Distributed energy resources (DER)

Products and solutions for the DER transformation
Distributed Potential

The electric power grid as we know it is changing ...

Traditionally, electric power grid economics dictated the use of large central generation stations and one-way power flow to customers. Today, however, these economics are being challenged by an even greater need to minimize investments in new grid infrastructure due to changing load patterns, high peak demands and aging equipment. Distributed Energy Resources (DER), a marriage of local electric generation, power storage, customer demand reductions (demand response) and information technology is one way this challenge is being met. Low-cost wind, solar and natural gas electric generation or power storage technologies located at or near end-user sites are driving the economics of DER. For customers not directly involved with distributed generation or storage, DER provides an added benefit in minimizing future costs for new grid infrastructure.

DER does not alter the requirements for proper grid operation in the areas of reliability, power quality and availability. In fact, additional investments are required in the areas of communications, networking, substations and other infrastructure improvements in order to operate an electric power grid in a stable and predictive manner. The role of the electric utility is changing also. No longer limited to just an electric power supplier, utilities are increasingly transforming themselves into a power coordinator role, in which they communicate and balance the needs of all electric grid elements to ensure proper operation.

Phoenix Contact is part of the DER revolution. At many of our facilities throughout the world, efficient on-site electric generation and automated demand response are helping to reduce our electric power grid footprint, protect the environment and reduce energy costs. Our experience with DER allows us to gain valuable insight into developing effective solutions to meet our customers’ DER project needs and requirements.

Beyond our own experiences, many of the products and solutions in the Phoenix Contact portfolio can help meet the needs of DER installations. The areas of reliable connections, efficient communications, secure data transmission and effective monitoring are all important elements in implementing DER systems. The stories in this issue of Update magazine contain just a few examples of ways Phoenix Contact can partner with you in the DER transformation.
Renewable power generation in the United States

In 2013, RENEWABLE ENERGY accounted for 10% total U.S. energy consumption and 13% electricity generation.

The largest share of electricity generated by RENEWABLE SOURCES in 2013 came from:
- 52% hydroelectric power
- 32% wind
- 8% biomass
- 4% biomass waste
- 3% geothermal
- 2% solar
- 8% wind
- 3% solar
- 2% geothermal
- 1% biomass
- 1% hydroelectric
- 1% other renewable

Electricity generation from wind increased from about 6 BILLION KILOWATTHOURS in 2000 to roughly 168 BILLION KILOWATTHOURS in 2013.

Most renewable-generated electricity is from HYDROPOWER.

Renewable Portfolio Standards require electricity providers to generate or acquire a percentage of generation from renewable sources. Most states have renewable portfolio standards or goals.

Sources:
http://www.eia.gov/tools/faqs/faq.cfm?id=92&t=4
http://www.eia.gov/energy_in_brief/article/renewable_electricity.cfm

Source: Interstate Renewable Energy Council, Database of State Incentives for Renewables & Efficiency (as of March 2014)
Distributed sources

Distributed power generation requires new solutions

Power generation is in a constant state of change, transforming from a central structure into a distributed one, driven by the energy revolution. The demands placed on technology are changing, and manufacturers and users are faced with new challenges in terms of distributed generation applications. Phoenix Contact is very much a leader in this sector and supports customers with focused solutions.

From the very start, Phoenix Contact has actively worked with companies involved in power generation and transmission. This is highlighted in particular by the fact that the first modular terminal block was developed back in 1928 in response to the demands from the field of power transmission. To this day, Phoenix Contact continues to be a recognized technology and solution partner for this industry. Numerous designers and operators of power stations use products from the Phoenix Contact, ranging from connection technology, electronic components, surge protection and automation solutions.

Driven by the industry’s need for maximum reliability of supply, Phoenix Contact has established an understanding of quality and a high degree of application competence, which many of our partners rely on today.

Demand for new technologies and competencies

In recent years, the development of distributed energy generation systems, such as wind power plants, photovoltaic systems or combined heat and power plants, has advanced significantly, both economically and technologically. This has influenced the products and services offered by Phoenix Contact.
A much discussed topic in photovoltaics is DC power technology in connection with the special requirements of the installation environment. For example, in an inverter high-direct currents need to be incorporated safely on a PCB. In field cabling, fast and above all error-free installation technology is required. In a larger system with several strings, the strings must be combined in a durable solution in string combiner boxes. The temperature response during operation is the key factor here. Last but not least, in larger photovoltaic systems, currents need to be measured and processes need to be controlled and visualized — for example, in tracked systems.

