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A POWER QUALITY NEWSLETTER

Point of View

As today's global businesses connect increasingly diverse electronic systems into industrial, commercial, and residential sectors, the power quality challenges facing transmission and distribution companies continue to grow. Maximizing utilization of existing assets and resources while maintaining grid power quality will be very challenging for the restructured transmission and distribution companies.

However, with this challenge come opportunities. Opportunities to use power quality monitoring systems for asset maintenance. Opportunities to increase revenue while meeting customer power quality expectations through a performance-based rate mechanism. Opportunities to use various data sources such as relays, recloser/breaker/capacitor controls, and intelligent substation data acquisition devices for tracking the quality of power. Opportunities to minimize the interconnection issues of distributed generation by reducing the power quality impact. Opportunities to assess the electrical environment in order to create better end-use product immunity standards.

Realizing these opportunities will require a collaborative effort involving transmission and distribution companies, manufacturers, regulatory authorities, end

Point of View: Continued on back

The Custom Power Decade

By Brad Roberts

During the 1990s, several significant programs were conceived and developed to demonstrate ways to improve the quality of utility power delivered to critical-load customers and to improve the efficient use of electricity. These projects came about largely through the efforts of EPRI and the U.S. Department of Energy.

At the end of the decade, power users and utility companies saw power quality and reliability issues become front-page news, fueled by the frenzy to build large Internet hotels and fiber-optic communications networks to support the booming e-business economy. From 1996 to 2000, the demand for uninterruptible power supply (UPS) systems and diesel generators almost tripled. Utilities had to deal with power demands that averaged 5 to 10 times larger than normal, as building load projections reaching 200 watts per square foot became commonplace.

By the end of 2000, it was clear that too much capacity had been built and virtually all new business disappeared. However, the need for highly reliable utility power had been established, and the custom power industry is now starting to benefit from that stimulus.

All of these events will make the first decade of the new century a period of major growth in new ways to improve the delivery of clean and secure electric power.

The Move to Protected Services

Opportunities for custom power solutions will continue to grow across all industries as automation and productivity demands make the need for stable and reliable electric service more important. Because critical equipment is deployed in buildings or plants wherever needed, it is generally impractical to isolate voltage-sensitive systems in one area of a facility. And as the number of critical devices in a facility increases, power quality protection at the point of use can become more difficult to implement than protection of the entire load. More utilities are testing ways to improve power flow and address the needs of customers who require a "premium power" source.

The primary causes of voltage disturbances continue to be weather, animal/bird contact, and equipment malfunction. However, as the dynamics of the utility grid evolve through the introduction of more distributed generators and renewable source connections, overall voltage stability may be impacted in new ways. This issue is compounded by the desire to minimize the flow of VARs in the transmission system. Making sure reactive power demand is kept to the lowest level possible is a challenge. Simply adding more

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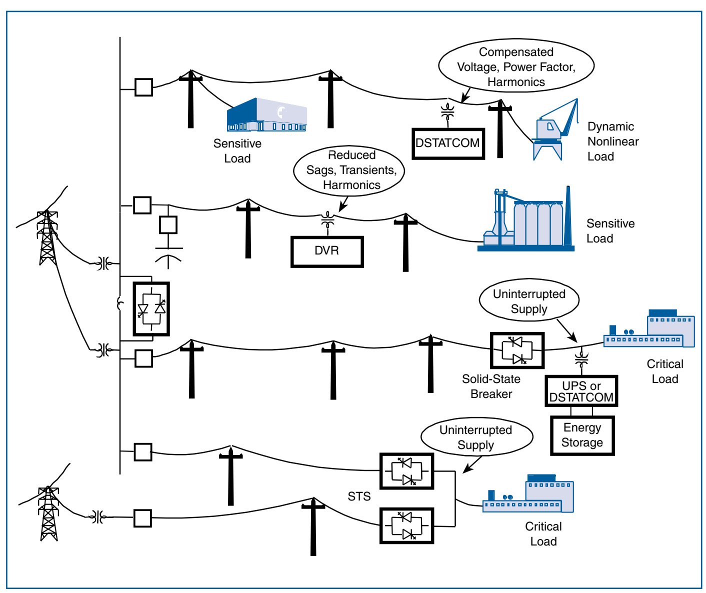


Courtesy of S&C Electric Company

Custom power solutions can be applied to utility distribution systems in a variety of configurations.

