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Simply More Reliable Solar

Laying the Foundation for the Grid-Tied Smart Inverter of the Future

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The purpose of this white paper is to highlight the major economic benefits and technical advancements PV Powered and its partners—Portland General Electric (PGE), Schweitzer Engineering Laboratories (SEL), Sensus, and Northern Plains Power Technologies (NPPT)—are pursuing under the Solar Energy Grid Integration System (SEGIS) Stage 2 program to address the challenges utilities will experience as the penetration of distributed photovoltaic power generation increases.

The SEGIS program advancements will help lay the foundation for an "intelligent" or smart inverter capable of integrating large-scale photovoltaic power generation into the Smart Grid with greater stability and protection, and at a far more competitive Levelized Cost of Energy. By providing the monitoring, control, and other capabilities utilities need to successfully integrate high penetrations of distributed photovoltaic power, the industry will be in a better position to satisfy even the most aggressive Renewable Portfolio Standards.

Introduction

- In the next 10 years the electric grid will change more than it has in the past 50. Some utilities are already embracing the new Smart Grid; others are clinging to the status quo, believing "if it isn't broke, don't fix it." But whether driven by mandates or market forces—or both—the migration to the Smart Grid is inevitable for all electric utilities.

- The primary driving force is the Renewable Portfolio Standard (RPS), which a growing number of states are adopting to set target percentages and dates for the integration of renewable sources of energy. The impact on the grid of large-scale intermittent distributed energy resources like wind and solar will be profound, forcing the grid to transition from a one-way source of power distribution to an intelligent, multi-directional infrastructure. Society and utilities both stand to benefit in many ways long-term as the percentage of renewable sources grows, although achieving these benefits will require overcoming some challenges.

- In its Renewable Systems Interconnection Technical Report, the U.S. Department of Energy (DoE) states: "Now is the time to plan for the integration of significant quantities of distributed renewable energy into the electricity grid. Concerns about energy independence, climate change, the adoption of state-level renewable portfolio standards and incentives, and accelerated cost reductions are driving steep growth in U.S. renewable energy technologies. The number of distributed solar photovoltaic (PV) installations, in particular, is growing rapidly. As distributed PV and other renewable energy technologies mature, they can provide a significant share of our nation's electricity demand. However, as their market share grows, concerns about potential impacts on the stability and operation of the electricity grid may create barriers to their future expansion."

- To address the challenges presented by high penetrations of distributed PV power generation, the DoE created the Solar Energy Grid Integration System (SEGIS) program. (See sidebar.) The challenges of integrating renewable energy sources are becoming familiar to many utilities as the percentage of intermittent generation, such as solar and wind, continues to increase over traditional power sources. One of the biggest challenges with photovoltaic power is the existing requirement in the IEEE 1547 and UL1741 standards for inverters to disconnect from the grid at the first sign of instability, which limits the inverter's ability to help stabilize the grid. But as the penetration of PV power production increases, such behavior threatens to undermine grid stability and the real potential of this important renewable source of energy. With smarter inverters capable of contributing to grid stability, utilities stand to gain the monitoring and control they need to successfully integrate PV power on a large-scale, distributed basis.

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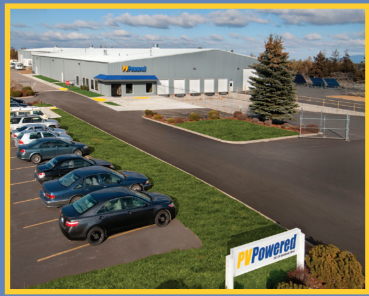

SEGIS Vision and Objective

The SEGIS Program Concept Paper outlines the following vision and primary objective for the program:

Vision: Solar Energy Grid Integration Systems (SEGIS) concept will be key to achieving high penetration of photovoltaic (PV) systems into the utility grid. Advanced, integrated inverter/controllers will be the enabling technology to maximize the benefits of residential and commercial solar energy systems, both to the systems owners and to the utility distribution network as a whole. The value of the energy provided by these solar systems will increase through advanced communication interfaces and controls, while the reliability of electrical service, both for solar and non-solar customers, will also increase.