With regard to combined heat and power plants, they present other challenges: internal control processes have a significant influence on efficiency and are a particular area of focus for manufacturers and operators. Control technology, teamed with consultation and engineering, can provide the key to increasing efficiency.

Wind power plants also place particular demands on control technology and electrical equipment: the operator’s need for maximum availability means that servicing is often complex, especially in the case of offshore systems. Vibration and shock, as well as increased operating voltages, mean that sophisticated solutions are required. Numerous international manufacturers rely on Phoenix Contact’s experience and product quality in this field.

**Distributed sources for power generation**

Along with the direct generation technology, the added challenge of distributed power generation compared to a central structure is remote accessibility. Central large-scale power stations are manned — i.e., operating personnel are there directly on site in order to operate and maintain the plant. This is not the case with distributed generation systems. There is no one at the inverter station of a PV system, at a small-scale combined heat and power plant or in the nacelle of a wind power plant.

Along with wind or solar park management, remote control technology has become more important than ever before due to the distance from other installations. In order to ensure the reliable operation of distribution networks, it is essential that local stations and distributed generation systems are integrated into the system in terms of communication. Phoenix Contact also offers numerous tried-and-tested components for this challenge, including complete solutions, which have been rigorously tested in combined operation.

**Frank Welzel**

[www.phoenixcontact.com](http://www.phoenixcontact.com)
Cybersecurity for critical control systems in the power industry

Best practices and recommendations for preventing and detecting cyber attacks

It has become almost a weekly occurrence to read about some new cyber security attack, whether it is intended to obtain private information or to deliberately bring down a particular company’s network. However, cybersecurity attacks are not limited to just IT networks. With the advent of Stuxnet, cyber security attacks on control and SCADA systems have become a reality. The threat of cyber security attacks on our nation’s critical control systems infrastructure, which includes power generation facilities, presents yet another challenge to utility directors and staff.


The National Cyber Security Division (NCSD) established the Control Systems Security Program (CSSP) and the Industrial Control Systems Cyber Emergency Response Team (ICS-CERT) to protect and secure our critical control systems and the rising threat of cyber attacks. ICS-CERT is responsible for responding to control systems incidents, including on-site services as well as coordinating vulnerability studies and the disclosure of this information to the public. In its recent annual review, ICS-CERT noted that, of the 200 incidents during the first half of 2013, more than 50 percent belonged to the energy sector.

Stuxnet

The most infamous cyber attack to date is “Stuxnet,” which was discovered in 2010. Stuxnet, which has been well documented in both the industrial and mainstream press, was an incredible eye opener in many ways. Ralph Langner, a German cybersecurity consultant who worked on deciphering the Stuxnet code, deemed it a “cyber weapon of mass destruction.” Two important facts remain:

- It was the first reported malware to target an industrial control system. Stuxnet confirmed that industrial control systems are vulnerable and can be exploited, leading to significant damage.
- With the discovery of Stuxnet, the concern now is copycat attacks. With this code being discovered and available to the world, potential cyber terrorists can use it as a blueprint to attack critical infrastructure in the United States and throughout the world.

NERC-CIP cybersecurity standards

In the United States, the energy sector has made significant strides in protecting the critical cyber assets at power generation facilities through the voluntary efforts of the North American Electric Reliability Corporation (NERC). A nongovernmental,
independent and not-for-profit organization, NERC seeks to ensure the reliability of the bulk electric system in North America through the development and enforcement of standards. NERC is subject to oversight by the U.S. Federal Energy Regulatory Commission, but as of June 2007, NERC was given the legal authority to enforce reliability standards with all users, owners and operators. These reliability standards include the Critical Infrastructure Protection (CIP) Standards. (For a more detailed discussion of the specific requirements of the NERC-CIP standards, please see the white paper referenced at the end of this article.)

Best practices and recommendations

Energy facilities and utilities can apply several best practices to help meet the requirements of the NERC-CIP standards, including:

Device-Level Firewalls – Protecting the process controller with a device-level firewall can add significant robustness to a Bulk Electric System (BES) Cyber System.

