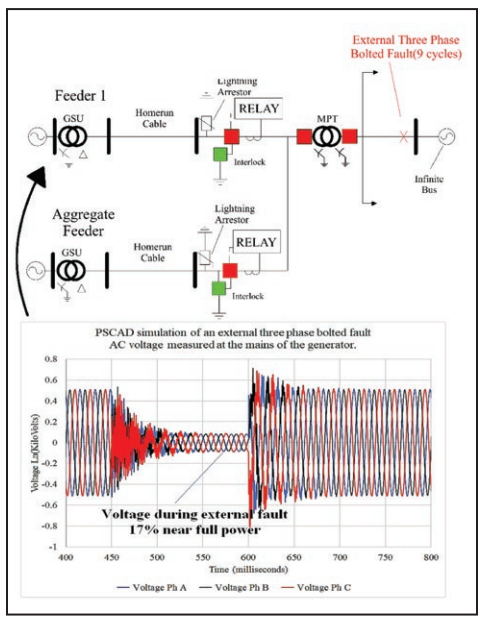


Figure 3: *External Fault location (top) and Voltage measured at the mains of the Generator (bottom).*

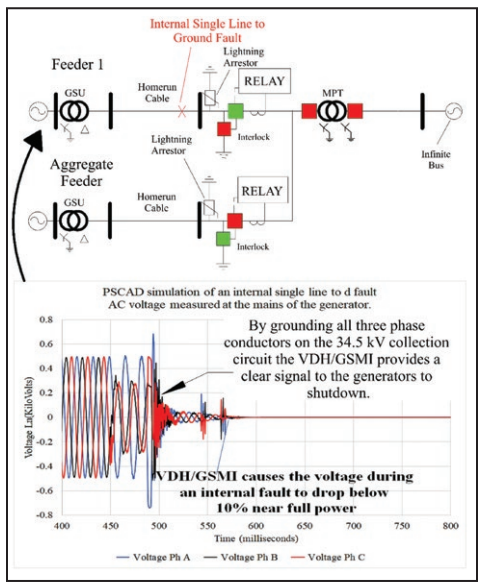


Figure 4: *Internal Fault location (top) and Voltage measured at the mains of the Generators in a farm equipped with VDH/GSMI (bottom).*

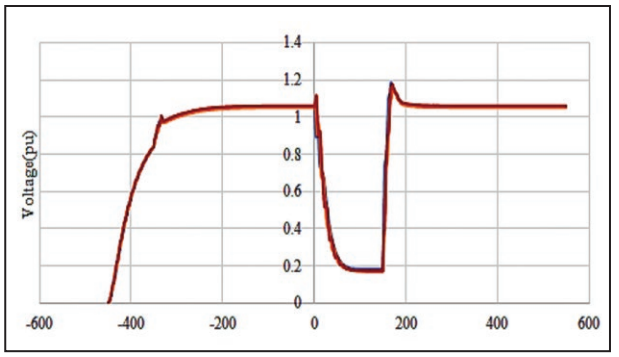


Figure 5: *Voltage drop at the generator terminals subjected to an External Fault.*

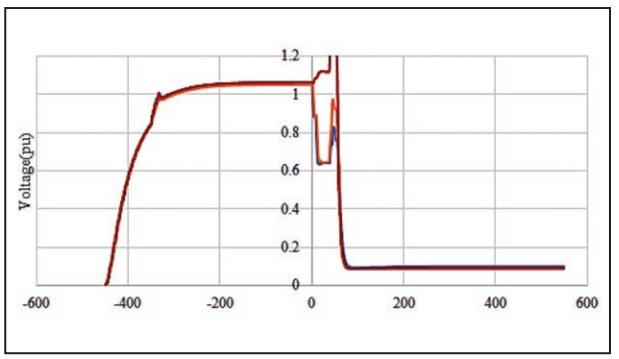


Figure 6: *Voltage drop measured at the terminals of the Generator, caused by the fast action of VDH/GSMI after clearing the fault.*

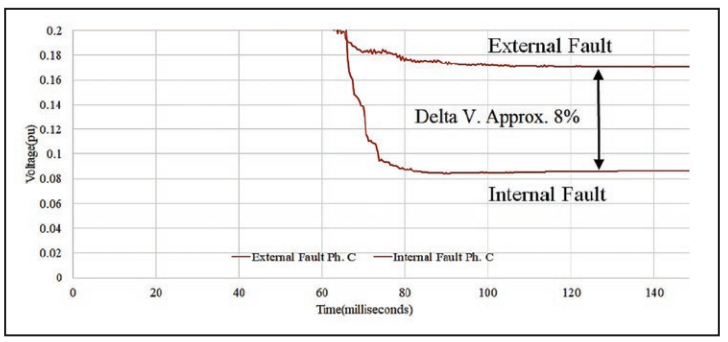


Figure 7: *Comparative of voltage drop at the generator terminals – Amplified overlap of Figure 5 and 6.*

The result of these simulations shows that this rapid impedance change, made by the combined circuit breaker and high-speed grounding switch (VDH/GSMI) as a feeder breaker, can help design engineers provide PRC-024-2's required functionality and protection systems by making it easier to differentiate between Internal and External Faults.

This special feeder breaker signals the generators that the fault is inside the plant, and shuts them down when under-voltage ride through is not necessary. This provides a valuable discriminatory function that regular MV circuit breakers do not.

The balanced three-phases short to ground, caused by VDH/GSMI, dropping voltage to zero at that point, should be treated as a shutdown signal. This signal starts at the substation, and goes through the power cables to all the generators of the collection circuit - faster and safer than any other means - and gets to all of the connected generators at the same time.

By measuring voltage at generator terminals, it's possible to identify a fault outside the plant and keep generating power, while complying with PRC-024-2.

Augusto X. Morando is a Sales Engineer at EMA Electromechanics. EMA was founded in 1952 in Buenos Aires Argentina, supplying low, medium and high voltage apparatus to major utility companies throughout Latin America. Product innovation and continuous growth in the electrical market led to EMA's expansion into the North American market.

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Based on Delta's transformer-less (TL) solar inverter series, the residential E-Series consists of the E6, E8, and E10 models, which have maximum output power levels of 6,000VA, 8,000VA, and 10,000VA. These Delta systems with built-in solar inverters integrate power conditioning capabilities for power back-up applications, and can supply power directly to the home, grid, or energy storage systems. The E-Series is compatible with both DC and AC coupled for high- and low-voltage batteries, as well as standalone applications. With the ability to support a wide variety battery backup systems and predefined energy management applications, the E-Series increases the ROI of a homeowner's entire solar system. With Bluetooth and Wi-Fi compatibility, as well as a user-friendly human machine interface (HMI), the E-Series supports cloud-based data collecting, provides transparency into system operations, and is capable of performing remote firmware upgrades, reducing the need for on-site support visits. Simple wiring creates a quick and easy installation experience, taking 15 minutes from start to finish, including system configuration. Designed in compliance with UL1741SA testing to fulfill HECO and California Rule 21 conditions, the E Series is able to effectively operate in the smart grid environment. The E series also offers a high accuracy, integrated optional revenue grade meter (RGM) that complies with ANSI standards.

Delta Group | www.deltaww.com

Thermal Energy Storage for a Low-Carbon Future

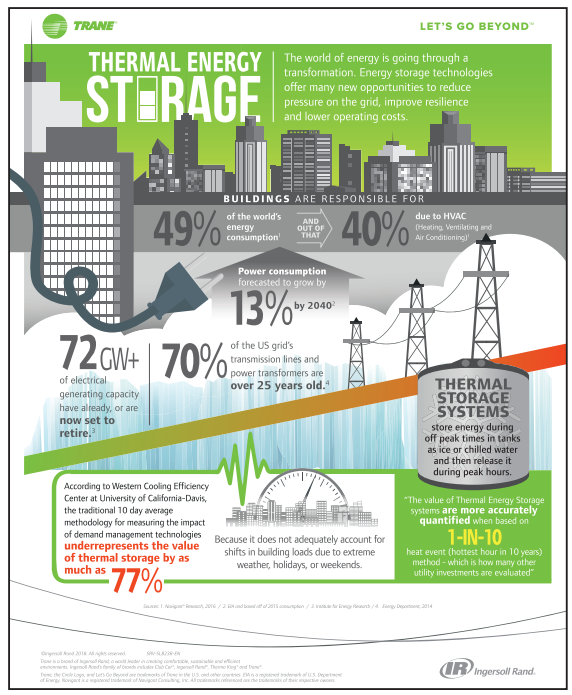
by Mark MacCracken

Buildings are responsible for 47 percent of global greenhouse gas emissions and, according to Navigant Research, the global building stock is expected to grow by 13 percent from 2014 to 2024.[1] However, their contribution to global greenhouse gas emissions can be changed. Much of those emissions come from energy used to operate buildings - this can be reduced, but how? One key element is thermal energy storage technologies.

Thermal energy storage technology allows excess energy to be stored and used at different times throughout the day, lessening the demand on and use of the grid. Thermal energy storage technology is becoming more prevalent as the industry looks for ways to increase resilience, improve sustainability, and lower operating costs. Shifting peak demand to off-peak hours helps utilities plan for peak capacity requirements, and helps the grid incorporate more renewables. At the same time, it helps electricity customers save money and reduce emissions.

Thermal energy storage systems add considerable value to utilities. The research project, Valuation of Thermal Energy Storage for Utility Grid Operators, conducted by the Western Cooling Efficiency Center at the University of California-Davis (UC Davis), found that thermal energy storage is up to 77 percent more valuable than utilities previously estimated.[2] This research demonstrated that the current method for estimating the electrical grid impact of thermal energy storage systems, based on a "10-day average baseline" and "typical meteorological year (TMY3)," underestimates the impact of disconnecting the cooling system on the electrical grid. Thermal energy storage can have a major influence on reducing electrical grid reliance and use. In fact, it's already doing more than we thought to help reduce greenhouse gas emissions.

As a distributed energy resource, thermal energy storage improves the utilization of transmission and distribution lines, and renewable generation. Therefore, it's important that we accurately estimate electrical grid impact of thermal energy storage devices, to allow for resource adequacy planning and proper financial compensation for their service. Thermal energy storage requires a holistic view of



energy use; it must take into consideration how it can mitigate peak load demand, and the ambient conditions at which peak load is evaluated. As the ambient temperature increases, the value of stored thermal energy increases.

Thermal energy storage has the most value when it's needed the most. Therefore, its benefit to the grid should be based on how it can perform in extreme-heat conditions. This value is most accurately quantified when based on an American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) 1-in-10 heat event approach (hottest hour in 10 years), and when accounting for the dynamic nature of building load.

The ASHRAE approach is often used for traditional utility infrastructure, and includes more extreme weather conditions. When this approach is applied to thermal energy storage, the value increases by 28 percent compared with other approaches.[2] The prevalent "10-day average baseline" approach underpredicts the value of thermal energy storage up to 77 percent, by excluding demand response events, weekend, and holiday heat events.[2] When weekends are excluded, "temperature drift" and the significant higher thermal loads, required to offset on Mondays following a hot weekend, are not evaluated. To properly quantify the value of thermal energy storage, the value should be based on the load that would have otherwise been needed to provide cooling during extreme-heat conditions. The UC Davis findings reinforce the benefits of thermal energy storage to offset thermal load, and show how we can more accurately estimate electrical grid impact.

Looking more closely at the buildings themselves, the HVAC system is one of the biggest energy-use culprits, making up almost 40 percent of that energy use.[1] This is due to conventional air-conditioning systems that run a chiller during peak energy usage and demand times to instantaneously cool. By using thermal energy storage systems, building owners can store energy for later use. These cooling systems run the same chiller mentioned above, but at off-peak or lower-cost times, to store energy in thermal energy storage tanks. The stored energy can then be used to cool the building during peak demand and rate periods, with or without instantaneous cooling from the chiller. These systems help optimize peak load management, and can boost renewable resource use by as much as 50 percent.[3] In doing so, grid dependency is reduced, lowering the utility bill.

Even though buildings are large contributors to global greenhouse gas emissions, there is something we can do. Using thermal energy storage systems not only brings those emissions down, but can also save money. It's a win-win. With a better understanding of energy storage benefits, building owners can optimize sustainable building designs and respond more intuitively to grid demand and cost pressures - leading to fewer overall greenhouse gas emissions and lower energy costs. With these benefits in mind, thermal energy storage will be essential for a low-carbon future.

Mark MacCracken is Vice President of the CALMAC portfolio at Trane.

Trane | trane.com

[1]Navigant Research, Global Building Stock Database. https://www.navigantresearch.com/research/global-building-stock-database. Accessed March 21, 2018.
[2]Dichter N, Modera M, Fortunato P. Valuation of Thermal Energy Storage for Utility Grid Operators. https://www.trane.com/content/dam/Trane/Commercial/global/about-us/Thermal%20Energy%20Storage%20Case%20Study.pdf. Accessed March 12, 2018.
[3]Reindl D, Van Asselt A, Nellis G, Klein S. Design and Utilization of Thermal Energy Storage to Increase the Ability of Power Systems to Support Renewable Energy Resources. 2017. https://www.techstreet.com/standards/rp-1607-design-and-utilization-of-thermal-energy-storage-to-increase-the-ability-of-power-systems-to-support-renewable-energy-resources?product_id=1982754.Accessed March 12, 2018.

Small and lightweight efficient inverter

SolarEdge's HD-Wave technology inverter, winner of the 2016 Intersolar award and 2018 Edison Award, is now available in more power classes. HD-Wave is able to synthesize a clean sine wave which leads to a dramatic reduction in the magnetics and heavy cooling elements. This small and lightweight inverter enables simplified shipping and storing, and one-person installation. The efficiency allows more energy production for an improved ROI. Features include: small and lightweight, 99% CEC weighted efficiency, up to 155% DC/AC oversizing allowed, long strings (up to 6,000W per string), and optional integrated revenue grade data, ANSI C12.20 (0.5% accuracy).

SolarEdge | www.solaredge.com

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Factory-direct, Field-Fast™ solar racking is higher-quality, pre-assembled and costs developers less. Plus, time to install is 35% faster.

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Time to install pre-assembled, Field-Fast solar racking is 35% faster than the leading competitive brands.

OMCO Solar has strategically integrated pre-assembly throughout all Field-Fast racking components to simplify installation, cut deployment costs and ensure proper field construction on every build.

**Time Study Data Ranking*

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Amount of solar structures currently in the ground, completed with OMCO Solar factory-direct racking.

Our metric continues to rise as we move forward with expansion of OMCO's Field-Fast racking and our proprietary structures + trackers for First Solar Series 4 modules, plus other new products currently in development.

1 Source Partner

As a one-source, OEM partner with a nationwide manufacturing footprint, OMCO Solar optimizes logistics costs for solar developers and notably shrinks project lead time.

By crafting our Field-Fast racking product from start to finish, OMCO Solar saves developers' money without compromising on quality. We craft our racks from tip-to-tail, even offering OMCO-certified, turnkey installation.

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Our Field-Fast racks were developed at the nexus of experience and innovation, through 60 years of custom roll-forming, 10 years of utility-scale solar manufacturing, and 8 GW of solar projects worldwide.

With four, OMCO-owned manufacturing facilities across the U.S., we optimize delivery to project sites through strategic location targeting and ultramodern, high-velocity manufacturing processes.

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Batteries

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

SEE AD ON PAGE 29

Narada

Product: VRLA Batteries

Description: Narada REXC lead carbon high cycle life batteries. Specifically designed for (PSoC) applications with fast recharge and capable of 3000 cycles at 80% DoD.