South Australia Prepares for Upcoming Power Quality Challenges

By Bob Burgstad

Recognizing the importance of a reliable, high-quality electrical power supply, the South Australian Independent Industry Regulator (SAIIR) and the South Australian electricity distributor (ETSA Utilities) jointly commissioned a project to determine power quality and reliability needs of South Australia through 2010, including upgrading the distribution system to cater to the Digital Age.

This study, Project 2010, provided an idea of the methodology and cost of improving power quality and reliability, and an ensuing survey will assess customers' willingness to pay for such improvement. Survey results, which are expected in the last quarter of 2002, will be used in the utility's price review in 2005.

The study recognizes the region's increasing dependence on digital and information technology in workplaces and in homes. Virtually all residential, commercial, and industrial energy users in South Australia will become increasingly sensitive to disturbances in the power supply.

Jointly undertaken by EPRI and the University of Wollongong in New South Wales, Australia, the study examined the most cost-effective ways of providing enhanced supply, reliability, and quality to customers; the technology, planning, design, and maintenance procedures necessary to achieve reliability and quality in electricity supply; and how such changes will affect price levels for customers.

The study evaluated the existing regulatory framework and power quality and reliability (PQR) baseline, as well as improvement initiatives already in progress by ETSA Utilities. Evaluation of future PQR requirements for South Australia took into account the impact of electricity deregulation there and the new Australian voltage standard, as well as worldwide technology trends.

Recommendations provide a roadmap for developing the South Australian electricity-delivery infrastructure. The Project 2010 report stresses that ETSA Utilities' power quality program should be based on an ability to measure power quality in a quantitative manner—to identify and correct actual problem areas—and an ability to take proactive measures based on developments in power quality parameters. Improvement must be based on developing the infrastructure required to track customer power quality through a monitoring system (PQMS). Customer education about load characteristics and sensitivity to electrical disturbances is another key component of meeting future requirements.

By tracking power quality levels, ETSA Utilities will obtain early warning of network equipment failures, which can have distinctive signature patterns in monitoring data. The PQMS system should also report momentary interruptions. Using a statistical technique, data from a limited set of monitors could be extrapolated to indicate the overall

Courtesy of ETSA Utilities

ETSA Utilities is already undertaking network upgrades aimed at meeting new demand and improving reliability and power quality. This photograph was taken at one of the utility's newest modular substations, in the Barossa wine region.

frequency of momentary interruptions across the network. This provides an economical way to predict and prevent power disturbances. One of the surprises of the study was the impact that industrial facilities can have on the power quality of the distribution network, including voltage dips caused by starting currents of large motors and the introduction of harmonics by solid-state rectifiers and variable-speed drives.

A recommended level of improvement in reliability will come about through continued implementation of targeted initiatives to achieve the baseline levels set by SAIIR and low-cost enhancement to ETSA Utilities' planning criteria to control 11-kV and 230/400 voltage levels and loading of street transformers.

Also crucial to reliability improvement is significant infrastructure enhancement designed to minimize the risk of catastrophic subtransmission line or substation failure. Such interruptions result in approximately 25% of the average annual duration of supply interruptions. According to the report, the risk of losing a substantial amount of load for such an event should be accounted for in any planning policy that is geared to address the customer PQR requirements for 2010 and beyond.

For the urban network, a quantum leap in reliability improvement can be achieved by making provisions to split feeders into several switched zones (which are distributed among neighboring feeders during a contingency) and by using an outage-management system to remotely switch feeder sections from the Network Operations Center. For the rural network, the quantum leap in reliability improvement can be achieved by implementing alternate subtransmission line supply to rural substations and provisions for installing additional feeders, associated switch gear, line fault indicators, and additional reclosers.