Program Objective: The objective of this program is to develop the technologies for increasing the penetration of PV into the utility grid while maintaining or improving the power quality and the reliability of the utility grid. Highly integrated, innovative, advanced inverters and associated balance-of-system (BOS) elements for residential and commercial solar energy applications will be the key critical components developed in the effort. Advanced integrated inverters/controllers may incorporate energy management functions and/or may communicate with stand-alone energy management systems as well with utility energy portals, such as smart metering systems. Products will be developed for the utility grid of today, which was designed for one-way power flow, for intermediate grid scenarios, and for the grid of tomorrow, which will seamlessly accommodate two-way power flows as required by wide-scale deployment of solar and other distributed resources. For more information, see www.sandia.gov/SEGIS.

- Sandia National Laboratories, tasked by the DoE with administering the $24M SEGIS program, utilizes a competitive bidding process to determine award recipients. Of the 27 proposals received during Stage 1 for Proof-of-Concept and Feasibility, PV Powered was one of 12 recipients. During Stage 2 for Prototype Design and Testing, only five awards were granted, including one to PV Powered for development of prototypes for advanced inverters and other balance of system (BoS) components. Based on the company's history of innovation leadership and the technical merits of its proposal, PV Powered received the largest award granted in Stage 2. The SEGIS program includes a future Stage 3 for full commercialization of the prototypes developed in Stage 2.

- The purpose of this white paper is to highlight the major economic benefits and technical advancements that PV Powered and its partners—Portland General Electric (PGE), Schweitzer Engineering Laboratories (SEL), Sensus and Northern Plains Power Technologies (NPPT)—are pursuing under the SEGIS Stage 2 program. Building on those advancements already made by PV Powered, including in SEGIS Stage 1, these additional advancements will help lay the foundation for a grid-tied smart inverter capable of integrating high penetrations of distributed photovoltaic power generation.

Advancing the State-of-the-Art for Smart Inverters

PV Powered's Stage 2 SEGIS project addresses both economic and technical challenges involving the inverters used in PV power generation. The material in this section is, therefore, divided into these two areas:

1. Energy Economics, which covers the five advances that have the greatest impact on lowering the Levelized Cost of Energy for photovoltaic power generation; **and**

2. Utility Systems Integration, which covers three technological advances that together complete the foundation for a smart grid-tied inverter.

The focus on inverters here is not meant to downplay the importance of solar panels and other balance of system components in the economics and technology of photovoltaic power generation; its emphasis is, rather, a recognition of the key role the inverter will play as a smart interface to the utility's Smart Grid. As such, the smart inverter has paramount importance to a utility's ability to successfully integrate distributed PV power generation on a large scale.

Energy Economics

SEGIS is part of the DoE's Solar America Initiative (SAI) that has a goal to make PV power cost-competitive with other sources of energy by 2015. Lowering the Levelized Cost of Energy (LCOE) by reducing lifetime PV system costs and increasing overall PV performance are, therefore, also goals of SEGIS — and PV Powered. Five such advances are highlighted here.

Improving Inverter Reliability

Objective: Enable more dependable production of photovoltaic power by minimizing disruptive and costly failures in the inverter.

Historically, inverters have been one of the least reliable components in a solar power generation system. The reason is understandable: Harsh environmental conditions place tremendous stress on this piece of electronic equipment. Traditional hydroelectric, nuclear, and coal- or gas-fired power plants typically reside in a controlled environment. By contrast, most components of a solar PV power plant are directly exposed to the outside environment, subjecting them to temperature fluctuations and extremes, humidity, corrosive elements, dust and other environmental stresses that are influenced by the geographic location of the installation and which must be factored into any reliability analysis.

PV Powered's work under the SEGIS program will, therefore, build on the existing industry-recognized advances the company has made in the field of inverter reliability. PV Powered has designed commercial and utility-scale inverters from the ground up for maximum reliability and uptime with improvements at the component, sub-system and system levels, and extensive quality control measures are utilized during the manufacturing process. Rigorous stress-testing with root cause analysis during the design phase yielded the greatest gains in reliability, while redundant Smart Air Management™ cooling features help extend the service life of the inverter.