Chemistry: Lead-acid

Capacity (Ah @ 20hr rate): 2000Ah

Voltage: 2VDC

Energy: 1.1kWh

Peak Power: 2.1kW

Cycle life: 3000 cycles @ 80% DoD

Operating temperature range: -4°F to 122°F (-20°C to 50°C)

Dimensions: 9.13" x 17.9" x 20"

Weight: 253lbs (115kg)

Warranty: 10-year warranty

Certifications: UL, CE

Key Features:

- High PSoC cycle performance;
- Robust design to ensure superb safety and reliability;
- Available capacities from 200 to 2000Ah up to 1000V configurations;
- Full containerized grid storage systems to off-grid cabinet/rack solutions.

www.mpinarada.com

SEE AD ON PAGE 46

U.S. Battery

Product: US RE L-16XC2

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

Chemistry: Flooded lead acid

Capacity (Ah @ 20hr rate): 401Ah

Voltage: 6V

Energy: 2.41kWh

Cycle life: 675 Cycles at 80% DoD, and 1150 Cycles at 50% DoD

Operating temperature range: 0°F to 120°F (-17°C to 49°C)

Dimensions: 11.875" x 7.125" x 16.75"

Weight: 114lbs (51.7kg)

Warranty: 5-year warranty

Key Features:

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

www.usbattery.com

Maxdura Battery

Product: DCS12-50

Description: The DCS series is newly developed deep cycle battery for solar systems. Its key benefits include high specific power, long cycle life, high large current discharge performance, and fast charging performance. It’s a solution for household energy storage, solar and wind energy, emergency, and other cycling systems. Larger capacity can be obtained when connected in parallel.

Chemistry: Lead-acid

Capacity: 50Ah @ 20hr rate

Voltage: 12V

Energy: 600kWh

Cycle life: 3000+

Dimensions: 13.8" x 6.54" x 6.85"

Weight: 56.2lbs (25.5kg)

Warranty: 3-year warranty

www.maxdurabattery.com

Concorde Battery Corporation

Product: VRLA-AGM Batteries

Description: Concorde Battery Corporation has been manufacturing SunXtender deep cycle AGM batteries for the solar, photovoltaic, and renewable energy industry since 1987.

Chemistry: Lead-acid

Capacity: 1215Ah @ 24hr rate

Voltage: 2V

Energy: 2.4kWh

Peak power: >1.6kW

Cycle life: 1000 cycles @ 50% DoD

Operating temperature range: -40° to 160°F (-40°C to 71°C)

Dimensions: 11.64" x 6.95" x 15.73"

Weight: 124lbs (56.2kg)

Certifications: UL 1989 (File Number MH-17983)

www.sunxtender.com

GS Battery

Product: SLR Series

Description: The GS Battery SLR Series batteries are designed for high-cycle applications using advanced nano-carbon technology.

Chemistry: Advanced lead-acid

Capacity (Ah @ 10hr rate): 50Ah to 1000Ah, depending on model

Voltage: 2V to 12V, depending on model

Energy: 48kWh @48VDC

Cycle life: 5000 cycles @ 70% DoD; 5500 cycles @ 50% DoD

Operating temperature range: 5°F to 113°F (-15°C to 45°C)

Dimensions: 11.3" x 6.5" x 19.41"

Weight: 147lbs (67kg)

Warranty: 10-year warranty

Certifications: UL

www.gsbattery.com

Storage Battery Systems, LCC

Product: Renewable Energy Storage Cell SBS-6PzS967

Description: Designed and developed with precision in mind, these bolt-on renewable energy cells provide high charge acceptance and long and durable service life. The design and use of high-quality raw materials guarantees the reliability and efficiency of this energy solution.

Chemistry: Lead-acid

Voltage: 2V

Cycle Life: 3250 cycles at 50% DoD

Dimensions: 7.80" x 4.69" x 28.31"

Weight: 114lbs (51.7kg)

Warranty: 120 months: 5-year full warranty with balance prorated based on prices at the time of replacement

www.sbsbattery.com/solar

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Dynapower

Product: BTM-250kW Fully Integrated Energy Storage System

Description: The BTM-250 is a fully integrated 250KW/500KWH behind-the-meter energy storage system. The BTM-250 couples Dynapower's UL 1741 SA listed MPS-250 smart inverter with Samsung SDI's E2 batteries. The system is available in 2, 4, and 6 hour configurations and can be used in both grid-tied and microgrid applications. Multiple units can be paralleled together.

Chemistry: Lithium-ion

Voltage: 480 VAC 3 Phase, +10%, -12%

Energy: 550kWh

Peak power: 250kW

Operating temperature range: -13°F to 112°F (-25°C to 44°C)

Dimensions: 136.25" x 72" x 108.50"

Weight: 17,000lbs (7711kg)

Warranty: 5-year standard warranty, extendable

Certifications: Inverter: IEEE 1547, UL 1741 SA Listing Batteries: UL 1973 (Tray), UL 1623

Key Features:

- Dynamic transfer with seamless transition from grid-tied to islanded mode;
- Redundant HVAC cooling system;
- Optional direct release fire detection and suppression system;
- Black Start;
- All AC and DC switchgear.

www.dynapower.com

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Panasonic

Product: Harbor Flex Expandible Smart Battery

Description: The Harbor Flex smart battery offers homeowners a high-performance energy storage system at an attractive installed price per kilowatt-hour. Featuring Panasonic DCB-105 lithium ion battery modules, the Harbor Flex can be expanded to make a Harbor Plus smart battery with even more energy and power capacity, making it simple for system owners to accommodate their changing energy needs. This scalable and flexible smart battery unit is designed for solar-plus-storage applications including self-supply, rate arbitrage, and clean backup power.

Chemistry: Lithium-ion

Voltage: 360V to 420V

Energy: 10.6kWh

Peak power: 4.5kW to 10kW

Operating temperature range: 32° to 122°F (0°C to 50°C)

Dimensions: 68" x 22.5" x 9.5"

Weight: 335lbs (152kg)

Warranty: 10-year warranty

Certifications: UL 9540, UL 1741, UL 1973, UL 1642

Key Features:

- Powered by Panasonic Li-ion Battery Technology;
- 136% of the continuous power, and 114% of the usable capacity of other DC-coupled batteries;
- 10.6kWh usable energy, expandable to 15.9kWh;
- 4.5kW continuous power, expandable to 6.7kW;
- Fast installation time via Rapid-Rack design; 1-2 technicians can install Harbor in under an hour.

www.business.panasonic.com

AIMS Power

Product: 6 Volt, 225 Amp, AGM Deep Cycle Battery

Description: Packed with 225 amps, this battery is made with high quality components at an affordable price. The AIMS Power battery is maintenance free and can be installed in any position. The thick lead plates provides power throughout the discharge of the battery and provide high resistance to vibration.

Chemistry: AGM

Capacity (Ah @ 20hr rate): 225Ah

Voltage: 6V

Cycle life: 1400 cycles @ 30% DoD

Dimensions: 13" x 6.73" x 8.74"

Weight: 74lbs (33.5kg)

Warranty: 5-year warranty

www.aimscorp.net

Battery Systems, Inc.

Product: Centennial CB6-400 AGM Deep Cycle

Description: L16 group size, large valve regulated lead-acid AGM deep cycle battery

Chemistry: Lead-acid AGM (Absorbed glass matt)

Capacity (Ah @ 20hr rate): 416Ah

Voltage: 6V, nominal voltage

Energy: 2.49kWh

Peak power: 24kW

Cycle life: 500 cycles @ 80% DoD, 1200 cycles @ 50% DoD, 3000 cycles @ 20% DoD

Operating temperature range: 23°F to 77°F (-5°C to 25°C)

Dimensions: 11.61" x 7" x 15.91"

Weight: 126.76lbs (57.5kg)

Warranty: 7-year limited solar/RE warranty (2-years free + 5-years pro-rated)

www.batterysystems.net

Discover Battery

Product: 42-48-6650 / 12-48-6650

Description: Discover Battery's Advanced Energy System (AES) LiFePO4 batteries offer a low cost of energy storage per kWh. Deep cycling, fast recharge, >95% round-trip efficiency, 1C continuous charge/discharge, 5C peak current, and a 10-year warranty combined with zero maintenance provide customers with bankable performance and total cost of ownership savings.

Chemistry: LiFePO4/LFP

Voltage: 48V nominal

Energy: 6.65kWh

Charge temperature: 32°F to 113°F (0°C to 45°C)

Discharge temperature: -4°F to 122°F (-20°C to 50°C)

Dimensions: 18.5" x 13.7" x 14.7"

Warranty: 10-year warranty

Certifications: IEC 62133, UL 1973, UN 38.3

www.discoveraes.com

LG Chem

Product: RESU10h Home Battery

Description: The RESU10h, compatible with SolarEdge7600, is LG Chem's first home battery in North America. RESU10h can be used for grid-tied backup and TOU applications.

Chemistry: Lithium-ion

Voltage: 400V

Energy: 9.8kWh

Peak power: 5kW

Operating temperature range: 14°F to 113°F (-10°C to 45°C)

Dimensions: 29.3" x 35.7" x 8.1"

Weight: 214lbs (97kg)

Warranty: 10-year warranty

Certifications: Cell UL1642 Battery Pack UL1973 / CE / RCM / TUV (IEC 62619) Emissions FCC Hazardous Materials Classification Class 9 Transportation UN38.3 (UNDOT) Ingress Rating IP55

www.lgesspartner.com

SimpliPhi Power

Product: AccESS

Description: SimpliPhi's plug-and-play, all-in-one AccESS streamlines equipment and costs by integrating power storage into new/existing on/off grid solar installations. AccESS combines SimpliPhi's cobalt-free, non-toxic LFP batteries with inverter charge controllers, power electronics, and system management in a NEMA 3R outdoor-rated box. Available in 10.5 or 6.8kWh, AccESS can scale up and be safely installed indoors or outside in with no risk of thermal runaway or fire.

Chemistry: Lithium-ion (LFP)

Capacity (Ah @ 20hr rate): PHI 10.5kWh - 207Ah 48VDC, OR PHI 7.0kWh 138Ah 48VDC

Voltage: 195 to 550VDC (PV array, operating)

Energy: Available in 10.5kWh or 7.0kWh; can scale for more capacity

Peak power: 6.8/8.5 kW (10.5 kWh Model)

Cycle life: 10,000 @ 80% DoD

Operating temperature range: -4°F to 122°F (-20°C to 50°C)

Dimensions: 16" x 28" x 72"

Weight: 10.2kWh - 701.31lbs (318.1kg); 6.8kWh - 625.8lbs (283.8kg)

Warranty: 10-year warranty

Certifications: ETL Certified UL 1973 Standard, CE listed, UN/DOT and RoHS compliant components

www.simpliphipower.com

Canadian Energy

Product: MIXTECH

Description: MIXTECH prevents acid build up from killing batteries and can extend their life by up to 4x. It's 100% maintenance-free, provides sustained performance, and offers low total cost of ownership.

Chemistry: Lead-acid

Capacity (Ah @ 20hr rate): 115Ah

Voltage: 12V

Dimensions: 13" x 6.8" x 9.5"

Warranty: 36-month warranty

www.cdnrg.com

Hoppecke Batteries, Inc.

Product: Batteries

Description: Reliable German-designed, valve regulated lead-acid batteries for high cycling renewable applications. Systems range from off-grid microgrids to solar PV on-grid smoothing.

Chemistry: Lead-acid

Capacity (Ah @ 20hr rate): 350Ah

Voltage: 6V

Cycle life: 3,000 at 50% DoD and 8,500 at 20% DoD

Dimensions: 15" x 8" x 15"

Weight: 161lbs (73kg)

Warranty: 10-year prorated warranty

Certifications: DIN 40742, IEC 60896-21/22

www.hoppecke.com/en/

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MK Battery

Product: Deka Solar M100-33 Maintenance Saver

Description: Deka Solar Maintenance Saver High-Capacity Flooded-Batteries are available as a single, 3, or 6-cell configuration. They are designed to offer reliable, low maintenance power for renewable energy applications where frequent deep cycles are required and minimum maintenance is desirable. Design variations can be based on specific application needs.

Chemistry: Lead-acid

Capacity (Ah @ 20hr rate): 1896Ah

Voltage: 2V cells (optional 3 cell - 6V and 6 cell - 12V)

Cycle Life: 3400 cycles @ 50% DoD

Operating temperature range: -22°F to 122°F (-30°C to 50°C)

Dimensions: 12.81" x 6.56" x 31.3"

Weight: 275lbs (124.7kg)

Key Features:

- High capacity flat plate cells;
- Long life: 12 to 14 years in cyclic service application;
- Extended watering interval of up to six months due to the large reservoir for electrolyte;
- Thermally sealed cover to container with custom design modules;
- Robust, long-lasting epoxy coated steel trays.

www.mkbattery.com

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Rolls Battery Engineering

Product: Rolls 2 YS 62P

Description: Offering double the delivered Amp-Hour capacity of the Rolls 2 YS 31P, the new 2 Volt 2 YS 62P model offers 4860 AH in a single dual-container case design, offering significant storage capacity for large-scale off-grid and grid-tied applications.

Chemistry: Flooded lead-acid

Capacity (Ah @ 20hr rate): 4860Ah

Voltage: 2V

Energy: 9.72kWh

Cycle life: 3200 @ 50% DoD; 5000 @ 20% DoD

Operating temperature range: -4°F to 110°F (-20°C to 43.33°C)

Dimensions: 27 3/8" x 9" x 31 5/8"

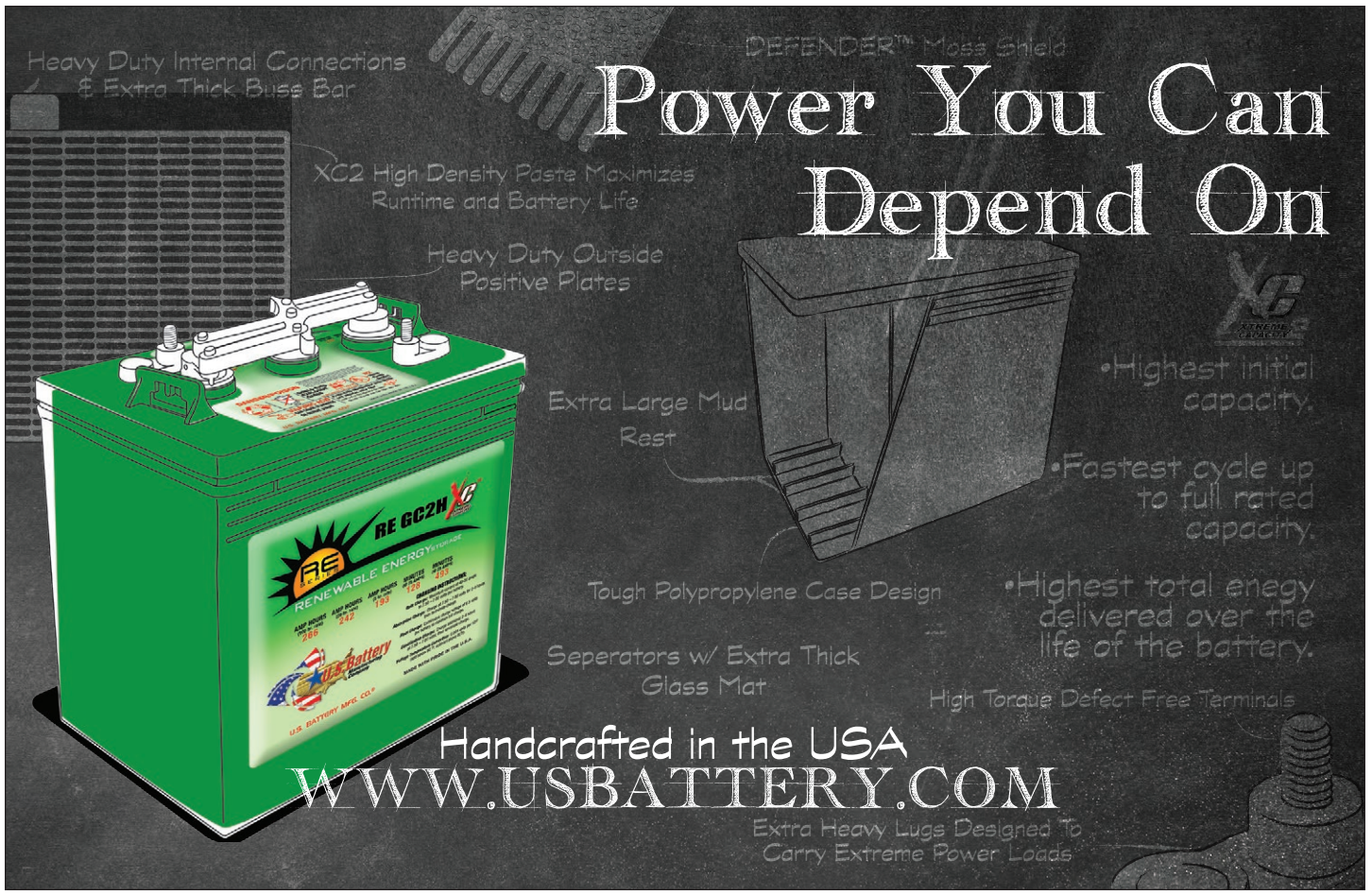
Weight: 570lbs (259kg)

Warranty: 10-year manufacturer warranty, covering 3-year full replacement and 7-year pro-rated warranty

Key Features:

- Durable, dual-container construction and industrial grade robotically welded cell formation;
- Included Rolls hydrogen R-cap reduces watering frequency, safeguarding against cell damage;
- Double the AH capacity of the popular 2 YS 31P model in a space saving single case design, reducing footprint for large-scale applications.

www.rollsbattery.com



EnerSys

Product: PowerSafe SBS XL

Description: PowerSafe SBS XL batteries are front-terminal batteries for high-temperature stable grid float applications. A Thin Plate Pure Lead (TPPL) battery, the PowerSafe SBS XL battery has a 10-year design life at a continuous 95°F (35°C). Due to its Valve Regulated Lead Acid (VRLA) design, it does not require a separate battery room and can be mounted in any orientation except inverted.