Within its yearly budget, ETSA Utilities undertakes certain activities for power quality enhancements and targeted reliability measures. However, infrastructure improvement for risk minimization and across-theboard change in reliability performance will require significant investment and have an impact on the electricity price paid by consumers, which is 11.2 cents/kWh (Australian). It is estimated that ETSA Utilities' average aggregate revenue requirement over the next nine years would have to increase by more than 20% if all of the reliability and quality improvement initiatives are implemented, although some of that increase could be offset by associated efficiency gains. If any of these initiatives are implemented and it is agreed that ETSA Utilities can recover the capital cost by raising prices, then the SAIIR, as the principal regulatory body in South Australia, would maintain critical oversight to ensure that consumers benefit from such investments.

The SAIIR and ETSA Utilities are currently reviewing the report with the aim of implementing the less-expensive recommendations during the current regulatory period (until 2005) and other recommendations during future regulatory periods. ■

Bob Burgstad is the Manager of Electricity for the South Australian Independent Industry Regulator (SAIIR), which is located in Adelaide, South Australia. He can be contacted at *bob.burgstad@saiir.sa.gov.au.*

Distributed Generation Impacts on Distribution System Voltage

By Reginald Comfort

As distributed generation is added to distribution systems, it becomes imperative that utility system designers work closely with distributed generator (DG) owners to determine what changes will be necessary to ensure continued service quality to end users.

There are many positive aspects to the use of DGs. Distributed generation can offer greater service reliability to its owners. If the area utility were to experience a forced outage, the DG could isolate from the grid and continue to receive power. In cases where they do not require utility standby service, DGs could offer a means of offsetting load, allowing the utility to avoid capital outlays associated with constructing infrastructure to support new load growth.

There is one thing, however, that both the utility and the DG owner/operator need to remember. DGs can—and sometimes do—affect distribution voltage.

Although such effects are not common with a single DG installation of 50 kW or less, it is a fallacy to assume that utility voltage levels will not be affected if customer-owned generation equipment is connected to the distribution system. Utility distribution systems are designed for unidirectional power flow, and DGs impact voltage profiles regardless of the mode of DG operation. Field testing performed by Reliant Energy at a Houston petrochemical plant showed the effects that a 5-MW gas turbine generator had on utility feeder voltage while the generator was in operation. Shortly after the DG synchronized with the utility, it was tripped off-line due to overvoltage. Both Reliant and the customer thought the DG tripped off due to an error in the overvoltage relay setting.

Reliant allowed the DG to raise the overvoltage set point to 132 volts on a 120-volt base. That setting is allowed by proposed voltage standards in the Institute of Electrical and Electronics Engineers (IEEE) P1547, which is due for a final vote at the end of this year.

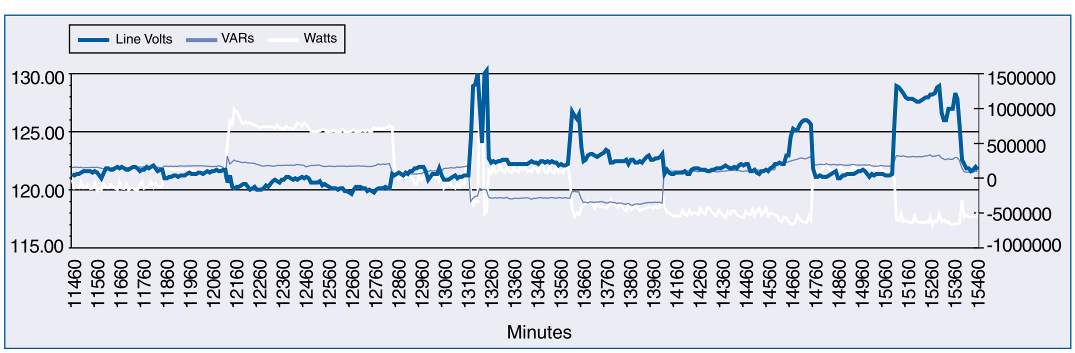
Next, Reliant installed power quality monitoring equipment at the service entrance to monitor feeder voltage, as well as kW and VAR output of the generator. As the DG exported power (at maximum kVA), the feeder voltage magnitude changed, varying from 124 to 130 volts. When the DG stopped exporting power and began to consume both watts and VARs, the feeder voltage returned to normal levels.

Testing demonstrated that sustained overvoltage was caused by the DG's operation. That overvoltage was beyond the range allowed under American National Standards Institute (ANSI) C84.1 and could result in damage to both customer and utility equipment. If such damage occurred, who would be responsible?