Multiple Firewall Manufacturers – Using redundant firewalls from multiple manufacturers increases protection against exploitation of one company’s security vulnerabilities. The firewalls should use the same set of rules and configuration parameters. This will provide time to patch potential vulnerabilities.

SIEM Technologies – Security Information and Event Management (SIEM) technologies provide a central console for security personnel to review logs from Intrusion Detection Systems, firewalls and other cyber security devices. This streamlines the review of logs, SNMP traps and event management.

Patch Management – While security patch management is difficult, especially with legacy control systems, DHS recommends that end users or responsible entities (RE) put a proper backup plan in place for each cyber asset in the network. This includes testing in a simulated environment and verifying those results with vendors for double verification.

Where we are headed

Cybersecurity in the industrial world is already maturing to catch up to the enterprise world. “Conveniences” such as keeping the same password on a system for 10 years and open access to all data will be replaced by common-sense security practices. These practices will include much more authentication and authorization – most likely with a combination of passwords, certificates, smart cards and biometric data. Accessing data, performing programming updates or pulling diagnostic information will all result in a much larger audit trail than exists today. Information about “who did what when from where” will be logged, audited and reviewed.

Data will require more stringent safeguards. It will be protected where it resides and encrypted when it travels, as VPNs will be put to greater use in both inter- and intra-network communications. Vendors will need to integrate more aggressive security into their products. Clear text authentication and unauthenticated protocols will no longer be acceptable to the industry (or the government and compliance officers), forcing security down to a lower and more fundamental level of the system.

As the presidential executive order demonstrates, the U.S. government recognizes that protecting our critical infrastructure from a major cyber incident is of paramount importance. Of the 16 critical infrastructure sectors, the power industry continues to be at the forefront of promulgating regulations and standards and adding enforcement measures to protect our bulk electric systems.

W. Michael Sutton, Deralee Bowlin and Dan Schaffer


REFERENCES


In order to achieve maximum possible system availability and therefore maximum profitability, renewable energy generation places special requirements on the components installed in systems. The power supply is very important: if the controller of a tracking system is not supplied with 24 V DC, for example, the solar system cannot generate a high yield.

The demands placed on power supplies vary depending on the type of renewable energy being generated. In solar systems, for example, single-phase power supply units from Phoenix Contact’s Quint Power series are used, which usually operate with nominal currents of 5 A or 10 A at an output voltage of 24 V DC. The modules are used to supply the tracking system controller. This type of tracking system continuously orients the solar collector or the solar lens toward the sun.

Weather stations are another area of application for the industrial power supply units. Here, performance-related weather data for the photovoltaic system is measured and sent to the controller. The values that are recorded include the global irradiance, the module temperature, humidity and air temperature.

Wide temperature range

An essential requirement for power supplies used in this field is that error-free operation is ensured over a wide temperature range. All the devices in the Quint Power series are therefore designed for ambient conditions from -25 °C to +70 °C. A cold restart is even possible at -40 °C.
With efficiency in excess of 94 percent, the Quint Power power supply units generate just a small amount of power dissipation, which results in negligible self-heating. In addition, photovoltaic systems involve high voltages, which can put a strain on the power supply. For this reason the power supply units are designed for an electric strength of up to 300 V AC. The voltage shoots up, especially when inverters switch off. On account of this, the Quint Power power supplies are exposed to surge current loads (surge) in accordance with EN 61000-4-5 in test procedures. High values of 4 kV in the case of asymmetrical loads and 2 kV in the case of symmetrical loads mean that they can be used under challenging conditions.

High shock and vibration resistance

Superior levels of performance are required in wind power plants. The Quint Power modules with 24 V DC output voltage are also used here. Single- and three-phase power supplies supply nominal currents of 10, 20 or 40 A.

So that the angle of attack of the rotor blades changes according to the wind force, pitch systems are operated hydraulically or using electric motors. The power supply units supply the motors and the pitch controller with an adjustable output voltage of 18 to 29.5 V DC according to the application. All modules inside the rotor hub are subjected to extreme vibrations.

With all this in mind, the power supply units meet particularly high demands with regard to shock and vibration. The vibrations are measured during operation in accordance with standard IEC 60068-2-6 with 15 Hz at an amplitude of ±2.5 mm. Furthermore, all power supplies undergo testing at 15 Hz to 150 Hz, where they are subjected to a 2.3g load for 90 minutes. Shock testing according to IEC 60068-2-27 is performed with a 30g load in each space direction.