Chemistry: Lead-acid

Capacity (10-hour rate, 1.75Vpc @68°F): Dependent on model; 80 to 170

Voltage: 12V

Operating temperature range: -40°F to 149°F (-40°C to 65°C)

Dimensions: Dependent on model; 16.4" - 22.1" x 4.1" - 4.9" x 10.1" - 12.4"

Weight: Dependent on model; 58.8lbs to 127.8 lbs (26.7kg to 58kg)

Certifications: IEC 60896-21 and -22; ISO 9001:2008, ISO 14001:2004 and OHSAS 18001 certified

www.enersys.com

BAE Batteries USA

Product: Energy Storage Stationary Battery

Description: Low carbon, deep cycling, and high reliability advanced lead-acid batteries for demand response or frequency regulation for renewable and energy storage applications.

Chemistry: Lead-acid

Capacity (Ah @ 20hr rate): 67Ah to >4000Ah

Voltage: 2VDC to >1000VDC

Energy: Depends upon application

Peak power: Depends upon application

Cycle life: 2000 to >5000 depending upon discharge parameters

Operating temperature range: -4°F to 113°F (-20°C to 45°C)

Warranty: 5-year full warranty, 10-year warranty on post/post-seal

Certifications: ISO, IEEE 535 (Europe), IEC Testing Requirements

www.baebatteriesusa.com

Iron Edison Battery Company

Product: Lithium Iron Phosphate Battery

Description: The Iron Edison Lithium Iron Battery brings new technology to energy storage projects, and is a plug-n-play replacement to lead acid battery options. Fully compatible with inverters and charge controllers, Iron Edison's Lithium Iron Batteries offer a safe, simple, and dependable energy storage solution for off-grid and grid tied battery backup applications.

Chemistry: Lithium-ion (Lithium Iron Phosphate)

Capacity (Ah @ 20hr rate): 400Ah to 5,500+Ah

Voltage: 48V and High Voltage Custom Configurations

Energy: 18.5kWh to 286kWh

Peak power: 9.75kW to 104kW

Cycle life: 5,000 cycles @ 50% DoD, 2,000 cycles @ 80% DoD

Operating temperature range: 32°F to 113°F (0°C to 45°C)

Dimensions: Varies

Weight: 550lbs to 9,000lbs (272kg to 4082kg)

Warranty: 10-year warranty

www.ironedison.com

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Crown Battery Manufacturing Company

Product: 2CRP3690 Power Module

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

Chemistry: Lead-acid

Capacity (Ah @ 20hr rate): 2550 Ah

Voltage: 2V

Energy: 7.1586kWh (100hr), 4.9470kWh (20hr)

Cycle life: 1500 cycles @ 100% DoD; 4300 cycles @ 30% DoD

Operating temperature range: -40°F to 120°F (-40°C to 49°C)

Dimensions: 12.81" x 6.56" x 33.38"

Weight: 313lbs (141.9kg)

Warranty: 5-year full replacement limited warranty

Certifications: Conforms with BCI and IEC Test Standards

Key Features:

- Rugged internal construction with heavy-duty plate, cast-on strap, and terminal-post components, which deliver strong performance and durability;
- Posi-Wrap Plate Protection ensures active material retention, protecting from internal short-circuits to deliver proven ROI for customers;
- Low-maintenance design features reduced frequency of preventative maintenance to lower service costs and total cost of ownership;
- High-capacity 2-Volt Power Module design includes fixed handles and the flexibility to be installed with or without battery racks;
- Lead-acid batteries are 99% recyclable.

www.crownbattery.com

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Trojan Battery Co., LLC

Product: Trojan SIND 02 2450 with Smart Carbon

Description: Smart Carbon is a standard feature in Trojan's Industrial flooded battery line to address the impact of Partial State of Charge (PSOC) on batteries in renewable energy (RE), inverter backup, and telecom applications. Trojan's Smart Carbon proprietary formula provides improved battery charge acceptance and faster recharge in PSOC applications.

Chemistry: Advanced lead-acid - flooded technology

Capacity (Ah @ 20hr rate): 1882Ah

Voltage: 2V

Energy: 4.90kWh

Cycle life: 3600 Cycles at 50% DoD

Operating temperature range: -4°F to 122°F (-20°C to 50°C). At temperatures below 32°F (0°C) maintain a state of charge greater than 60%

Dimensions: 17.33" x 10.22" x 24.01"

Weight: 278lbs (125kg)

Warranty: 10-year warranty

Certifications: IEC 61427, ISO 9001:2015

Key Features:

- Designed to achieve 17 years in renewable energy system;
- High amp-hour capacity batteries are suitable for use in large off-grid photovoltaic (PV) systems, off-grid hybrid PV systems, grid-tied PV systems with battery backup, smart grid peak shifting systems, and a variety of other applications;
- Features Smart Carbon, Trojan's proprietary formula which addresses the issue of partial state of charge (PSOC);
- The SIND family includes high capacity 2V, 4V, and 6V products ranging from 610 to 2,405Ah @ C100 hr.;
- Housed in a dual container construction for enhanced battery protection.

www.trojanbattery.com

Lithium Power, Inc.

Product: ESS-500-48

Description: ESS-500-48 is a rechargeable NMC backup battery pack to suit for Telecom UPS applications. ESS-500-48 consists of the battery gas gauge controller and protection IC (BM3398). BM3398 is used to monitor the current, individual cell voltages, capacity, temperature, and other critical battery parameters, and generates control signals required by the Battery Management System (BMS). Various hardware and software protection features are included to ensure the battery safety.

Chemistry: Lithium-ion

Capacity (Ah @ 20hr rate): 44Ah

Voltage: 48V

Energy: 2.112kWh

Cycle life: over 300 with retention capacity over 60%

Dimensions: 19" x 20" x 3.5"

Weight: <55lbs (<25kg)

Warranty: 5-year warranty

www.lithiumpowerinc.com

Sharp

Product: Sharp SmartStorage

Description: The SmartStorage system is an "intelligent" storage system. As a building's demand starts to spike, the intelligent, predictive controllers trigger a rapid power discharge to offset the spike. Sharp SmartStorage installations are available with a 10-Year Asset Management Agreement which includes a 10-Year Performance Guarantee.

Chemistry: Lithium-ion

Voltage: 480V, 3-phase (208V option)

Energy: 80kWh or 40kWh

Peak power: 30kW

Operating temperature range: 50°F to 105°F ambient (10°C to 40.5°C)

Dimensions: 42" x 28" x 59"

Weight: 1600lbs (726kg)

Warranty: 10-year service warranty

Certifications: UL1741, IEEE1547

www.sharpsmartstorage.com

NantEnergy (formerly Fluidic Energy)

Product: Energy Storage Solutions

Description: NantEnergy's proprietary Zinc-Air battery technology enables low cost solutions for long and short duration applications. The company's energy storage solution has been deployed at over 3000 sites worldwide, including at over 100 remote community micro-grids.

Chemistry: Zinc-air

Capacity (Ah @ 20hr rate): 525Ah

Voltage: ~1.1 to 1.2V

Energy: 575kWh

Peak power: 75kW

Cycle life: Based on discharge hours, life is not dependent on number of cycles

Operating temperature range: 32°F to 122°F (0°C to 50°C)

Dimensions: 18" x 14.5" x 5"

Weight: <40.7lbs (<18.5kg)

Warranty: 2-year standard warranty with 5- and 10-year extension options available

www.fluidicenergy.com

Princeton Power Systems

Product: PEMS250-500

Description: Outdoor-rated all-weather AC battery system for off-grid and on-grid applications.

Chemistry: Lithium-ion

Capacity (Ah @ 20hr rate): 752Ah

Voltage: 480VAC

Energy: 500kWh

Peak power: 250kW

Cycle life: >4000 over 10 years

Operating temperature range: -4°F to 122°F (-20°C to 50°C)

Dimensions: 12.1' x 4.9' x 8.3'

Weight: 15,100lbs (6850kg)

Warranty: Under negotiation at time of print

Certifications: UL1642, UL1973RU, UN38.3, UL 741, IEEE 1547

www.princetonpower.com

Nilar, Inc.

Product: Nilar EC Series

Description: Nilar offers a nickel metal hydride (NiMH) bi-polar design which provides safe, reliable, and cost efficient energy storage. The battery's compact high voltage design is made for industrial use.

Chemistry: NiMH

Capacity (Ah @ 20hr rate): 10Ah

Voltage: 144VDC

Energy: 1.44kWh

Cycle life: 2000

Operating temperature range: -4°F to 122°F (-20°C to 50°C)

Dimensions: 13.26" x 12" x 5"

Weight: 75lbs (34kg)

Certifications: IEC 62485-2, IEC 62675

www.nilar.com

Valence Technology, Inc.

Product: Valence U1-12RJ

Description: The U1-12RJ is a 12V 40Ah module best suited for single-module 12V applications. The U1-12RJ has the equivalent run time of a large 55Ah lead acid battery while being housed in the smaller Group U1 BCI size.

Chemistry: Lithium-ion

Capacity: 40Ah

Voltage: 12.8V

Energy: 512Wh

Cycle life: >4000 cycles @ 80% DoD

Operating temperature range: -4°F to 122°F (-20°C to 50°C)

Dimensions: 7.75" x 5.15" x 7.20"

Weight: 14.33lbs (6.5kg)

Warranty: 5-year warranty

Certifications: UL1642 (cells), UN 38.3, UL2054, IEC 62133

www.valence.com

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Fullriver Battery

Product: DC400-6

Description: Fullriver DC Series Deep-Cycle AGM batteries are specifically built for cyclic use in demanding solar applications. The thick plate design and AGM construction combine for a robust battery delivering optimal performance in both fair weather and extreme climate conditions, all in a spill-proof, non-hazardous, and maintenance-free package.

Chemistry: Lead-acid suspension (Absorbed glass mat)

Capacity (Ah @ 20hr rate): 415Ah

Voltage: 6V

Energy: 2.4kWh

Cycle life: 1700 cycles to 50% DoD

Operating temperature range: 5°F to 104°F (-15°C to 40°C) recommended, -40°F to 159.8°F (-40°C to 71°C) maximum

Dimensions: 7.0" x 11.6" x 16.7"

Weight: 123lbs (55.8kg)

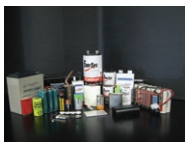
Warranty: 7-year warranty in approved solar applications

Certifications: ISO9001, ISO14001, ISO18001, UL, CE, TUV

Key Features:

- Rugged construction inside and out;
- Over partition welded straps;
- Heavy-duty, pure lead plates;
- Sealed and maintenance-free, with little or no gassing.

www.fullriverbattery.com



Rose Electronics

Product: Battery Pack Assemblies

Description: All major chemistries

Chemistry: Li-Ion, LiFeP04

Capacity (Ah @ 20hr rate): 2Ah-3.4Ah

Voltage: 3.2-3.7V per cell

Energy: 300+Wh/l

Cycle life: 300-2000

Operating temperature range: 32°F to 113°F (0°C to 45°C)

Weight: 48g to 82g per cell

Warranty: 1-year warranty

Certifications: ISO 9001, UL 1642, IEC 62133

www.rosebatteries.com

K2 Energy Solutions

Product: K2 Pro Series Battery

Description: The K2 Pro Series is safe, clean, and reliable with long cycle life. Lightweight, K2 batteries need less replacement and lose only 2% charged capacity per month.

Chemistry: Lithium-ion

Capacity (Ah @ 20hr rate): 111Ah

Voltage: 12.8V

Energy: 1420.8kWh

Peak power: 12kW for 3 seconds

Cycle life: Up to 3000+

Operating temperature range: -4°F to 149°F (-20°C to 65°C)

Dimensions: 12.1" x 6.6" x 8.3"

Weight: 30lbs (13.6kg)

Warranty: 90-day workmanship and quality warranty under normal use

Certifications: UN38.3 Test Compliant

www.k2battery.com

Plan B Energy Storage

Product: Energy Storage

Description: Plan B Energy Storage provides energy solutions for marine, grid-tied, and heavy industrial applications.

Chemistry: Lithium-ion

Capacity (Ah @ 20hr rate): 75Ah

Voltage: 77 to 1000VDC

Energy: 6.7kWh

Peak Power: 6C continuous

Cycle life: 15000 cycles @ 80% DoD

Operating temperature range: -40°F to 140°F (-40°C to 60°C)

Dimensions: 22.8" x 14" x 12.5"

Weight: 198lbs (90kg)

Certifications: DNV GL Type Approval, SO 9001:2015 Certification

www.pbes.com

BMZ

Product: ESS 9.0

Description: A modular, lithium-ion based energy storage system, which stores the surplus of collected solar energy for later use. Energy can either be directed into the storage system or be fed into the public grid via an inverter.

Chemistry: Lithium-ion NCA

Capacity (Ah @ 20hr rate): 6.265A for 20 hours, total usable capacity 125.3Ah

Voltage: 54V Nominal

Energy: 8.5kWh Nominal, 6.8kWh Usable

Peak Power: 18kW

Cycle life: 5000 cycles

Operating temperature range: 35°F to 113°F (1°C to 45°C)

Dimensions: 19" x 25" x 17"

Weight: 214lbs (97kg)

Warranty: 10-year, 5000 cycle warranty

Certifications: CE, UN 38.3, IP21

www.bmz-group.com

Darfon America Corp.

Product: 5kWh Lithium Battery

Description: Darfon's 5kWh lithium battery is designed to replace lead-acid batteries in residential storage applications. The lithium-ion cells are lightweight and have a long cycle life. The battery integrates communication and has a thin profile for wall-mounting. It has the flexibility to be applied in grid-tied, off-grid, peak-shaving, or time-of-use situations.

Chemistry: Lithium-ion

Capacity (Ah @ 20hr rate): 95.4Ah

Voltage: 51.1V

Energy: 4.88kWh

Cycle life: 2500 cycles

Operating temperature range: 14°F to 113°F (-10°C to 45°C)

Dimensions: 24" x 28" x 6.6"

Weight: 99.6lbs (45.2kg)

Warranty: 5-year warranty

Certifications: UL1642, UN38.3, CE

www.darfonsolar.com

ESS Inc.