To accurately predict component stresses and associated wear-out mechanisms that solar inverters experience due to natural cycles, a complex time-dependent modeling approach is required. Because temperature cycling contributes to device wear-out, simpler constant hazard rate and MTBF calculations that might apply in other situations are not accurate in this case. PV Powered has created a set of time-dependent prediction tools and analytical methods to predict real-world inverter reliability with much greater accuracy and granularity than the simpler methods commonly used today.

The result of these efforts is the industry's first 20 year warranty offered as an option on all commercial PV Powered inverters. Continual improvements in reliability, combined with the advances being made under the SEGIS program, may enable PV Powered to extend the warranty to 25 or 30 years, further lowering LCOE for PV power generation.

Increasing Energy Harvest

Objective: Demonstrate and quantify possible energy harvest improvements, under both static and dynamic irradiance conditions, with Maximum Power Point Tracking (MPPT) algorithms optimized for specific solar module types.

Although MPPT functionality is fundamental to inverter technology, its greatest contribution is ultimately economic. Inefficient solar power generation increases LCOE, and further improvements are necessary to achieve PV power parity on the grid. The situation is further complicated by the lack of universally accepted Maximum Power Point (MPP) efficiency testing standards.

Under the SEGIS program, PV Powered is pursuing two developments. The first is a proposed MPP testing plan, which weights static and dynamic irradiance and temperature conditions equally, quantifying the efficiency of the inverter to track the Maximum Power Point of the connected solar panel array. As an essential metric for total energy harvest, the proposed testing matrix will take into account observed energy harvest of the total PV system. Conversion efficiency is also a vital metric in the planning, development and even the rebate structures of PV installations. But current metrics fail to reflect the contribution of MPP efficiency to the overall efficiency of the inverter system, and ultimately, to the actual energy harvest of the PV power system. The proposed testing methodology would allow for third-party measurements to qualify MPP performance of inverter manufacturers as part of a standard listing. The end result would be an efficiency number (much like the California Energy Commission's efficiency number) that more accurately quantifies the ability of the inverter to harvest energy from the solar panel arrays.

The second development effort is intended to produce a set of MPPT algorithms optimized for different types of solar modules. The different fill factors, temperature and irradiance effects, as well as settling times for different solar modules, are driving the need to improve energy harvest algorithms and otherwise maximize the total energy harvest from each type of module. The algorithms being developed allow the inverter to be "customized" to the specific module type and perhaps manufacturer, enabling it to perform optimally with commercially available solar module panels. The plan is to include the following solar module technologies: crystalline silicon, thin film silicon, copper indium gallium arsenide (CIGS) and cadmium telluride (CdTe), including in concentrated photovoltaic (CVP) and tracking configurations. The effort also includes incorporating enhancements being made to DC-side intelligence (DC boost) and functionality at the string- and subarray-level that contribute to increased energy harvest.

About Northern Plains Power Technologies

Northern Plains Power Technologies (NPPT) is an engineering services firm providing support to the renewable electricity industry. NPPT primarily performs computer simulation services, and can provide model development, model verification, complex system simulation, and development of system design and control requirements and recommendations. The company works with National Laboratories, utilities, manufacturers of renewable energy equipment, and other engineering services firms. NPPT is based in Brookings, South Dakota. For more information, see www.northernplainspower.com

Enhance Balance of System Monitoring and Performance

Objective: Development of string and zone monitoring and control solutions capable of improving overall system uptime and performance.

While string-level monitoring could contribute substantially to improving overall PV energy harvest, the technology has proven to be very difficult to integrate cost-effectively into the PV control system. As a result, its use has been limited. An effective but less expensive approach is needed to lower LCOE for distributed PV power.

This effort builds on PV Powered's existing IntelliString™ line of smart string combiner boxes. IntelliString's performance monitoring at the string level enables more rapid and accurate diagnosis of PV system underperformance due to failed modules, shading or soiling. Enhancements under the SEGIS program for inverter-integrated string and zone combiner monitoring are expected to further reduce downtime and, thereby, improve system performance and lower total lifetime costs. To maximize the benefit, these enhancements will be tightly integrated with the existing inverter monitoring and control system that continuously measures and records its power output.