Sufficient power reserves

The power supply units must operate reliably, even when the mounting position is rotated. This is because the devices rotate in the rotor hub and the recommended mounting position is not possible. In this case, convection cooling is no longer optimal and the modules automatically reduce the output current. The nominal current is then no longer available. In order to avoid voltage dips, the option of planning a power reserve provides security for the system operator.

Thanks to the static Power Boost power reserve, the Quint Power power supplies supply a constant voltage, which is up to 1.5 times the nominal current.

Preventive function monitoring

Thanks to continuous monitoring of the output voltage and current, critical situations are visualized and indicated to the controller via an LED, floating relay contact and active signal output before problems can occur.

All devices with the designation “CO” (coated) satisfy extreme environmental requirements. For these devices, the protective coating on the PCB protects all wired components, such as bridge rectifiers or power semiconductors, against dust, corrosive gases and 100 percent humidity as well as against failure caused by corrosion-related creepage currents and electrochemical migration. In addition, OVP (Over Voltage Protection) limits surge voltages to 32 V. The temperature range is further extended to cover -40°C to +70°C.

Anja Moldehn
www.phoenixcontact.com
Transparent yield
DC monitoring in the Zuera II solar park in Spain

In Spain, solar irradiation values of up to 2100 kWh/m² are reached each year. So that this energy does not go unused, a growing number of megawatt systems are being created to generate solar power. The long-term efficiency of these systems depends on the use of high-quality components and, crucially, maintenance. Operational management and monitoring must therefore be optimally organized and sustainable. In the Zuera II solar park, the feed in power of the PV modules is measured and visualized down to the actual segment. The solution used here is from Phoenix Contact.

The Zuera II solar park, situated near the city of Zaragoza in northern Spain, has a capacity of 11.5 megawatts. The system consists of 54,000 crystalline modules, which track the course of the sun on a horizontal single axis. The system, which covers an area of more than 30 hectares, generates solar power for more than 10,000 inhabitants. In total, it has helped to reduce carbon dioxide emissions by more than 40,000 tons per year.

The 2,034 strings of the solar park are divided into nine segments of 256 strings each. Each of these segments is connected to two central inverters via 16-string combiner boxes. To ensure the continuous and efficient operation of the entire system, as well as effective maintenance, the operator requires constant monitoring of the strings. To achieve this, Phoenix Contact designed a string combiner box for 16 strings using the Solarcheck string monitoring modules.

Alarm generated in the event of unusual deviations

The operator relies on a web-based visualization solution from Phoenix Contact for the visualization and monitoring of the 12,000 or so values and messages from the solar park. This solution shows the performance and weather data for the system, which the operator can either access locally via a web page or view in real time via the Internet. This way, the operator has access to all relevant information available at all times from any location. The web page provides a meaningful overview of the actual power produced by each individual segment of the solar park. An error report documents any failures that have occurred, while an alarm system or SMS notifies maintenance personnel directly in the event of unusual deviations. For troubleshooting, more detailed information about the device that caused the fault is always available with just a click of the mouse.
The measuring data can be attributed exactly to the respective strings in the field, since they are stored in a predefined register table. The table clearly lists each current measuring channel and each measuring module on the communication module.

Efficient use of staff and resources

DC string monitoring is the backbone for control and monitoring at the Zuera II solar park. Thanks to the accurate acquisition of measuring data, maintenance personnel can take the necessary targeted action quickly in the event of errors. This also reduces operating costs in the long term, as the staff and corresponding resources required for maintenance work can be used efficiently. The modularity and effectiveness of the Solarcheck string monitoring system also impressed the operator. The capacity of the measuring modules in the 16-string combiner boxes has proved ideal. Furthermore, the energy supply for the entire string monitoring system has been implemented efficiently, as there is no need for a power supply in the string combiner boxes. The measuring modules are instead supplied with energy via the communication cabling provided in the respective control boxes.

Through complete control of the solar park based on string monitoring and the visualization of the values acquired, energy yield is safeguarded in the long term. The operator chose Phoenix Contact based on the high quality of the overall solution as well as the comprehensive support for components and systems.

The automation specialist’s team provided support throughout the startup phase. As all questions from the companies involved in the construction project were swiftly answered, the solar park was able to feed into the power grid as planned.