Product: Energy Warehouse

Description: Utilizing earth-abundant iron, salt, and water for its electrolyte, and simple materials for battery components, the Energy Warehouse (EW) from ESS Inc. is a durable, environmentally safe, long-duration storage solution. The EW provides levelized cost of storage (LCOS) and deep charge and discharge cycles.

Chemistry: Flow

Voltage: 600V to 850V

Energy: 400kWh

Peak power: 100kW (DC)

Cycle life: >20,000

Operating temperature range: 23°F to 122°F (-5°C to 50°C)

Dimensions: 320 sq. ft.

Weight: 34,612lbs (15,700kg) dry, 79,807lbs (36,200kg) wet

Warranty: Comprehensive 20-year warranty with continuous extended service agreement

Certifications: NRTL, UL, Intertek Field Labeling, IP54, IE60529

www.essinc.com

Enphase Energy

Product: Enphase AC Battery

Description: The Enphase AC Battery is simple to install, safe, reliable, and provides a low lifetime energy cost for both new solar customers and retrofit customers. Installers can design the right system size to meet the needs of the homeowner.

Chemistry: Lithium iron phosphate (LFP)

Capacity (Ah @ 20hr rate): 48.5Ah

Voltage: 240 / 211 / 264VAC

Energy: 1.2kWh

Peak power: 280VA

Cycle life: 7,300

Operating temperature range: -4°F to 113°F (-20°C to 45°C)

Dimensions: 47" x 39" x 36"

Weight: 55lbs (25kg)

Warranty: >80% capacity; up to 10-year warranty or 7,300 cycles

Certifications: UL 9540, Cell safety certifications: TUV Rheinland, UL

www.enphase.com

Leoch Battery Corp.

Product: Leoch Model LFeLi-48100C

Description: Constructed using Lithium Iron Phosphate prismatic cells (safe lithium) and packaged in metal container with built-in BMS, each 48V100Ah unit is easy to install in cabinet, rack, or wall-mounted. Up to 16 modular units can be combined to create as much as 76,800kWh of stored, usable energy. Fast charging performance and low self-discharge rate.

Chemistry: Lithium-ion

Capacity (Ah @ 20hr rate): 100Ah

Voltage: 48V

Energy: 4800kWh

Cycle life: 5000+ cycles 80% DoD

Operating temperature range: -4°F to 140°F (-20°C to 65°C)

Dimensions: 17.4" x 15.55" x 8.74"

Weight: 159lbs (72kg)

Warranty: 5-year conditional warranty

Certifications: UL, CE

www.leoch.us

SCHMID

Product: EverFlow Storage Container

Description: Power and capacity of the EverFlow Storage Container are easily scalable, making the intrinsically safe VRFB attractive for various applications. All components and tanks are integrated in a single 20ft or 40ft container for fast and easy installation, safe operation, and controlled environmental conditions.

Chemistry: Vanadium Redox Flow

Capacity: 20ft container typically offers up to 50kW / 200kWh

Voltage: 400V/230V / 3-phase AC

Energy: Up to multiple MWh

Peak power: Up to multiple MW, usually in 25kW steps

Cycle life: Typically 10,000

Operating temperature range: -4°F to 014°F (-20°C to 40°C)

Dimensions: 20ft or 40ft containers

Warranty: 1-year warranty

www.schmid-group.com

WINDPOWER 2018

May 7th-10th, 2018
McCormick Place – Chicago, IL

Wind power continues to lift the American economy. The industry closed 2017 strong, delivering 7,017MW of new wind power capacity. That new capacity represents $11 billion in new private investment. There are now 89,077MW of wind power installed across 41 states, enough to power 26 million American homes. The wind industry is powering forward to continue growth into 2018 and beyond. WINDPOWER is where the industry comes together to plan for the future and keep this success story growing. Join other wind industry leaders at the largest wind energy event in the Western Hemisphere.

www.windpowerexpo.org

show in print

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

Carbon brushes and brush holders

Helwig Carbon is a manufacturer of carbon brushes and brush holders used on wind turbine generators. American made ISO certified. Their products are designed to provide long life and low maintenance costs.

Helwig Carbon Products, Inc.
www.helwigcarbon.com
Booth 5328

Developer & operator

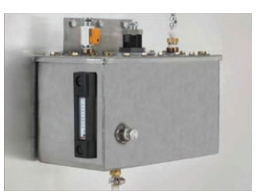
BayWa r.e. Wind, LLC is a turn-key developer and operator of renewable energy projects in North America. Headquartered in San Diego, CA, the company has been active in the U.S. since 2001. The company's business model is to develop, construct, own and operate renewable energy projects. It seeks to complete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

BayWa r.e. Wind, LLC
www.baywa-re.us
Booth 3916

Versatile and durable torque tester

SmartCheck is a newly launched small sized, versatile, and easy-to-use torque tester suitable for any workshop and service vehicle. Its compact dimensions coupled with its rotatable display and the ability to mount it horizontally or vertically, provides versatility in any location. With a splash-proof display and keypad, it can be operated through power supply or battery. SmartCheck quickly provides information on whether or not a torque wrench is within the prescribed tolerances or if it requires adjustment. The integrated visual and audible overload protection mechanism and impact resistant plastic housing ensure the durability associated with STAHLWILLE products.

STAHLWILLE
www.stahlwille-americas.com
Booth 4315



Closed-loop cooling system

Many 1.5MW wind turbines use traditional open-loop water/glycol cooling systems. Regular water evaporation in the reservoir elevates the mixture's viscosity, prohibiting cooling of the IGBT and associated critical controls, causing the wind turbine to overheat unless serviced, which, in turn, means turbine downtime and high maintenance costs. Parker's KleenVent Coolant Evaporation Inhibitor (KV-CEI) is a simple add-on to the legacy cooling system, that eliminates water evaporation in the coolant solution and stops the ingress of airborne contaminants, by enclosing the cooling loop. The KVCEI also removes the need for continuous coolant monitoring during the warm season. Traditional maintenance calls to replenish or rebalance the fluids, take the wind turbine and transformer offline, resulting in significant downtime and revenue loss. Parker's cooling system solution optimizes wind turbine uptime and revenue, reduces maintenance costs, and increases overall efficiencies.

Parker Hannifin - Energy
solutions.parker.com
Booth 4244

Tools

Dakota Riggers is a stocking distributor for Tuff Bucket products. These high-quality lifting buckets feature the innovative roll-down closure system. This closure system allows for the bucket to fully load, rated both right side up and upside down. Tuff Buckets are available in a variety of different sizes, in either heavy-duty canvas or vinyl-coated polyester material.

Dakota Riggers | www.dakotariggers.com
Booth 4838

Coating systems

Duromar has a full-line of high performance, zero VOC, color stable coating systems for the repair, resurfacing, and long-term protection of wind turbine blades, including the leading edge. Whether a blade is suffering from cracks, pits, or general wear, Duromar has a repair solution. OEMs may also apply these coatings for long-term blade protection starting at day one of operation. These products are easy to apply by hand or by spray.

Duromar | www.duromar.com
Booth 1943

Tools, safety & onsite consultation

Snap-on Industrial is a global innovator, manufacturer, and marketer of tools, equipment, safety, and productivity solutions for professional users performing critical tasks. During its more than 90 years in business, Snap-on Industrial has developed complete solutions for tool management including: torque calibration equipment; proprietary software for asset management and tool layout; lean kitting processes; custom kits for wind turbine maintenance and repair; a drop prevention program that includes engineered and tested attachment points on each tool; and a custom mobile tool container (Conex) program. In addition, Snap-on Industrial's 300+ industrial solutioneers provide onsite service, warranty, and consultation.

Snap-on Industrial
www.snapon.com/industrial
Booth 4234

Full service industrial contractor

Fagen, Inc. is a renewable energy design-build company, having constructed a variety of projects including wind power, biomass to power, conventional power, renewable fuels, and other industrial process facilities throughout the country and also internationally. Fagen, Inc. is consistently ranked among contractors and design-builders by Engineering News-Record (ENR) top 400. Utilizing their database of over 25,000 direct-hire employees, Fagen, Inc. is prepared to mobilize quickly and self-perform civil, structural, siding, insulation, piping, instrumentation, electrical, and start up services. They are fully prepared to meet industrial demand growth with a large inventory of cranes equipped specifically for the wind industry.

Fagen, Inc. | www.fageninc.com
Booth 2820

Energy and environmental services

Established in 2002, Run Energy is a full service provider to the North American wind industry. Run's 190 wind technicians have multi-platform experience and provide a wide range of services covering: scheduled and unscheduled maintenance, installation and commissioning, project QAQC, facility O&M, balance of plant, retrofits, upgrades, major component exchange, oil changes, end of warranty inspections, site management, consulting, and training. Run has experience with GE, Acciona, Suzlon, Gamesa, Vestas, Nordex, Mitsubishi, Goldwind, and Repower platforms and completes services on over 8GW of installed turbines annually.

Run Energy | www.runenergy.com
Booth 1143

Wind blade coatings products

Mankiewicz announces two new advanced coatings products that maintain turbine blade surfaces for optimal performance and efficiency. BladeRep Profile Filler 5 advantages include a short time to sand, fast pot life to drying ratio, and a wide application window allowing all-season repairs. BladeRep LEP 10 is designed to provide single-layer protection for the leading edge areas of turbine blades from damages caused by rain and particle erosion. These coatings meet the requirements of the cosmetic blade maintenance market, as well as OEM blade specifications for high quality and durable products.

Mankiewicz Coatings
www.bladerep.com
Booth 3827

Global blade services

WindCom is a global blade service company with headquarters in Houston and offices in Madrid, Spain, and Brazil. The engineering staff provides blade repair work instructions and quality assurance while the operations staff coordinates projects worldwide. With OEM materials, modern access equipment, and highly trained technicians, projects are completed safely with high quality and value. Services include inspections, leading edge protection VG installs, lightning damage, leading or trailing edge splits, structural cracks, and balancing. WindCom provides free counseling, planning for preventative maintenance, and quotations for damages.

WindCom | www.windcomservices.com
Booth 2012

Over-dimensional transportation solutions

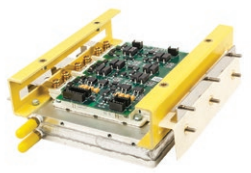
Totran Transportation Services is an independently owned and operated Canadian heavy haul specialized company operating across North America from their head offices in Calgary, Alberta, and US office in Conroe, Texas, just north of Houston. Since their beginnings in 2006, they have provided transportation and niche customer needs for the movement of project cargo for all different types of industries requiring heavy haul transport. They have worked with many industries including, oil and gas, wind and power generation, mining, and construction. Totran Transportation Services is not limited to working with these industries; but are open to hauling over-dimensional loads for other industries as well.

Totran Transportation Services
www.totran.ca
Booth 3451

Wind project services

Sargent & Lundy brings the knowledge, experience, and resources to help their clients tackle all aspects of wind energy projects: from planning to commissioning; from due diligence to complete facility design; to grid interconnection solutions. They have been providing engineering, consulting, and support services to the wind power industry for over 15 years. Their experience spans the spectrum of geographic sites, wind turbines, complex terrain, and grid interconnection requirements as well as integrating battery energy storage into renewable generating facilities. Sargent & Lundy has been serving clients including utilities, developers, financial institutions/lenders, constructors, and manufacturers worldwide for over 125 years.

Sargent & Lundy
www.sargentlundy.com
Booth 2019



Repair services for wind turbine components

Ludlum Wind provides new upgraded ESS and non-ESS rotor and line IGBT assemblies for the GE 1.5 series turbines. They have provided thousands of IGBTs to the industry since 2010, featuring short delivery times (typically 3 days) with products maintained in stock. Ludlum has over 400 employees and over 55 years of manufacturing experience. Upgraded components and Ludlum's custom AEBM board are integrated to provide improved operation at high temperatures and a long operating life. Reusable packaging with custom cut high-density foam and custom reusable steel shipping plates protect the fiberglass standoffs and the bus connections during shipment to the customer, ensuring products arrive safely every time. Ludlum's highly integrated manufacturing allows them to have control over product quality, delivery time, costs, and allows them the capability to offer long-term support.

Ludlum Wind | www.ludlumwind.com
Booth 4647

Renewable energy consultants

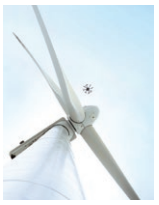
Natural Power is an independent consultancy with hands-on and in-house expertise in the entire wind farm development, construction, and operations cycle. Their operations experience, full lifecycle services, and products provide perspective for renewable energy project developers, owners, and financiers alike. They take a practical, proactive, and engaged approach to conducting technical due diligence and prioritize customer care. As plant operators of over 175 sites across four countries, they are positioned to provide insight into wind plant and turbine performance, turbine technology, as well as long-term operational planning considerations including OPEX and CAPEX.

Natural Power | www.naturalpower.com
Booth 3420

Wind turbine condition monitoring unit

B&K Vibro's DDAU3 (Diagnostic Data Acquisition Unit) is a condition monitoring platform designed with the newest technology to meet the condition monitoring challenges of today and many years to come. It will help customers with their increasing need to optimally reduce downtime and overall life-cycle costs of wind turbines by implementing enhanced condition monitoring methods, easy system integration, built-in cyber security and simple IT solutions. DDAU3 is backward compatible to existing DDAU2 devices, and has a seamless interface to the VibroSuite Condition Monitoring Software or popular data historians. DDAU3 is flexible, scalable, and offers application/machine specific monitoring strategies as well as customized solutions. The DDAU3 functionality and design concept make it a solution for nearly any remote condition monitoring task.

Brüel & Kjær Vibro | www.bkvibro.com
Booth 2823



Proactive blade lifecycle management

BladeEdge is an artificial intelligence-driven software portal that transforms big data from aerial inspections into actionable intelligence which informs maintenance and repair decisions. BladeEdge was designed to help improve wind farm safety and efficiency while reducing costs. Degraded blades are inefficient, even small amounts of leading edge erosion can lead to tremendous efficiency loss. The BladeEdge software portal automatically tracks conditions over time and identifies damage and wear in early stages. BladeEdge can help users develop a blade management program, improve AEP, and take charge of proactive maintenance and repair.

BladeEdge | www.bladeedge.net
Booth 2928

High torque bolting system

Since 1970, AIMCO has been providing global assembly and critical bolting tooling solutions for the automotive, AG/off-road, electronics, aerospace, energy services, and general assembly industries. In 1999, AIMCO began manufacturing its AcraDyne line that produces a complete line of D/C Controlled Tools ranging from 1 – 12,000Nm. Coupled with AcraDyne's Controller, the HT Series tools combine high torque and performance in an electric bolting system providing accuracy, speed, and safety.

AIMCO | www.amico-global.com
Booth 1716 & 2455

High performance cabling solutions

Lapp introduces their SOHL Tower Cable System, a Turnkey Power Cable, and Drip Loop Solution. Lapp Group components have been field-proven to withstand temperature extremes, hydraulic fluids, corrosive oils, and the vibration and torsion stress often found in wind turbines, helping to deliver high performance and revenue generating wind farms. Lapp is introducing ÖLFLEX TRAY VTC, a flexible tray cable with TC-ER for easier installations. Engineered with premium PVC insulation provides greater flexibility over PVC/nylon without sacrificing cable size.

Lapp Group | www.lappusa.com
Booth 4649

Wind energy and turbine technology program

Since 2004, Iowa Lakes Community College has been preparing technicians for the wind energy industry, utilizing state-of-the-art technology and training assets to provide the realism top technicians deserve. Iowa Lakes has the nations' first AAS in Wind Energy & Turbine Technology and partnerships across the spectrum of the industry. Iowa Lakes provides courses including siting and analysis, operations and maintenance, drop prevention and working at height and rescue. Iowa Lakes Community College's program is AWEA-recognized for wind technicians.