Improve Solar Power Forecasting

Objective: Utilize forecasting and other techniques to minimize problems caused by the adverse effects of irradiance transients, which are currently a barrier to effective short- and long-term planning for integration of distributed photovoltaic power resources.

Rapid changes in cloud cover create intense power transients that can shorten the life of switch gear, and distort power quality and stability at the host facility and in the utility grid. The transients also make it difficult for power producers, energy traders, utility dispatchers and commercial users to effectively match PV power generation to electrical demand.

This PV Powered effort under the SEGIS program leverages a partnership with Northern Plains Power Technologies (NPPT) to pursue enhancements at two levels:

1. Utility level with the use of long-term irradiance forecasting to enable more accurate predictions for optimal integration into utility planning processes; **and**

2. Inverter level with the use of real-time satellite imagery on cloud position, movement and transparency to soften weather induced transients.

Integrating weather "awareness" into the inverter control system is the most promising approach for reducing the adverse effects of cloud position, movement and transparency. When coupled with the ability of the inverter to curtail output power using pre-defined ramping functions, the result is a reduction of the duty factors on tap changers and other voltage regulation equipment. This effect is more recognizable on feeders with higher penetrations of PV power generation. Further, as a future metric, the inverter's ability to "foresee" cloud transients will allow for more seamless integration of energy storage capabilities. These enhancements are laying the foundation that enables inverters to produce more stable power and avoid faults that can occur during and after cloud transients.

Integration with Building Energy Management Systems

Objective: Ensure that inverters can interoperate with leading building energy management systems using advanced energy control algorithms to minimize energy utilization and costs, and maximize return on investment (ROI).

Under the SEGIS program, the term "Energy Management System" refers to the customer's control over its use of energy, and not to the utility's EMS. As such it involves the participation of the inverter in demand-side management, potentially during an islanding condition.

Integration with building energy management systems will simplify and reduce the cost of managing commercial-scale PV, while unlocking opportunities to utilize PV more effectively as part of a comprehensive energy management strategy. The integration effort leverages standard Modbus communications over both RS485 and TCP to ensure interoperability for basic monitoring of and optional advanced control over inverter's energy production. Integration of the controls, communications and safety features of the PV plant into the building EMS system sets the foundation for future optimization of energy usage, including a path toward reliable, integrated on-site storage. This effort currently involves popular energy management systems from Johnson Controls, Delta, Tridium and Echelon.

Utility System Integration

Many of the challenges to integration of distributed PV power generation on a large scale remain technical. For this reason, the primary objective of SEGIS is "to develop the technologies for increasing the penetration of PV into the utility grid while maintaining or improving the power quality and the reliability of the utility grid." Three such advances are part of PV Powered's efforts under the SEGIS Stage 2 program.

Real-time, Two-way Utility Communications and Control

Objective: Leverage existing and emerging communications technologies, including Advanced Metering Infrastructure (AMI) and others, which already do or will cover utility service areas to enable real-time, two-way communications with and control of distributed smart inverters.

Utilities today are unable to exert significant control over inverters, especially those owned by their customers. Anticipated changes to regulations, which now prohibit such control in most situations, are expected to clear the way for numerous advancements in this area.

PV Powered is working with Sensus during the SEGIS Stage 2 program; however, the objective here is to enable remote inverter control via any networking technology.

As the intelligent node in solar electric power generation, a utility's ability to communicate with and exert control over distributed inverters will facilitate effective integration of high-penetration PV power generation into the grid. These control capabilities include ramp rate, curtailment, power factor (volts-amp reactive support) and on/off functionality. The ability to remotely control an inverter's output characteristics minimizes the adverse impacts of solar power as an intermittent source of energy. The additional ability of a utility to treat distributed generation as an aggregate resource to improve power quality and regulate voltage on the grid facilitates PV penetration rates that can far exceed what is feasible today. This real-time, two way communications capability, coupled with a base-line set of controls, will lay the foundation for a new set of interactive Smart Grid support features for the utility.