Lotte Ehlers, Maren Gast
www.phoenixcontact.com
the same performance in less space – the trend toward downsizing also extends to the PV industry: since the cost of materials and logistics is lower for flatter photovoltaic modules, solar modules are becoming increasingly smaller, even as their performance and capacity increases. This development presents a challenge for manufacturers of modules with fully integrated inverters.

Flat photovoltaic modules require compact inverters with equally compact connection technology, all of which should fit in the module frame. Conventional circular connectors with an average height of 25 mm, however, are often too big for this application. The rectangular Sunclix micon AC connection system from Phoenix Contact is just 20 millimeters tall, making it ideal for slim photovoltaic modules.

Sunclix micon is based on components from the field-proven Sunclix family. AC Y connector and main connector versions are available with a three-position mating face for the North American and European market. The connection system is likewise suitable for traditional trunk drop and daisy chain cabling. The key feature: with Sunclix micon the drop line is not inserted in the trunk line; instead, it is integrated into one of the two trunk connectors to form a Y. The trunk line remains intact, and unnecessary contact resistance is avoided.

Safe connection

The IP67 connector has a robust locking mechanism that reliably prevents unintentional disconnection. If the manufacturer wishes to maintain or extend the photovoltaic modules, the connector can be removed easily and conveniently using the special unlocking tool. The tool is simply attached to the connector and this releases the latch on the side.

Sunclix micon has been specially developed for the requirements of photovoltaics and is also suitable for other outdoor applications. It is resistant to UV radiation, ammonia and salt water. The pre-assembled customer-specific connectors also reduce the installation time on site.

Andreas Beck
www.phoenixcontact.com
New M23 hybrid connectors for signal, data and power transmission

The new M23 hybrid circular connector from Phoenix Contact is an all-in-one connector that securely transmits signals, data and power. The compact M23 connector can handle currents up to 30 A and voltages up to 850 V DC or 630 V AC.

The connector features a centrally located protective earth (PE) ground, along with four power contacts and four signal contacts. The data pins have a 0.8-mm diameter and can provide an optional Ethernet connection in accordance with CAT 5e.

www.phoenixcontact.com/hybridconnectors

Multifunctional safety relay

The PSR-MXF multifunctional safety relay is the newest addition to the Phoenix Contact PSR safety relay line. This relay can help small and medium machine builders reduce cost and save space. The PSR-MXF accepts up to three dual-channel safety sensors: two local, independent sensor circuits, as well as an overriding safety circuit useful for simultaneous shutdown. With this safety circuit, one safety relay can do a job that would otherwise require three safety relays or a configurable safety relay.

www.phoenixcontact.com/multifunctionalsafetyrelay

Leverage the power of the industrial computer for control

PC WORX SRT (Soft Real Time) is a cost-effective control system that runs within the Windows operating system environment. It features programming using PC WORX Express, the free version of the PC WORX development platform.

Features include:

- Remote connectivity using MODBUS TCP and PROFINET, as well as Phoenix Contact’s extensive library of IT protocols
- Use of the BPC Mini’s onboard I/O system

www.phoenixcontact.com/pcworx

Molded Deutsch and Superseal cordsets for mobile hydraulic applications reduce on-site installation costs

Phoenix Contact now offers Deutsch and Superseal connectors as pre-molded cordsets. These connectors are 100 percent factory tested and ready for use in mobile hydraulic applications. While the Deutsch and Superseal connectors are well established as quality field-wired solutions, crimp technology and on-site installation often add to hidden labor costs.

www.phoenixcontact.com/outdoorcabling
Owners, investors, EPCs: Maximize every dollar you invest in your solar array. Only one string-level PV monitoring system can do that: SOLARCHECK from Phoenix Contact.

**SOLARCHECK allows you to:**

- **Receive clear and precise fault monitoring**
  - Quickly identify faults in the affected array string via a standard MODBUS control system connection

- **Eliminate combiner box power supplies**
  - Power via the data cable eliminates extra cost, reduces heat and simplifies installation

- **Maximize ROI**
  - Ensure that your solar array is generating as much revenue as possible, at all times

- **Position anywhere in the box**
  - Vertical, horizontal or anywhere in between; mounting simplifies combiner box layout

To learn more about SOLARCHECK, call 1-800-322-3225 or visit: www.phoenixcontact.com/solarcheck