Iowa Lakes Community College
www.iowalakes.edu
Booth 4652

Preventive blade maintenance with lightning current monitoring

The Lightning Monitoring System (LM-S) from Phoenix Contact detects and analyzes in real time the magnitude, duration, number, and other parameters of surge current events caused by lightning strikes. System components include a hub-mounted evaluation unit with up to three fiber-optic-connected sensors, which can be on each turbine blade. The LM-S is suitable for both new blade and retrofit applications. The flexible and cost-effective Phoenix Contact Lightning Monitoring System can be a key component in improving the operation and maintenance profile of wind turbines. The LM-S is part of the Blade Intelligence suite of solutions, which include ice detection and performance optimization.

Phoenix Contact
www.phoenixcontact.com
Booth 2620

Powered access and safety solutions

Power Climber Wind helps major wind turbine OEMs, owners, and service providers manage their operation and maintenance (O&M) costs by providing reliable access equipment and expertise to improve employee safety, productivity, and retention. Their solutions for global wind farms include IBEX climb assist, turbine service lifts, tower and blade access platforms, safety equipment, and training.

Power Climber Wind | www.powerclimberwind.com
Booth 4016

Wind industry solutions

Timken has designed a Tapered Double Inner (TDI) roller mainshaft bearing as a direct drop-in, high-performing, reliable solution. Timken's bearing product line now includes two deep groove ball bearing options, designed to reduce electricity arcing across the bearing. Lovejoy couplings have an anti-flail device and use an integrated electrical isolation joint to prevent generator eddy current damage to gearbox bearings. The WindTC from AeroTorque is a torsional control device that reduces damaging loading in the drivetrain. Timken has developed a special grease formulation to suit unique needs, helping customers select the right mix of high-temp, anti-wear, water-resistant additives. In addition, a Groeneveld automated lubrication delivery system that remotely dispenses precise amounts of grease will be featured.

The Timken Corporation
www.timken.com
Booth 3620

Integrated solutions

Ulteig has contributed design and field services to over 21GW of renewable energy projects across the U.S. Their team of experts provides a full range of services to support every aspect of a wind project, from a particular engineering scope, to fully integrated project design and management services. From project start through completion, they assist their clients by providing successful on-time and on-budget performance, regardless of the project size, scope, and structure. The continued demand for cost effective and reliable renewable energy sources is driving the need for a high level of engineering expertise necessary to support this trend. Ulteig provides energy developers, owners, contractors, and utilities with solutions and full project support and execution.

Ulteig | www.ulteig.com
Booth 2134

High performing gearbox oil

Shell's engineers have created a wind turbine gearbox oil that delivers exceptional oil life, tested using the ASTM D2893 method. ASTM D 2893 exposes the lubricant to heat and oxygen (in the form of air) for prolonged periods to accelerate aging. A measure of the viscosity increase at the end of the test is used to gauge the resistance to ageing. The less the lubricant thickens, the higher its resistance to ageing. Shell's new wind turbine gearbox oil, Shell Omala S5 Wind, was tested against the standard test, and subjected to a four-fold increase in the test duration. Shell Omala S5 Wind offers an oil life of ten years in the field, giving wind turbine owners and operators peace of mind of its longevity and performance in today's challenging conditions.

Shell | www.shell.com
Booth 1030

High yield wind turbines

The Nordex Group has installed more than 23GW of wind energy capacity in over 25 markets, and, in 2017, generated revenues of EUR 3.1 billion. The company currently employs a workforce of approximately 5,000. The product portfolio of the group is focused on onshore turbines in the 2.4 to 4.5MW class, which are tailor-made for the market requirements in developed and emerging markets. The group offers multi-megawatt wind turbines for nearly all geographical regions, from grid-constrained, unrestricted projects to sound restricted, land-constrained, complex terrains.

Nordex USA Inc.
www.nordex-online.com
Booth 2626

Fully automated blade inspections

SkySpecs is a robotics company offering fully automated blade inspections. After the push of a single button, their inspections are completed in under 15 minutes, and data is available for viewing in the SkySpecs portal in under 48 hours. SkySpecs provides worldwide onshore and offshore inspections for their wind energy customers.

SkySpecs | www.skyspcs.com
Booth 4847

Anchor bolts and fastening systems

Cooper & Turner is a manufacturer of high quality, high strength, safety critical, large diameter (M16 to M100) hex bolts, double ended studs, and thread rod. Employing automation (including in process NDT inspection) and robotics results in high quality and consistent products, having full lot traceability, for supplying the global wind turbine market, OEM's, and major tiers as well. Recently opening an anchor bolt manufacturing plant in Pueblo, CO., they use 100% USA material and manufacturing, producing anchor bolts to ASTM A615 Grade 75 and Grade 90, plus ASTM A722 Grade 150, with all accessories (nuts, washers, and PVC sleeves), with bolt caps and grease optional. All assemblies are tested in a USA independent lab.

Cooper & Turner
www.cooperandturner-usa.com
Booth 4644

Mobile calibration services

Alltite offers custom equipment packages, and mobile calibration services for wind turbine erection and maintenance. Alltite offers an Online Tool Management System, TorqueWare, along with 24-hour turnaround for ISO 17025 accredited calibrations.
Alltite | www.alltite.com
Booth 1145

Transportation, distribution, and storage

The Port of Stockton is an inland facility located in the extended San Francisco Bay Area that has handled breakbulk cargo since 1933. It has 2.5 miles of on-dock rail connecting to the UP and BNSF that offer service throughout the United States. The Port is adjacent to less congested highways, I-5, CA-4, and CA-99, and is an hour from I-80. It has handled shipments of clean energy cargo of all shapes and sizes. The Port of Stockton has around the clock security and uniquely offers customers 24/7 access to their freight.
Port of Stockton | www.portofstockton.com
Booth 1041

HUB converter upgrades

PSI Repair Services, Inc., provides product upgrades for H bridges (aka hub converters) to the wind energy industry. Their custom upgrades prevent failures from high heat loads and stripped ground screws. PSI's custom Switching Driver replaces the OEM part and efficiently translates into less heat, while reducing mean time between failures by 80%. Steel inserts are used to create more durable ground lug threads. PSI has field tested this upgrade on over 3,000 installations with successful results. PSI offers component repair and engineering services for GE, Vestas, Gamesa, Siemens, Suzlon, RePower, and Clipper wind turbines. They cover the critical electronic, hydraulic, and precision mechanical components driving the turbines' pitch and yaw systems, and down-town electronics.
PSI Repair Services, Inc. | www.psi-repair.com
Booth 4552

Blade protection tape

3M introduces a Wind Protection Tape 2.0 designed to extend turbine blade life and maintain AEP by protecting the leading edge from erosion due to rain, sand, dirt or other debris. Easy to apply with no special tools, 3M Wind Blade Protection Tape 2.0 shows no damage even after 50 hours of accelerated rain and erosion testing. 3M WPT 2.0 tape is made from a translucent polyurethane – resistant to puncture, erosion and UV rays – backed by a highly durable acrylic adhesive.
3M Renewal Solutions | www.3M.com/wind
Booth 4012

Blade inspection and repair

Many owners don't think of blade inspections and repairs as a top priority- until they experience a failure. Not only are damaged blades a large contributor to wind farm underperformance, but they can be costly to fix if problems aren't caught early. EDF RS provides advanced blade inspection processes. They use modern imaging technology to pinpoint damage and problem areas. Their technicians then work with owners to formulate a repair plan to bring blades back to peak performance and keep them running for years to come.
EDF Renewable Services | www.edf-rs.com
Booth 1634

Project cargo services

Martin Bencher Group is a Scandinavian based shipping and freight forwarding company, transporting and specializing in the handling of projects and oversized/ heavy cargo. Their expanded network and strategically located offices offer services to customers worldwide. Martin Bencher Group currently serves the following industries; oil and gas, shipbuilding, paper and pulp, power, mining, cargo handling equipment, yachts and wind power.
Martin Bencher Group
www.martin-bencher.com
Booth 1431

Qualified elevator contractors

The Elevator Industry Work Preservation Fund represents over 450 elevator companies providing trained union mechanics from the International Union of Elevator Constructors (IUEC) who keep elevators running safely, and offer efficient installation and preventative maintenance to protect their customers elevator equipment investment.
The Elevator Industry Work Preservation Fund
www.eiwpf.org
Booth 2214

Smart automation not only increases turbine efficiency, but also helps to structure and connect the ever-increasing masses of data involved.

Maintenance Advantage:

Make your condition monitoring data work for you

WITH AN AGING FLEET COMES INCREASED EXPENSES, unexpected failures, and unplanned downtime. Regain control over your turbines with CMS and start planning for your tomorrow.

Condition monitoring systems (CMS) equip turbines with sensors that continuously monitor vibrations across the drivetrain at key locations from the main bearing to the generator. As components begin to wear and degrade, very specific patterns appear within the vibrations which are acquired by the sensors and identified by the CMS unit. In near real-time, these patterns are analysed to localize the defect, diagnose the issue, and assess the severity. With this knowledge, operators can then plan targeted maintenance activities around an optimal schedule (low wind speeds, multiple repairs, etc.), resulting in reduced O&M spending and a quick return on investment. "Bachmann also has products that are tailor-made for wind turbines and wind farms. They are easy to retrofit, control integrated and user-friendly. The knowledge from 20 years of monitoring wind turbines in Europe is combined in our wind power SCADA, atvise® visualisations and in the highly robust hardware", says Brian Hill, General Manager of Bachmann's North American office.

There is a 30 per cent cost difference between being able to use all the available data and not having it at your disposal.

THE COMPETITIVE EDGE: BACHMANN'S PLC INTEGRATED CMS

Utilizing the existing turbine controller to operate the CMS unit doesn't only save money by making use of the existing controller and tower communication, but it provides a future oriented solution. Fully integrated CMS opens the door to smart automation driven by machine health and resulting in optimal yield. With system security at the core of Bachmann's M1 platform, this means safe and reliable results for years to come. "With a capable Bachmann controller already in place, it becomes very cost effective to install a Bachmann integrated CMS with only a few new pieces of hardware. Saving cost by not needing additional networking infrastructure when compared to traditional stand-alone systems," emphasizes Hill. Stand-alone CMS options are also available for wind turbines not controlled by a Bachmann M1 system. "Depending on the design, an integrated installation can be aimed for here as well as a stand-alone solution," adds Brian Hill.◆

Engineered lifting and securement solutions

For more than 83 years, Dolezych has provided lifting equipment, slings, ropes, and load securing technologies. They have a team of more than 600 employees in Dortmund and in their worldwide subsidiaries. Their catalog displays their secure and reliable solutions for the transport, assembly, and maintenance of wind power stations. They can produce a wide range of steel, textile, or composite products. On request, they design and produce custom-made lifting solutions.
Dolezych | www.doleco-usa.com
Booth 1846

Formulation-centric lubrication strategy

ExxonMobil's Mobil SHC Gear 320 WT synthetic wind turbine gear oil is formulated to help deliver outstanding protection for critical turbine components over long oil drain intervals. Specifically, Mobil SHC Gear 320 WT has shown the ability to deliver equipment protection across a wide range of onshore and offshore conditions, including: outstanding protection again micropitting and wear; reliable foam-control performance; exceptional water tolerance; and, superb oxidative stability and excellent viscometrics, even at temperatures as low as -45ºC (-49F). This performance is backed by a 7-year limited warranty.
ExxonMobil | www.mobil.com/wind
Booth 2243

Low profile, versatile, and powerful bolting solution

For bolting applications requiring powerful performance in tight spaces, Titan's LP power head cylinder fits in small spaces without sacrificing power. The piston dampening system eliminates tool breakdown and reduces repair cost. The LP Series Hydraulic Torque Wrench's "Wide Track" ratchet tooth design distributes stress evenly, which provides a large contact area delivering the strength required. Each hydraulic torque wrench has a calibration certificate with traceability to N.I.S.T. All testing equipment is calibrated by NVLAP Accredited Calibration Laboratory. Titan's hydraulic torque wrenches are powerful, accurate, durable, robust, and efficient.
Chicago Pneumatic Tool Company LLC
www.cp.com
Booth 3531

Wind development region

Kansas is ranked No. 2 in wind potential and is among the top five states for operating wind farms, with 5110MW of wind farms currently in operation and 1000MW in new projects announced. Kansas wind is cost effective due to high capacity factors, and has therefore been attractive to corporate and out-of-state off-takers, which are purchasing a significant percentage of the wind energy produced in Kansas. Centrally located in the heart of the wind corridor, Kansas offers access to the key regions for wind farm development and an advantageous operating environment for developers, wind turbine component manufacturers, logistics, and other service providers. The Kansas Department of Commerce is the primary point of contact to assist companies in learning about the state's wind industry and finding the ideal site for their operations.
The Kansas Department of Commerce
www.kansascommerce.gov
Booth 1538

Wind turbine inspection and maintenance services

Zuma Rope Access performs specialized inspection, repairs, and maintenance in the wind energy industry. Their experienced rope access technicians are capable of mobilizing rapidly, getting towers repaired and back online quickly. Rope access provides a high level of flexibility on difficult to access areas of wind turbines, including: mechanical, composite, or cleanings.
Zuma Rope Access | www.zumaropeaccess.com
Booth 5049

Reliable foundation anchor bolts

Williams Form Engineering Corporation has been providing threaded steel bars and accessories for rock anchors, soil anchors, high capacity concrete anchors, micropiles, tie rods, tiebacks, strand anchors, hollow bar anchors, post tensioning systems, and concrete forming hardware systems to the construction industry for over 95 years. Each wind tower supported by a Williams foundation anchor bolt can be dependently relied upon to perform throughout the life of the turbine.
Williams Form Engineering Corporation
www.williamsform.com
Booth 4817

Community acceptance and security around wind farms

Technostrobe present LIDS (Lighting Intensity Dimming Solution), a new solution that helps wind energy developers gain a greater level of community acceptance for their projects by reducing the intensity of the lights on wind farms. LIDS technology can effectively and safely adjust the intensity of the light to the surrounding visibility present at wind farms. Light intensity can now be dimmed by 90% under clear skies conditions (10km or more of visibility). When the intensity of the lights is adjusted according to the surrounding visibility, pilot safety is maintained when they are flying near wind farms, and it significantly mitigates the impact of the beacons on local communities.
Technostrobe | www.lidsinfo.com
Booth 3231

Fully integrated wind energy solutions

Siemens Gamesa is constantly developing advanced products adapted to customers' needs. As a technology partner to their clients, they've created a wide product range, with wind turbines of modular and flexible design which are adaptable to every site, under all environmental conditions. Their new SG 4.2-145 wind turbine, developed by combining technology with experience, provides reduced LCoE in any location.
Siemens Gamesa Renewable Energy
www.siemensgamesa.com
Booth 2127

Wind turbine in real-time monitoring

Directly integrated in the gearmotor, Bonfiglioli patented integrated load-cell for yaw and pitch drives is monitoring in real-time load peaks through the measurement of torque. Connected by a cable, the system enables the automatic shifting of the motor to protect the drive. The output signal of the transmitter turns the electric motor off, if necessary, or reduces the capacity of the frequency inverter and provides information to the PLC.
Bonfiglioli | www.bonfiglioli.com/wind
Booth 3117

Battery torque wrench

Torkworx introduces the new Digital BRAD, up to 2x faster than their previous version. The DBRAD powered torque wrench is a digital cordless 18V lithium-ion battery tool with advanced patented technology containing digital display and single increment torque settings. With programmable preset torque and angle settings, this torque wrench has an accuracy of +/-5%. It offers an automatic 2-speed gearbox and available gear turning accessories.
Torkworx | www.torkworx.com
Booth 3730

Gearbox servicing

The team of RMW and MG have decades of combined experience in the gearbox industry, especially on-site service. They have worked with gearboxes in wind energy as well as other industrial applications. RMW and MG service all major gearbox manufacturers including, Jahnel-Kestermann (JAKE), Winergy (Flender), Lohmann Stolterfoht (Bosch Rexroth), Renk, Eickhoff, Brook Hansen, Moventas, and many more.
RMW and MG | www.rmwilson.com
Booth 1452

Hybrid tower system for high yield

With every additional meter of hub height added to a wind turbine, the annual energy yield increases by 0.5% to 1%. Reduced wind turbulence resulting in significantly better wind yield speak in favor of hub heights over 130 meters. This delivers a faster return on investment (ROI) for the entire project. With hybrid towers from Max Bögl Wind AG, hub heights of up to 180 meters can be realized economically. This is possible thanks to a combination of precast concrete parts and steel elements. For projects outside Europe, they provide local manufacturing in a mobile factory. This company offers the manufacturing, delivery, and erection of hybrid towers, and holds the record for the highest wind turbine tower with 178m hub height.
Max Bögl Wind AG
www.mbrenewables.com
Booth 2340

Smart components

In Texas, EMA Electromechanics produces the VDH/GSMI, which combines a circuit breaker and a high-speed grounding switch. Concerning PRC-024-1/2, the VDH/GSMI supports differentiation between internal and external faults, signaling the WTG in a fraction of the 150ms required by the standard, and providing valuable information to take the decision to shut down.
EMA Electromechanics, Inc.
www.emaelectromechanics.com
Booth 4220

Synthetic lubricant solutions

AMSOIL manufactures synthetic lubricants for all types of industrial gear, wind turbine, on-road and heavy-duty off-road applications, and sophisticated additives and filtration systems. AMSOIL products are cost-effective choices for prolonging equipment life, reducing maintenance, and increasing performance.