About Sensus

Sensus is a time-tested technology and communications company providing data collection and metering solutions for water, gas and electric utilities around the world. Sensus is a transforming force for the utilities of tomorrow through its ability to help customers optimize resources, as well as to meet conservation and customer service objectives. Sensus customers rely on the company for expert, reliable service in order to meet challenges and exceed goals. For more information, see www.sensus.com.

SENSUS

About Schweitzer Engineering Laboratories

Celebrating 25 years of innovation in 2009, Schweitzer Engineering Laboratories (SEL) serves the electric power industry worldwide through the design, manufacture, supply, and support of products and services for power system protection, monitoring, control, automation, and metering. SEL offers unmatched local technical support, a worldwide, ten-year product warranty, and a commitment to making electric power safer, more reliable, and more economical. For more information, see www.selinc.com.

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Smart Islanding Detection and Power Quality Enhancements

Objectives: Develop more intelligent intentional islanding techniques that can enhance power delivery and quality in high-penetration PV scenarios, while still ensuring the safety of utility personnel.

Currently, most inverters cannot differentiate between a true utility outage (when an anti-islanding disconnect is required) and a grid disturbance or brownout situation during which the PV system could actually assist in supporting grid stability. Even for those inverters that can differentiate between these two different conditions in many or most situations, current regulations (IEEE1547/UL1741) typically require the inverter to disconnect from the grid. In addition, many inverters now use a disruptive "perturb and observe" technique to determine if the grid is still connected, which may further degrade power quality, especially in high penetration scenarios. Finally, interactions between inverters from different manufacturers may result in false island detection and increased run-on times that compromise the safety of utility line personnel.

To address these issues, PV Powered is working closely with Schweitzer Engineering Laboratories (SEL) and NPPT on Smart Islanding Detection. Smart Islanding Detection is an enhancement intended to better distinguish between a true island condition and a voltage or frequency disturbance that could benefit from additional power generation by the inverter. The approach employs synchrophasor measurements to enable the inverter to detect both conditions more accurately. The synchrophasor measurements are taken at different locations in the power system, and then compared to provide a precise and reliable method of determining the state of the utility at the point of inverter interconnection.

The use of synchrophasor measurements for island detection has many near-term benefits. These include reducing power quality problems caused by taking active and intrusive "perturb and observe" measurements, and eliminating the potential for increased run-on time in installations with multiple inverters. The use of synchrophasors has also shown to be extremely reliable in detecting islanding events on those inverter installations that are coupled with synchronous generators, motors and other adverse loads on the same feeder line without subjecting it to false trips.

With the development of the synchrophasor-based islanding technique, it becomes feasible to utilize the synchrophasor measurements throughout the grid to implement other grid support and power quality enhancements. For example, intentional islanding for micro-grid partitioning is being investigated and shows promising results, as the islands can be synchronized before re-connection, allowing for loaded islands to be re-energized from a live feed with minimal current surging. Adaptive volts-amp reactive (VAr) compensation techniques are also being investigated that will allow for "self-healing" grid characteristics and improved power delivery to customers. In addition, the knowledge of upstream voltage and current enables the inverter to make changes in its control paradigm to improve power quality, regulate voltage and improve grid stability throughout the feeder line. Finally, synchrophasor-based island detection eliminates the safety concerns associated with multiple inverter crosstalk, inverter-to-generator crosstalk, and feeder lines that have unusual load/generation characteristics.

With the assistance of synchrophasor-based measurements, further enhancements to inverter operation and grid stability will become possible, further laying the foundation for a Smart Grid compatible inverter system.

Distributed and Hierarchical Smart Inverter Management

Objective: Integrate the advancements described above to afford utilities with unprecedented capabilities for managing distributed photovoltaic power generation.

To fully and successfully integrate high penetrations of renewable energy sources, utilities need better visibility into and control over these resources. Such control is virtually impossible today with the lack of standards and certain regulatory restrictions. PV Powered's work under the SEGIS program, therefore, involves both making advances in smart inverter management and coordinating those advances with the pertinent standards bodies.