AMSOIL, Inc. | www.amsoilwind.com
Booth 4830

Wind development region

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

Iowa Economic Development Authority
www.iowaeconomicdevelopment.com
Booth 4640

Transportation and logistics

TP&L's services can be introduced any where along the supply chain. They serve OEM's, project developers, and transportation companies. TP&L is also available to help plan rail load outs from port to pad. Their in-house engineer is open top loading certified and available every step of the way. TP&L's partners bring with them over 40 years of combined transportation experience in all sectors-port, truck, rail, and distribution services.

Transportation Partners and Logistics
www.tpandl.com
Booth 3551

Full service engineering and design

Electrical Consultants Inc. (ECI) was incorporated in 1985. Their in-house portfolio of services, including overhead and underground transmission engineering, substation and switchyard design, industrial power systems design, land survey and construction staking, right-of-way services, environmental planning, project management, construction management, and procurement services have provided a key resource for hundreds of utilities. ECI brings extensive experience in power delivery services through 500 kV to their clients.

Electrical Consultants, Inc.
www.electricalconsultantsinc.com
Booth 4941

Bolt tensioning cylinders

ITH bolt tensioning cylinders are designed for tightening large diameter bolts on all major OEM wind turbine applications including: foundation rods, tower bolts, bearing bolts, and more. They offer compact and lightweight designs, including patented safety features. A full catalogue of standard designs, and a large scope of modified and custom designs are available to meet specific customer needs.

ITH Engineering | www.ith.com
Booth 1137

Fire suppression system

The Firetrace automatic fire suppression system is a solution for the unique environment in a wind turbine unaffected by vibration, dust, airflow, and temperature. Their systems can protect the control panels, capacitor cabinets, braking system, transformer, and other at risk areas of the turbine, without requiring power or excessive space usage.

Firetrace International | www.firetrace.com
Booth 4927

Generator brush and slip ring upgrades for high output turbines

Mersen's experience in the protection of electrical rotating machines enables them to offer unique solutions which improve the reliability of a range of associated turbine components, such as non-drive end bearings, brush riggings, brush holders, and electronic cards. The expertise and design philosophy adopted by Mersen, while striving for continuous improvement, has led to significant advances in the domain of slip ring and carbon brush technology. New solutions, including carbon grades designed specifically for wind power applications, have resulted in reduced operating costs. The increased demands from today's high output wind turbines requires a deep technical understanding of the machine's intricate systems. Mersen has worked with all major OEM's and power utilities worldwide to understand these requirements. The SR13-15 is an upgrade to one of the most common wind turbine generators in North America. Its robust design allows high operating loads, has proven to run cooler, and increased availability in high winds.

Mersen | www.mersen.com
Booth 3212

Work-at-height safety training

ENSA provides development of industrial work and rescue at height technicians, whose careers are often established operating in remote settings and demanding environments such as wind turbines, telecommunications structures, and other structures requiring specialized access (bridges, water tower, and industrial chimney maintenance). ENSA runs under a strict quality management system (ISO9001), actively supporting and operating within industry-recognized best practice standards and regulations under industry-specific associations for both training and safety services. ENSA is currently recognized as a professional training provider within the following 3rd party organizations: Global Wind Organization Basic Safety Training Standards (GWO-BST/BSTR), National Wireless Safety Alliance Telecommunication Tower Technician (NWSA TTT1 & TTT2), and Society of Professional Rope Access Technicians - Safe Practice for Rope Access.

ENSA | www.ensawerks.com
Booth 4916

Battery powered torque wrenches

The new B-RAD Select battery series torque wrenches comes with two simple buttons to increase or decrease the value by 10ft. lbs. At the four-digit display, the set torque value is displayed. The B-RAD select remembers the last set torque value even after the battery has been removed. The B-RAD is suitable for pre-torque and service jobs where electricity or compressed air are not available. Torque ranges up to 5,000ft. lbs, equipped with the latest Lithium-ion Standard.

RAD Torque Systems
www.radtorque.com
Booth 2854

Modular, automated wind energy systems

For almost 50 years Bachmann has been accelerating the progress in automation technology. With flexible solutions to retrofit Controls, SCADA, and Condition Monitoring Systems and Grid Monitoring, Bachmann's solutions offer quality, and experience. They work with open systems and work to continuously extend holistic automation solutions.

Bachmann electronic
www.bachmann.info
Booth 2215

Next generation power cables

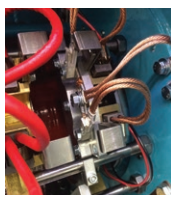
Helukabel's new HELUWIND WK 2000V ALU Power Cable is UL listed for RHH, RHW-2, 2000V. It is c(UL) listed for RW90, and rated for 90ºC dry/wet applications. The cable is highly flame retardant and passes UL 1685 cable tray test as well as the IEEE1202, CSA FT4 flame test. Aluminum can be a successful alternative to copper, in terms of performance and pricing, when proper engineering techniques are used; it is lightweight, robust, and flexible.

Helukabel | www.helukabel.com
Booth 5030

Lubricant solutions for wind turbine technicians

WD-40 brand provides multiple solutions which help wind technicians get the job done. WD-40 EZ-REACH includes an 8-inch flexible straw which allows lubricant to be delivered into hard-to-reach places. WD-40 Specialist Spray & Stay Gel helps prevent rust and corrosion build up on turbine bolts for up to one year. WD-40 Industrial-Strength Cleaner & Degreaser is engineered to be powerful and safe. Formulated with a bio-solvent which quickly breaks through tough grease and grime, it is safe for use on sensitive surfaces like aluminum, copper, carbon fiber, and glass. It meets the EPA's Safer Choice Certification criteria for safety and efficacy. Added corrosion inhibitors prevent valuable tools and equipment from flash rust.

WD-40 | www.wd40.com
Booth 2931



Compact, high reliability power generation systems

Morgan Advanced Materials is featuring new products including ground brush holders to eliminate ground ring grooving, SRS machining kits to improve slip ring conditions while producing power, pitch motor bearing protection, and spring kits.
Morgan Advanced Materials
www.morganelectricalmaterials.com
Booth 4741

Fall arrest cable sleeve

The new SKYLOTEC CLAW Vertical Fall Arrest Cable Sleeve is designed to fit a wide variety of wire ropes and travel along the vertical system while providing fall arrest when needed. Engineered to fit 3/8 and 5/16-inch wire rope, this high quality, lightweight stainless-steel device travels smoothly up and down the vertical system without hanging up. The redundant safety features reduce the risk of improper installation and unsafe situations. The CLAW is independently tested to meets ANSI A14.3-08, CSA Z259.2.5-17 and OSHA requirements.
SKYLOTEC | www.skylotec.com
Booth 1639

Engineering & consulting services

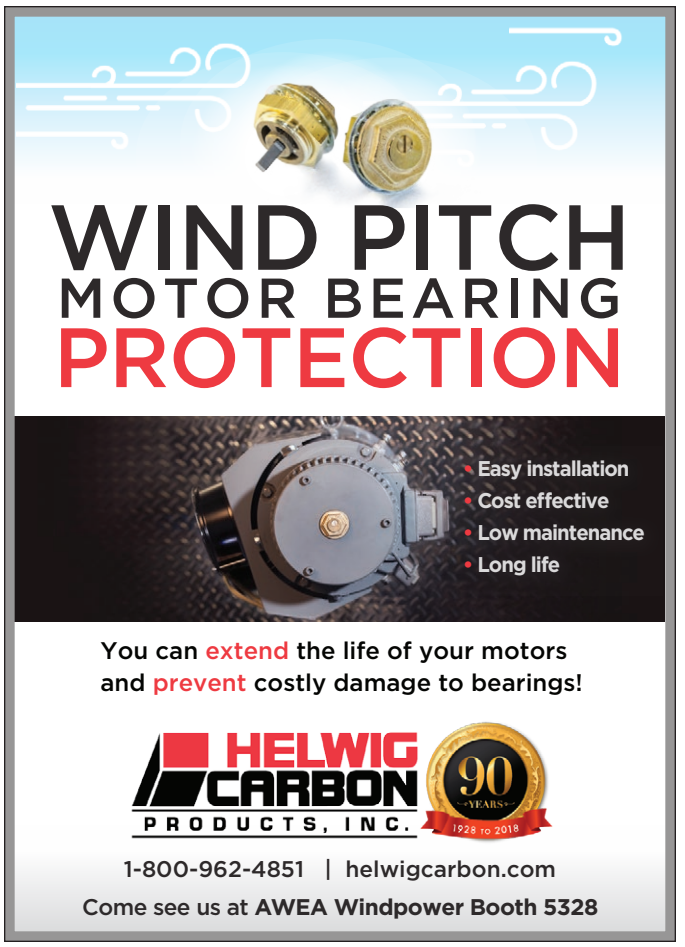
EAPC Wind Energy provides engineering and consulting services for wind farm development throughout North and South America, North Africa, and Europe. They help developers achieve their financial goals by providing intelligent wind farm design, accurate energy assessments, and bankable reports. EAPC Wind Energy provides energy assessment and feasibility studies, development consulting, contract negotiation and review, technical due diligence, financial and economic analysis, balance of plant design and engineering, strategy consulting, wind measurement services, and windPRO software sales and support. windPRO is a comprehensive software package for wind farm project planning and design. EAPC regularly conducts windPRO training workshops across North and South America.
EAPC Wind Energy
www.eapc.net/we/
Booth 4436

Self-hoisting crane

The Liftra Self-Hoisting Crane eliminates the need for large mobile cranes when changing major components. The crane climbs from its 40ft container to the nacelle, suspended and guided by its own wires. Atop the turbine, the crane turns 180° and is installed on its base inside the nacelle, ready for operation. The crane's standard 40ft container requires no civil works or other preparation of the site. No bridges or roads need to be reinforced, and no special permits need to be obtained. Other typical limitations of large cranes include wind window and turbine height. The Self-Hoisting Crane operates safely in winds up to 18 m/s and on turbines up to 170m in height. By removing large cranes from the equation, the Self-Hoisting Crane has unlocked major economic and environmental benefits for multiple OEMs, owners, and service providers.
Liftra ApS | www.liftra.com
Booth 1627

Alignment and geometric measurement solutions

The EASY-LASER alignment systems are specially configured with functionality and hardware suited for wind turbine alignment. No matter the manufacturer, coupling, or turbine type, EASY-LASER makes generator-to-gearbox alignment inside any nacelle easy. The EASY-LASER flange systems are ideal for measuring flatness on tower flanges regardless of diameter as well as for solving flange deformation problems.
LUDECA, Inc. | www.ludeca.com
Booth 1251



Wind farm inspection services

Measure offers full wind farm drone inspections which include comprehensive visual inspection for turbines, a full site overview with easy access to raw images and custom reports, and portfolio analytics to track the performance of wind turbines over time. Measure's drone solution improves inspection efficiency and turbine productivity, reducing man-hours for maintenance checks by 75% and requiring less downtime for expensive repairs.
Measure | www.measure.com/wind
Booth 3252

Engineering, design, and commissioning

POWER Engineers, Inc. is a consulting engineering firm supporting wind projects worldwide. With 2,500 employees in 40 U.S. offices, they provide owner's engineering, environmental, and engineering design services for medium voltage collection systems, site civil, communication networks, SCADA, and associated substations and transmission interconnect lines. They also perform up-front interconnection support and complete electrical system studies for developmental projects, as well as construction management, inspection services, and testing and commissioning for wind farm constructors and owner/operators. POWER's familiarity with multiple facets of utility, ISO/RTO, and developer interconnection requirements and solid understanding of environmental issues surrounding wind projects translates to full-service support for their clients, helping to implement clean, renewable energy across the globe.

POWER Engineers
www.powereng.com
Booth 1234

Heavy and specialized transportation

Landstar provides specialized and heavy haul transportation services. Whether hauling a single machine or managing a complex project, Landstar has the experience, capacity, and equipment to move any heavy/specialized freight. Their vast array of specialized equipment includes flatbeds, stepdecks, double drops, extendables, multi-axles, steerables, lowboys with 40-80 ton capacity, RGN units, beam, perimeter, and more. Landstar provides safe, secure, claim-free deliveries of over-dimensional, heavy weight freight.

Landstar | www.landstar.com
Booth 3427

Transformer solution provider

WEG Transformers USA, formerly CG Power Systems USA, provides transformer products, services, and integrated solutions serving the North American T&D, commercial & industrial, and renewable markets for more than 35 years from four North American manufacturing plants. Their product offerings include distribution, substation and power transformers, multi-winding (3, 4 or 6) step-up transformers for solar applications, shunt reactors, mobile substations, generator step-up, auto, voltage regulating, and arc furnace transformers. WEG Transformers USA has an installed base of more than 12,000 transformers (24MW) and provides consistent quality and on-time delivery.

WEG Transformers USA
www.weg.net
Booth 4823

Highly reliable pitch system

The Moog Pitch System 3 meets the growing need for wind farm operators and turbine manufacturers to reduce wind farm capital and operating expenses. The design of Pitch System 3 reduces the Levelized Cost of Energy by increasing wind turbine reliability and minimizing downtime. With an architecture that consists of significantly fewer parts, the Moog Pitch System 3 is up to three times more reliable than the industry's standard pitch systems, which reduces turbine downtime and maintenance.

Moog | www.moog.com
Booth 1912

High performance lifting slings

Cortland Company's high performance synthetic lifting slings made from their patented Plasma 12 x 12 braided rope are lightweight, safe, have an ease of handling, and are a cost-efficient alternative to traditional wire rope slings.

Cortland Company
www.cortlandcompany.com
Booth 4816

Renewable energy construction and services

Wanzek Construction provides renewable energy construction and services, as well as power, oil & gas, infrastructure, agriculture and industrial services, and crane services.

Wanzek Construction
www.wanzek.com
Booth 2043

SOLAR POWER SOUTHEAST

May 15th-16th, 2018
Sheraton Atlanta Hotel – Atlanta, GA

Solar Power Southeast leads the way for solar professionals doing business in this area of the U.S. Over 600 attendees and 50 exhibitors will venture to Atlanta this year. With ample opportunities to network with solar companies based in the region, as well as the chance to gain knowledge on the trends and policies impacting the Southeast, Solar Power Southeast proves to be the premier place to build your business and connect with industry leaders. This year's event features three workshops, multiple organized networking events, and 15 education sessions.

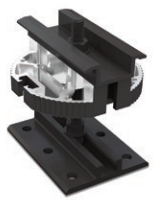
www.events.solar/southeast

show in print

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

Plug & play, wireless balance of systems

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.
Shoals Technologies Group
www.shoals.com



Rail-less mounting system

POWER DISK is a unique roof attachment that can go anywhere on residential rooftops. It does not need to be secured to rafters and allows solar modules to be installed in four simple steps. POWER DISK is flexible and adaptable; it allows installers to set modules in portrait or landscape format and can be attached directly to rafters, if desired. Fitting most framed 60- and 72-cell modules, POWER DISK is pre-assembled and quick-to-install with built-in electrical grounding clips integrated in the mount and optional flashing. POWER DISK in UL2703 code compliant. PLP's website also features a new POWER DISK design tool which provides optimal residential roof layouts with the unique deck mount attachment and offers built-in code compliant engineering, and a simple user interface.
Preformed Line Products
www.preformed.com

Topographically adaptable ground mount

DCE Solar offers the Contour ground mount system which delivers a wide selection of foundation types to cost. Contour's design conforms to challenging topography and accommodates all soil types to minimize or eliminate the need for expensive grading. Utilizing its shared foundations configuration will decrease the number of foundations per MW to further reduce cost and diminish ground refusals. Electricians enjoy the ease of wiring which offers compounded savings in both grounding and wiring costs. DCE's Contour is easy to install and reduces installation man hours. The DCE team always provides client support to ensure EPC's and developers meet or exceed their expected goals. All DCE products are backed with reliable delivery times along with a 20-year warranty.
DCE Solar | www.dcesolar.com

Versatile plug & play inverter solution

Ingeteam's Medium Voltage Inverter Station is a compact, customizable, and versatile plug & play solution that can be configured to suit each customer's requirements. This brand new medium voltage solution integrates all the devices required for a multi-megawatt system, customized up to 3.6MVA. With high adaptability and power density of 5.2 W/in^3, not only does Ingeteam's Inverter Station offer low CAPEX, but also low OPEX, thanks to its long-lasting design, ease of access and serviceability, and maximum protection. The high-performance design uses electronic conversion topologies capable of achieving efficiency values of up to 98.9%. Its dual channel air cooling system makes it possible to increase the ambient operating temperature for maximum enhanced functionality, thus maximizing return on investment. The INGECON SUN PowerMax B Series is certified in compliance with UL 1741 SA and pairs well with their INGECON SUN STORAGE PowerMax three-phase bidirectional battery inverters.
Ingeteam | www.ingeteam.com

Solar wire management clip

Nine Fasteners' NFI-1307-V90 is a UL Listed solar wire management clip designed to hold 1 or 2 PV wires securely to standard solar PV module frames. The NFI-1307-V90 is oriented at a 90° angle for when a standard oriented clip does not fit the application. This clip is designed to allow the solar panel to lay flat when implemented on a railed system, yet is still easy to install even without a lead lip. As with all of Nine Fasteners solar wire management clips, this clip is manufactured in the U.S.A. with a rolled outer edge for maximum wire safety.
Nine Fasteners | www.ninefasteners.com

Versatile ground mount system

The Advanced Modular ground mount system is a solution for large commercial and utility scale solar projects. Innovative features like integrated bonding, cable management trays, and UL Certified components reduce electrical costs. Engineered cross bracing, high strength steel, and physical testing on every site makes the Advanced Modular ground mount system a very rigid system. AP Alternatives' shallow helical foundations allow massive versatility with soil issues, including: soft soils, low friction soils, high water tables, shallow bedrock, deep frost lines, and rolling topography all at basically no cost increase.
AP Alternatives | www.apalternatives.com

Solar carports and support systems

Baja Construction's in-house design engineers create custom Baja Carport Solar Support Systems for their extensive Baja Carport product-line that meet the engineering specifications of the customer and their city's criteria. Baja's engineers provide customers with carport structure plans that seamlessly integrate into their property's layout for the greatest coverage and power production possible. Baja steel carports and canopies are engineered "site-specific" to meet live loads from 20 psf up to 60 psf, and wind speeds from 90mph to 140mph. Each Baja Carport is highly specialized, designed, and engineered to the customer's specification using pre-fabricated (with intention for no field welding), pre-galvanized high-tensile, light-gauge steel. They use their workforce to ensure quality from delivery to installation. Baja has logistics in place to complete projects anywhere; their customers include hospitals and medical centers, Fortune 500 companies, schools and colleges, municipalities, multi-family, and affordable housing.
Baja Carports | www.bajacarports.com

SOLAR CANADA ANNUAL CONFERENCE & EXPOSITION

June 20th-22st, 2018

BMO Centre – Calgary, Alberta, Canada

The Canadian solar energy market is growing rapidly. Provincial governments and consumers are focusing more on renewable energy in an effort to lower greenhouse gases and utilize more affordable sources of energy. This has created a tremendous opportunity for companies to expand their market presence in Canada. Solar Canada Conference & Exposition provides an excellent platform to connect with industry professionals and enter this growing market.

Take advantage of this unique opportunity to network with thousands of attendees and hundreds of exhibitors representing the entire industry: solar integration, development, engineering and EPC, equipment manufacturers, utilities, consultants, federal, provincial and municipal governments, communities, and students.

www.solarcanadaconference.ca

show in print

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

Integrated PV solution for harsh conditions

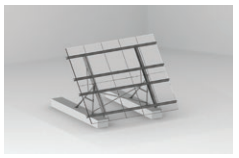
GP JOULE is a global renewable energy company developing, engineering, constructing, operating, and financing commercial and utility-scale renewable projects. Globally, GP JOULE has installed over 500MWs of PV projects and manages 600MWs of assets across Europe and North America. Their full range of PV products and services is focused on delivering low installed cost in tough environments. Combining turnkey EPC expertise with its proprietary PHLEGON single axis tracker, GP JOULE offers a bankable solution with engineering, installation, and commissioning services. Designed specifically for harsh climates and challenging sites, the PHLEGON tracker uses heavy-duty linear actuators that intelligently integrate German-engineered control systems. This technology contends with heavy snow and high winds to ensure production 365 days a year. Cost-effective PHLEGON utilizes up to 50% fewer piles, has a low fastener count, and offers easy ground maintenance access.

GP JOULE | www.gp-joule.com

PV system protective fuses

With a dedicated range of products to disconnect, clip, and isolate, that includes string and NH style fuses, supporting fuse gear, surge protective devices (SPDs), power distribution blocks (PDBs), and switches, Mersen provides the appropriate measures to shield the wiring between strings and protecting system components. With their HelioProtection product line, faulty circuits are safely isolated and system longevity and reliability are increased, allowing for continuous generation of clean and efficient power. Mersen recently introduced Crimp Cap Termination for their HP10M, HP15M, and HP15G HelioProtection photovoltaic fuses. In addition to the standard ferrule terminal, Mersen's wire crimp terminal (CC option) permits solderless wire-to-fuse connection for overmold encapsulation of fuse and wiring, specifically designed for in-line fuse applications. UL Listed.

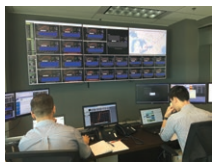
Mersen | ep.mersen.com



Seasonally adjustable ground mount

Kinetic Solar's new seasonally adjustable ground mount brings versatility and strength while being economical and fast to install. Each module section is balanced in order to make seasonal adjustments with 60- or 72-cell modules simple and easy, no heavy lifting required. Seasonal adjustment can offer a yearly increase in production of up to 14% (when compared to fixed tilt) without the added cost of a tracking system. Standard tilt angles include 20°, 45°, and 60°. It is engineered to withstand 1kPa of wind and 2.5kPa of snow, making it suitable for use in nearly any location in North America. Its design tilts flat for fast and easy construction. Available with optional string inverter mount, micro inverter mount, and rear cable shielding panels. The structure's sturdy steel construction and hot dip galvanized coating stands up to hostile environmental conditions.

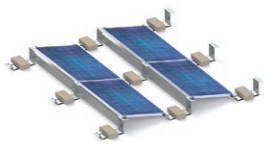
Kinetic Solar | www.kineticsolar.com



Independent service provider for PV O&M

Northwind is a progressive, customer-focused service organization delivering asset monitoring, performance analytics, and operations & maintenance (O&M) services to the renewable energy industry. Their mission is to minimize asset down time and maximize the value of renewable energy assets today and for the long term. Established in 2004, Northwind is a Spark Power Company. Founded in 2010, Spark Power is an integrated, end-to-end energy solutions provider, delivering technical innovation, project development, contracting, maintenance, service, and operational support to the ICI, renewable energy, and utility markets.

Northwind Solutions Group, Inc.
www.northwindsolutions.com



Non-penetrating solar mounting solution

KB Racking's EkonoRack 2.0 is a simple, non-penetrating solar mounting solution for commercial flat rooftops. The safe and robust system is ETL Certified and can be grounded with only one grounding lug per array. EkonoRack 2.0's design is composed of only one major component, acting as a ballast tray windshield mount and multiple panel support. The system's pre-attached roof mats save time on installation and provide maximum protection for the roof.

KB Racking | www.kbracking.com

O&M services

With 30 years of experience and 10GW of energy under contract in North and South America, EDF Renewable Services helps optimize plant performance, maximize availability, and minimize downtime. With services including full O&M, Asset Management, and 24/7/365 Monitoring, they bring an owner-operator sensibility to all projects. Their development group, EDF Renewable Energy, has over 9GW of renewable energy projects developed in North America.

EDF Renewable Services
www.edf-rs.com

Effective deep foundation solution

Helical piles are an increasingly popular and effective deep foundation option. Almita Piling's helical piles are composed of a steel pipe shaft with a 45° cut at the bottom and one or more formed helical plates welded outside. Helical piles reduce a project's environmental footprint, increase the speed of installation, and are suitable for applications within diverse soil and environmental conditions.

Almita Piling | www.almita.com

SOLAR POWER TEXAS

June 5th-6th, 2018

Hyatt Regency Lost Pines Resort & Spa – Austin, TX

Last year, Solar Power Texas provided solar professionals the opportunity to gain exclusive updates from local policy drivers and learn from leading businesses in the region. With over 400 attendees, a sold-out exhibit hall, and a networking reception that brought over 200 installers, contractors, manufacturers, and other industry professionals together, the event proved to be the premier location to connect with other professionals looking to tap into this growing market.

www.events.solar/texas

show in print

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

Affordable and space saving RSS

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 it isn't feasible for the string inverter to be within the array boundary (per NEC 690.12). Products can be configured for grounded or floating systems, and can accommodate inverters with single or multiple MPPTs. Additional options include capacitor bleed down and Low Voltage Ride Through functionality. All products are listed to UL-1741 for 1000 VDC photovoltaic systems and use compact NEMA-4X polycarbonate enclosures.

SolarBOS | www.solarbos.com

Affordable pile driven fixed tilt system

Max-Span Post System is a value-driven system which supports all double-sided glass thin film and other modules. Its galvanized Z purlins have integrated trays for easy wire management, and it's rugged beam and brace rapidly attach to pile with just six bolts. The Max-Span Post System provides 5° to 35° tilt with multiple inter-row spacing options, and with up to 4 ft. ground clearance, it eliminates snow and vegetation shading issues. GameChange Solar offers stamped layout and engineering analysis for every project. The system's earth screws and helicals are StickyPile G235 galvanized steel (HDG available), HDG, purlins, beams, and braces are G90 galvanized steel, and integrated grounding with star washers or teethed module clamps is included and approved under ETL /UL 2703.

GameChange Solar
www.gamechangesolar.com

High efficiency bifacial solar cells

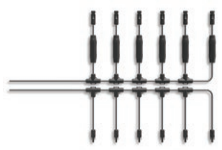
Panasonic has been producing high efficiency amorphous cell technology since 1975. Over 40 years of solar research and development goes into every HIT high efficiency home solar panel. Featuring high output 19.7 module efficiency and 330W per panel, Panasonic HIT N330 provides an advanced renewable energy source with zero emissions. A temperature coefficient of -0.258% /^{0}C produces high performance at high temperatures, generating greater electricity output on the hottest days. A combination of engineering detail increases output efficiency: A bifacial cell design captures sunlight from both sides, as the pyramid structure optimizes sunlight absorption by reducing electron loss and reflection. The Panasonic complete warranty covers linear power output and product workmanship for 25 years.

Panasonic | www.panasonic.com

Shared rail ground mount solution

Unirac, Inc. announces a shared Rail version of its popular Ground Fixed Tilt (GFT), an engineered package of standard ground mount components that is in stock and ready to ship from their ground mount distribution network. The new shared Rail design delivers enhanced system and labor optimization for maximum productivity. Unirac's commercial project support makes construction easy, from permitting through installation, including region-specific engineering and documentation. Kitted hardware, pre-assembled parts, integrated bonding, lightweight components, and straightforward connections allow for one or two-person assembly, and no specialized labor or training is required. System flexibility enables their customers to mount 60 and 72 cell modules and select from multiple foundation options to optimize their projects, all including Unirac's 25-year warranty.

Unirac | www.unirac.com



Streamlined integration of solar panels

Shoals' patented Interconnect System and home run harnesses reduce the specialized labor required in an installation, making the integration of solar panels simple. Whether purchased separately or pre-installed in the combiner box to streamline installation, Shoals home-run harnesses and Interconnect System are a solution for any PV project.

Shoals Technologies Group
www.shoals.com

ENERGY STORAGE INTERNATIONAL

September 24-27, 2018

Anaheim Convention Center | Anaheim, CA

The largest energy storage event in North America

From energy storage business models, to microgrid configurations

Energy Storage International, part of North America Smart Energy Week, brings together a variety of energy professionals from solar, wind to those interested in EVs and more. There are a variety of educational opportunities, from technical experience geared for engineers, to an energy storage 101 class that focuses on giving you a background of how energy storage works, and case-studies on how to successfully grow a storage component to your business.

POWERED BY SEIA Solar Energy Industries Association® | Smart Electric Power Alliance

Early bird rates are available until June 20, 2018.

Register and learn more at energystorageinternational.com

ESI ENERGY STORAGE INTERNATIONAL

Co-located with

SOLAR POWER INTERNATIONAL

SMART ENERGY MICROGRID MARKETPLACE

THE TECHNICAL SYMPOSIUM

The Crucial Key to the Industry's Fastest Growing Battery Chemistry

by Nick Renteria

If you follow the renewable energy storage industry even casually, then you have probably heard of at least one lithium battery company making waves. With market demand on the rise, lithium ion batteries are here to stay. It's up to industry professionals to hop aboard the train and learn how to make these batteries work up to their full potential.

Managing Lithium

In the days when the lead acid battery reigned supreme over the land of renewable energy storage, its internal voltage self-regulation meant that no additional communication was needed between the battery bank and the rest of the system components.

With the new age of lithium ion batteries came the need for a sophisticated Battery Management System (BMS), to monitor and regulate pack performance.

Many say lithium-type batteries are superior to their predecessors in nearly every way; they have a longer cycle life, higher energy density, smaller size, lighter weight, higher discharge rates, and maintenance free operation (i.e. no watering like flooded lead acid).

At the same time, this new technology faces serious challenges. Lithium batteries experience a steep voltage rise at the end of the charge cycle. One cell that reaches full charge before the rest of the pack will jump from 3.45V to over 4.0V in the blink of an eye. Without a BMS to control the incoming charge source, there will be significant damage to the overcharged cell.

In a traditional renewable energy system, a lead acid battery bank is connected at one point to the inverter/charger and solar charge controllers. The battery in this system is utilized as the sole power supply for the inverter and the solar charge controllers. If the lead acid battery reached a low state of charge (SOC), the inverter would be programmed to disconnect the AC output, preventing any further discharge from the battery bank. The battery would remain connected to the solar charge controllers and inverter, ready to accept a charge as soon as the sun or AC charge source became available.

When working with a lithium battery bank, there is often a disconnecting mechanism that resides on the battery pack. If the battery bank becomes becomes overcharged or over-discharged, the on-board contactor will disconnect the battery from the rest of the system in order to protect the battery. This is great for the overall safety of the battery, but causes a major problem for the rest of the renewable energy system.

When using a contactor to interrupt power going to, or coming from the lithium battery bank, the inverter and solar charge controllers no longer have a power supply to continue operation. This means that the inverter and solar panels are no longer connected to the lithium battery, and cannot recharge the battery without manual intervention to reset the on-board contactor. It is from this major pitfall that the need for a new disconnection method arises, to limit the charge into a full lithium battery, and the amount of energy supplied to the load when the SOC drops below a certain threshold.