This aspect of the SEGIS program builds on both existing management capabilities in PV Powered's inverters and the other technology advances being made in the program. The real-time, two-way communications and control capabilities are obviously fundamental to a distributed and hierarchical smart inverter management system. So too are the Smart Islanding Detection and power quality enhancements that together help enable the inverter to contribute to grid stability. These and other advances constitute the flexible communications and control platform that will be needed to interoperate with both the electrical grid of today and the Smart Grid of the future.

Although the "intelligent" or smart inverter management ecosystem is still evolving, some of the essential requirements utilities have for exerting direct control are already apparent. These include (in no particular order): automatic discovery with unique identification; power production monitoring; event data logging; time synchronization; remote on/off control; remote software updating; and power quality scheduling and control (including for storage). Additional capabilities will also be needed, of course, to afford full control over the inverter, and its prominent role in monitoring and managing other balance of system components.

The best and most likely management scenario for distributed generation is a corresponding distributed hierarchy. Under this hierarchy, smart inverters would be monitored and controlled centrally by the utility, either directly or via another system, such as a plant controller. Direct management is likely with individual or master/slave configurations of commercial and residential inverters. A hierarchy of control is likely to exist with large-scale PV power generation facilities, as well as where multiple sources of distributed generation are aggregated into a "virtual power plant."

PV Powered is actively participating with standards organizations to ensure interoperability for the advancements being made under the SEGIS program and elsewhere. These organizations include the National Institute of Standards and Technology (NIST), the Institute of Electrical and Electronics Engineers (IEEE), the Electric Power Research Institute (EPRI) and the SunSpec Alliance (www.sunspec.org). PV Powered is also monitoring other organizations for potential activity involving smart inverter management.

The combination of improving the economics of photovoltaic power and laying a full foundation for the management of smart inverters by utilities, the SEGIS program and PV Powered's leadership role in it are accelerating the adoption of distributed renewable sources of energy and helping to put PV's LCOE on the path to parity with traditional sources of electrical energy.

Portland General Electric (PGE)

PGE (www.portlandgeneral.com) is a fully integrated electric utility that was established in 1889, Today PGE has a 4,000 square-mile service area with a population of some 1,663,000 people and more than 818,000 residential, commercial and industrial customers, making it Oregon's largest electric utility. PGE's peak load has exceeded 4,000 MW, and the utility now has over 12 MW of solar capacity, three-fourths of which is customer-owned.

PGE earned a Solar Business Achievement Award from the Solar Electric Power Association (SEPA) for being the first utility in the nation to develop a unique third-party ownership model (a "turn-key" solar energy engineering, procurement and construction, or EPC, consortium) to help develop large-scale solar projects throughout its service area.

Portland General Electric

Putting the Smart Inverter to Work at Portland General Electric

In a "green" state like Oregon, it should come as no surprise that the largest electric utility, Portland General Electric (see sidebar), now generates over 10% of its electricity with renewable resources. Such an aggressive posture puts the utility well on its way to meeting the Oregon Department of Energy's Renewable Portfolio Standard of 25% by 2025.

Although most of the utility's renewable capacity is currently in wind energy, PGE already ranks 8TH in the nation for total solar capacity, according to the Solar Energy Power Association (SEPA). As a pioneer in distributed, renewable energy resources, PGE knew it would eventually face some challenges integrating wind and solar power. "What we didn't know, is just how soon we would need to tackle these challenges," says Mark Osborn, PGE's Distributed Resources Manager.

Osborn attributes the rapid growth in solar power to a convergence of several factors, including the state's aggressive renewable energy standard, generous federal and state grants and tax credits, the emergence of new business models for both utility- and customer-owned generating facilities, and the continual decline in the cost of PV power. Osborn also notes the growing risks posed by coal-fired plants with the likelihood of future restrictions or taxes being imposed on carbon emissions.

Rather than resist the inevitable, PGE is taking a leadership position by fully embracing PV power. "Most utilities look at distributed solar as just negative load," Osborn explains. "We view solar as the future of renewable energy, and are aggressively pursuing its adoption under several initiatives." Among those initiatives is the partnership with PV Powered under the SEGIS program.