The Software Solution

One answer lies in a software control system that can interface between the lithium battery, the inverter, and the solar charge controllers.

Some lithium battery companies offer a complete solution that includes a battery, inverter, and solar charge controller, but it's limited to a capacity that can power a house for just a few hours. Also, these packages are not compatible with existing inverters and charge controllers, which means that someone looking to replace a lead acid battery bank must replace all the other fully functional system hardware. Realistically, this total system replacement is not a feasible option for a customer simply looking to replace their battery bank.

The ideal solution is to interface the battery management system with any name brand inverter or solar charge controller on the market today.

When the battery is approaching a full SOC, a signal is sent to a device on the battery that can communicate to the solar charge controller, to slow down the incoming charge. If, at a reduced-charge level, the battery cells are still approaching the overcharge level, the software allows you to cease charging from any incoming source, whether it's the solar generator or the grid. The benefit here is that the contactor remains closed, and the battery keeps powering the load without interruption.

On the discharge side, as the battery is reaching a low SOC, the same on-board communication system is able to send a signal to the inverter to commence a new AC charge cycle from the grid or generator. If the battery continues

to discharge, and reaches a critically low SOC, the software system sends a signal to the inverter that will disable AC output. Essentially, the battery is dynamically setting the "low battery cut off" point based on state-of-charge, rather than simply on a preset voltage level. In this scenario, the battery is still connected to both the inverter's AC charger and the solar charge controllers, meaning the battery is ready to accept a charge whenever a source becomes available. Without this software control system, the lithium battery would have to open the onboard contactor and shut down the entire system.

Even with this sophisticated control system, it's important to utilize an on-board contactor to protect the lithium battery in case of software or communication system failures.

Forecasters expect years of strong demand for 48 Volt lithium batteries, in both the residential and light commercial energy storage market. Additionally, as lead acid batteries reach end of life in existing systems, customers will be looking to replace their batteries with the newest technology available. It's important to understand all the nuances associated with new lithium battery technology. It's our responsibility, as industry professionals, to offer the safest and most reliable solutions to our customers.

Nick Renteria works for Iron Edison Battery Company, writing articles, newsletters, guest blog posts and other company communications. He utilizes a passion for education and renewable energy to inform and excite readers about new industry developments.

Iron Edison | www.ironedison.com

Battery backup system design tool

The new POR Design Tool from SunWize is like their PRE Design Tool, but is for designing and selecting battery backup power systems (no solar), rather than off-grid solar power systems. Featuring project temperature and autonomy requirement inputs and the same advanced load calculator as the PRE Design Tool, their POR Design Tool brings battery backup and UPS design capabilities to the fingertips of their customers. Simply enter the project temperature, autonomy, and load requirements, and the appropriate battery backup system will be selected on SunWize's webstore, and will be available for immediate order. The tracking information will automatically be provided once the order has shipped.

SunWize | www.sunwizepower.com

Hybrid residential energy storage solution

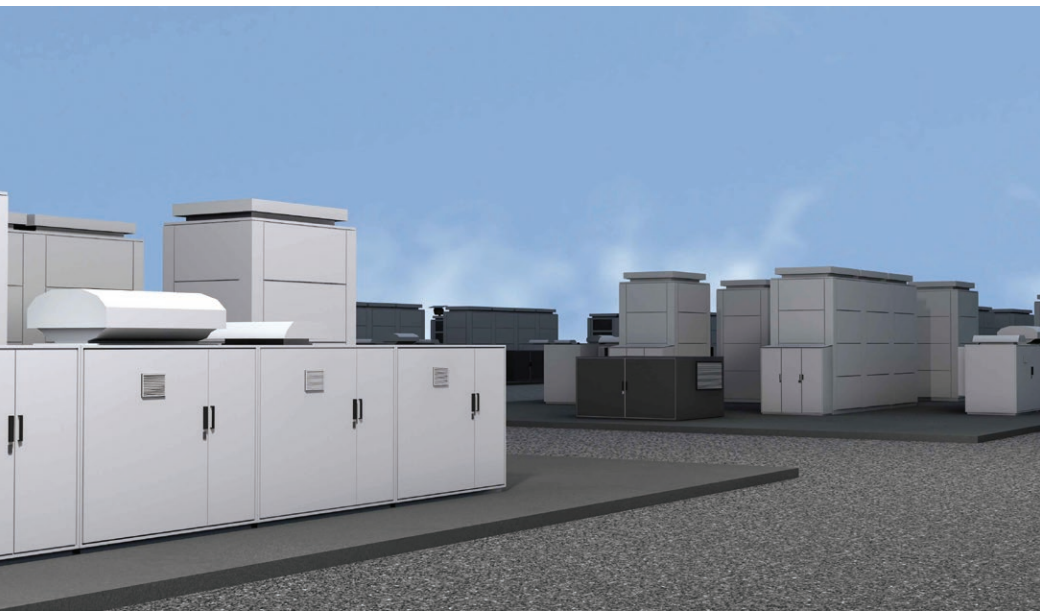
TrinaBESS' TrinaHome S Series is a new hybrid residential energy storage solution in the United States. TrinaBESS has adapted the product to respond to the American grid requirements and the UL, CA rule 21, and HECO standards. The solution was developed for new installations combining solar and energy storage. The hybrid inverter replaces both the PV inverter and the battery inverter, making the system more cost effective and reducing installation time.

TrinaBESS | www.trinaenergystorage.com

Absence of voltage tester

Panduit Corp. announced the North American release of its groundbreaking VeriSafe - Absence of Voltage Tester. VeriSafe is designed to minimize risk to electrical hazards by verifying the absence of voltage before equipment is accessed, making it easier for qualified electrical workers to determine an electrically safe environment in a fraction of the time compared to hand-held portable test instruments. Prior to performing de-energized work on electrical equipment, NFPA 70E requires workers to verify equipment is in an electrically safe state. One of the steps in that process involves a test for absence of voltage. VeriSafe ensures the entire process of verifying absence of voltage is performed in the proper sequence. The fail-safe and reliable process performed by VeriSafe tests the tester itself, verifies installation, checks for voltage, verifies installation, and retests the tester; all automatically performed in sequence with no risk of exposure to electrical hazards at the push of a button.

Panduit Corp. | www.panduit.com



How to Seize Storage Market Opportunities

Balancing environmental & engineering challenges

by Rob Jackson

RAPIDLY ADVANCING TECHNOLOGIES AND IMPROVING COST effectiveness are pushing U.S. utilities and developers to look to energy storage as a solution to grid resiliency and efficiency. Grid disruption from events like natural disasters, extreme weather conditions, and operational errors cost almost $100 billion dollars annually, according to insurance industry estimates. The technological advances in batteries, flywheels, compressed air, thermal, and pumped hydro storage are changing the way electricity is delivered.

According to the Energy Storage Association (ESA), energy storage systems currently make up roughly 2 percent of U.S. generation capacity, with systems in operation or development in nearly every state. In a recent presentation, ESA projected that the U.S. can expect to have 35GW of energy storage by 2025, which translates into $27 billion in reliability savings, and $4 billion in operational savings for the electric grid.

The US Department of Energy estimates that 95 percent of the 22.6GW of energy storage currently deployed is pumped hydro storage, a relatively mature technology. The advancement of battery energy storage technologies in the early adopter stage – such as lithium ion, nickel-based, and flow batteries – are changing the conversation. They now account for approximately 600MW of the total energy storage capacity.

Progress is happening quickly, with Federal Energy Regulatory Commission (FERC) Order 841 removing barriers to entry for energy storage participation in the capacity, energy, and ancillary markets, operated by Regional Transmission Organizations (RTO) and Independent System Operators (ISO). Demand continues for baseline pricing around wholesale markets, where the value has historically been low, but countervailing trends and indicators (spurred by Order 841) show that storage value is on the rise. Rules with objective reliability and performance metrics are needed for capacity markets, where there may be regulatory risks. ISOs and RTOs need to continue integrating storage as part of their rules; a firmer understanding of the value will follow.

An important economic policy tool for energy storage is the IRS interpretation of the Investment Tax Credit (ITC) and its application to utility scale energy storage projects. According to the National Renewable Energy Laboratory (NREL), the IRS ruled that a minimum of the 75 percent of the energy stored is required to originate from an electric generation source that qualifies for the ITC, such as solar, wind, or fuel cells. The amount of the tax credit is proportional to the percentage of energy originating from this qualifying generation source.

Current market conditions make this a unique opportunity. The majority of the energy storage deployment is expected to be utility scale and front of the meter, with the remainder being commercially implemented behind the meter.

Successfully developing and implementing large-scale storage projects, however, requires attention to several engineering and environmental challenges.

Engineering Challenges

While energy storage facilities have some unique needs, they share many of the same challenges as other power generation projects. Here are some important aspects to keep in mind:

- **Due diligence and siting:** Energy storage evaluation, new risk scenarios, and screening evaluations are needed to provide locations of resources and transfers to distribution.
- **Design:** Preliminary design drawings must follow local specifications, and cover existing and proposed site plans and details. Plant design considerations include cost estimates; performance predictions; grid interconnections; transmission and distribution engineering; substation engineering design; and capacity analysis.
- **Infrastructure:** Stormwater management engineering must account for NPDES permitting, site grading and soil erosion, and sediment control approvals. Other important areas include geotechnical and soils assessments; civil roadway and drainage design; SWPP development; and security.
- **Interconnection:** Utility considerations to front-of-the-meter energy storage projects include modeling storage deployments; identifying location feeders and storage distribution needs; voltage regulation; capacity deferral; phase balancing; and identifying time series constraints and constraint profiles. The associated power flow analysis and time series objectives help establish the value for the system and the associated economics. Utilities require an understanding of thermal and protection constraints of lines; phase and current voltage consistency; DR hosting capacity and reverse power flow; and if premium power scenarios can be offered.

Environmental challenges

There are also complex environmental considerations for energy storage facilities, including:

- **Regulatory issues:** In addition to identifying local regulatory requirements, applicable regulatory regimes for project sites must be documented. This includes determining which agencies are required to review the project, and which permits and approvals are necessary. Examples include nationwide permits from the U.S. Army Corps of Engineers, freshwater and/or tidal wetland permits from State Departments of Environmental Conservation or Protection, and regional requirements. Permitting schedules must be prepared for each site to assist in the determination of planned commercial operation dates.
- **Siting and land use:** When brownfields or retired coal and mining facilities are considered for siting of energy storage, it is critical to understand the current environmental status of

the site, and coordinate with the proper authorities. Due diligence can be completed through resource mapping, and review of GIS databases and aerial photography, to identify sensitive environmental resources including wetlands, protected habitats, floodplains, and historic/culturally significant sites. An inventory of the nearest sensitive receptors to each potential site, such as schools, hospitals, and residential areas, is also important. A preliminary land use assessment is also needed to document applicable zoning and local code requirements. Research into relevant zoning items must consider zoning designations, permitted uses, dimensional requirements, and the potential need for variances. Typically, a review of local codes is conducted to determine other applicable ordinances that would impact the development of a site. Examples include noise requirements, aquifer protection zones, and natural resources protection codes.

These challenges may seem daunting, but they're nothing new to utilities and power project developers that have executed large projects over the last 25 years. The robust market for energy storage all but ensures that any capital projects undertaken will quickly pay for themselves in the short term, and provide benefits over the long term.

Rob Jackson is National Market Director for Solar Power/Energy Storage at TRC. He has been involved with many firsts in the renewable energy industry, with experience in business development, energy and environmental policy, economics, due diligence assessment, permitting and design for renewable energy development. He also has broad experience in stakeholder negotiations and agency communication, and is an expert in contractor procurement including processes involving contract negotiations, bidding, and construction management. He is a registered professional engineer in the Commonwealth of Massachusetts.

TRC | www.trcsolutions.com

Smart objects doing more and consuming less

The latest ultra-low-power microcontrollers from STMicroelectronics can act as the central controller in a full range of fitness bands, smart watches, small medical equipment, smart meters, smart industrial sensors, and more. All these applications require sophisticated functions, instant responses, and minimal downtime for battery charging. STM32L4+ gives application designers features such as a strong processor performance with large on-chip memory, and advanced graphics capabilities for smooth and fluid user experiences. The new Chrom-GRC graphics controller can handle circular displays (TFT-LCDs) just as efficiently as square ones, without wasting resources managing pixels that are never displayed. Also on-chip is ST's Chrom-ART Accelerator, which enhances graphics performance.
STMicroelectronics | www.st.com

events**calendar**

MAY

07-10 **AWEA WINDPOWER 2018 Conference & Exhibition**
Chicago, IL; www.windpowerexpo.org

10 **Wind Energy Town Hall**
Chicago, IL; www.awea.org

11-12 **Solar Power Southeast**
Loews Atlanta Hotel – Atlanta, GA; www.events.solar/southeast/

19 **26th Anual Solar Boat Regatta**
Eden Prairie, MN; www.mnrenewables.org/solar-boat-regatta/

20-23 **Federation of New York Solid Waste Associations Strive For Sustainability Solid Waste & Recycling Conference with Trade Show**
The Sagamore, Bolton Landing – Bolton Landing, NY; www.nyfederation.org

JUNE

06-08 **Modern Solutions Power Systems Conference (MSPSC)**
Chicago, IL; www.selinc.com/MSPSC/home/

11-13 **12th Quebec Wind Energy Conference**
Baie Bleue Hotel – Carleton-sur-mer, QC; www.eolien.qc.ca

13-14 **Solar Power Texas**
Sheraton Austin Hotel at the Capitol – Austin, TX; www.events.solar/texas/

15-17 **The 29th Annual Energy Fair**
Norris Conference Centers Houston/City Centre – Custer, WI; www.theenergyfair.org

20-21 **36th West Coast Energy Management Congress (EMC)**
Washington State Convention Center – Seattle, WA; www.energyevent.com

26-27 **Regional Wind Energy Conference - Northeast**
Portland, ME; www.awea.org

JULY

10-12 **Intersolar North America**
Moscone Center – San Francisco, CA; www.intersolar.us

10-12 **ees North America**
Moscone Center – San Francisco, CA; www.ees-northamerica.com

17-19 **2018 Plugvolt Battery Seminar**
Plymouth, MI; www.plugvolt.com

SEPTEMBER

05-06 **Wind Power on Capitol Hill**
Washington, DC; www.awea.org

11-12 **Wind Resource & Project Assessment Conference**
Sheraton Austin Hotel at the Capitol – Austin, TX; www.awea.org

13-14 **Offshore Wind Executive Summit**
Houston, TX; www.offshorewindsummit.com

21-22 **Microhydro System Design and Installation Workshop**
Appalachian State University – Boone, NC; www.energy.appstate.edu

24-27 **Solar Power International 2018**
Anaheim Convention Center – Anaheim, CA; www.solarpowerinternational.com

OCTOBER

01-02 **Wind Energy Finance & Investment - East**
New York, NY; www.awea.org

05 **Wind Energy Finance & Investment - West**
San Francisco, CA; www.awea.org

10-11 **Horizon18**
Boston Convention and Exhibition Center – Boston, MA; www.awea.org

16-17 **Offshore WINDPOWER Conference**
Hyatt Regency Washington on Capitol Hill – Washington, DC; www.awea.org

NOVEMBER

06-08 **ESNA 2018**
Pasadena, CA; www.esnaexpo.com

13-15 **Wind Energy Fall Symposium**
Colorado Springs, CO; www.awea.org

JANUARY 2019

23-24 **The Energy Expo**
Miami Airport Convention Center (MACC) – Miami, FL; www.awea.org

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21	Nordic Fiberglass	www.nordicfiberglass.com
23	Olympus America	www.olympus-ims.com
40+41	OMCO Solar	www.omcoracking.com
27	Panasonic	business.panasonic.com/solarpanels
54	Parker Hannifin Corporation - Parker Energy Business Unit	solutions.parker.com/AWEA2018
58	Phoenix Contact	www.phoenixcontact.com/wind
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