Under this initiative, PGE is installing an enhanced prototype of a PV Powered inverter in a smart islanding demonstration along the Oregon Solar Highway that utilizes measurements from synchrophasors manufactured by Schweitzer Engineering Labs. The Solar Highway, the first of its kind in the U.S., is a photovoltaic proof-of-concept demonstration conducted by a collaboration of PGE, US Bank and the Oregon Department of Transportation (ODOT). The 100+ kW system contains about 8,000 square feet of solar panels extending about the length of two football fields along the right-of-way at the interchange of Interstate 5 and Highway 205 in Tualatin, a suburb of Portland. The state, through the leadership of its governor, has plans to build the world's largest Solar Highway with a total capacity exceeding 3 MW.

During the SEGIS demonstration project, PGE will evaluate different techniques for overcoming challenges in two key areas: unintentional islanding and grid instability, particularly when caused by voltage/frequency sags. According to Osborn: "We've found that inverters are rather benign when generating below 15 percent of the load on any distribution feeder. But as the percentage approaches 30, there can be significant problems if the utility fails to implement some means of monitoring and control."

This aerial view of the Oregon Solar Highway shows the PV Powered inverter located at the west end (left side) of the long array of solar modules.

A particular problem PGE wants to solve is one that results from the now common practice of inverters disconnecting during a voltage or frequency sag. "Sags usually occur during periods of peak demand, just when PV power is normally needed the most," Osborn notes. "Two-way communications with the inverters, combined with constant measurements from the synchrophasors, should enable us to use the inverters to mitigate against sags and flicker much more effectively." The two-way communications will also enable PGE to remotely disconnect and reconnect the inverters.

If time and resources permit, PGE will also explore two other advancements: using inverters to export VAr power and integration with the utility's GenOnSys distributed generation and demand response control system. GenOnSys, which was custom-developed by PGE, is the first such application to implement the International Electrotechnical Commission's new distributed resources standard (IEC 61850-7-420).

"The goal with GenOnSys is to make solar power more dispatchable by treating all inverters, whether owned by PGE or our customers, as a sort of 'virtual power plant' possessing significant capacity. With this approach, large-scale, distributed PV power can become more of an asset than a problem," Osborn explains.

Conclusion

By the year 2020 the electric grid will have undergone a remarkable transformation. PGE and many other utilities will be getting 20% or more of their power from renewable sources of energy. Key to this promising future will be the smart inverter. The smart inverter will be for the Smart Grid what the router is for the Internet: an intelligent device designed for coordinated, end-to-end control in a distributed environment. The result will be a more resilient and stable grid with better prediction of and management over widespread PV power generation from both utilities and their customers. Improvements in forecasting and integration of energy storage options will make it possible to better match supply with demand. Microgrids and their energy management systems will benefit from more intelligent islanding capabilities. And enhanced energy harvest and improved reliability, combined with continual declines in the cost of PV panels, will put the LCOE of solar on a par with other sources.

To learn more about how PV Powered is laying the foundation for the grid-tied smart inverter of the future, please visit us on the Web at www.pvpowered.com, or contact us by phone at (541) 312-3832 or by email at info@pvpowered.com.

About PV Powered

PV Powered is the innovation leader for grid tied PV inverters in the residential, commercial and utility markets setting the industry standard for reliability and efficiency. Founded in Bend, Oregon in 2003, and recently acquired by Advanced Energy Industries (AEIS) the company's vision is to tackle three significant issues affecting the growth of solar power usage world-wide – (1) dramatically improving the reliability of inverters, (2) lowering the Levelized Cost of Ownership for PV power generation and (3) making distributed PV a scalable and controllable resource on the utility grid.

We offer the industry's broadest range of inverters for residential applications, five models of commercial grid-tied inverters covering the spectrum of commercial rooftop applications, and our new 1MW PowerVault™ solution for ground mounted medium voltage utility-scale power systems. With the industry's first standard 10-year nationwide warranty and optional 20-year extended warranty, we stand behind our products in ways that count. The company's complete line of inverters is compliant with the Buy American Act and is eligible for use in government projects funded by the federal stimulus package. For more information on the company, visit www.pvpowered.com.

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