Although most DGs are nowhere near the size of the 5-MW DG studied by Reliant, a proliferation of many small DGs on a single distribution system could create the same effects.

For this reason, utility distribution system designers must coordinate closely with every DG installation that takes place on the distribution system. Conventional design methods used by utility engineers to maintain acceptable and stable voltage levels may no longer be effective. DGs added to utility distribution systems must never be treated as "plug and play" appliances.

Impacts of DG: *Continued on back*



Courtesy of Reliant Energy

Data from power quality meters show that as the distributed generator exports power, the feeder voltage magnitude changes.

Predicting System Failures With Power Quality Data

Signature interviewed power quality engineers at three utilities—Florida Power Corporation, American Electric Power, and Salt River Project—about the value of using power quality monitoring data from their substations to diagnose and predict distribution system failures. This article is based on those interviews and on three related case studies that are included in the EPRI Report, "Case Studies for Preventive Maintenance" (1000562).

Systems: Building a Knowledge Base

Over the last decade, power quality monitoring systems have proven to provide data for the diagnosis of power quality problems at end-use facilities and at substations within the distribution system. Now energy providers are finding that the data can be used to show impending equipment failures.

With the probability of random failure in distribution equipment as high as 89%, energy providers are exploring ways to integrate the predictive use of power quality data into managing their distribution systems. Data can help realize reliability and efficiency gains, while reducing investigation and maintenance expenses, as these cases illustrate.

Florida Power

"By applying power quality data to the distribution system, we have been able to improve customer service and lower our costs," says Charlie Williams, Principal Engineer–Power Quality and Reliability at Florida Power Corporation. "The data allows us to target repairs more quickly, at less expense.

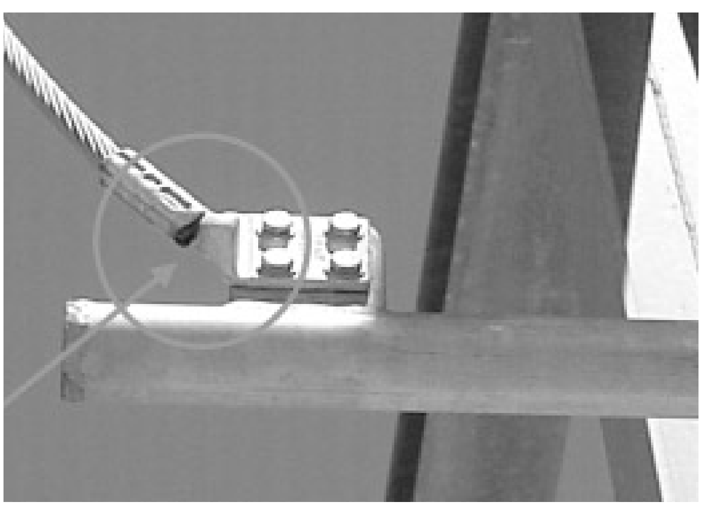
"We have seen how the data can be used to pinpoint problems before they even reach the customer," says Williams. "In one instance, we were able to prevent two system failures by paying close attention to data collected by a monitor in one of our substations."

Florida Power was receiving complaints from a customer that their uninterruptible power supply was frequently alarming and switching to a battery source. To address the problem, they installed a power quality monitor at the substation serving the customer. Monitoring data confirmed that faults were occurring on the power system, and were always initiated at or near peak voltage on the same phase.

The nature of the faults was not known until a 600-A, molded-rubber splice failed in a pullbox just outside the substation fence. Power quality data provided the key. The monitors had captured three unusual waveforms two days before the splice failure, and had logged 12 the day before the failure.

One week after the splice was replaced, the monitors recorded the same fault waveform, on the same phase as before. Investigation uncovered signs of insulation burning at a splice box, and Florida Power was able to prevent another failure on the circuit by replacing the cable. Three days later, monitoring revealed the identical waveform, caused once again by insulation burning in the splice box. Installing a new splice prevented a second circuit failure.

Upon inspection of cable samples, they found that the section from the splice to the overhead riser was filled with water. This was due to a defective overhead terminator that allowed rainwater to run directly down the cable strands.



Courtesy of AEP

A broken connector on AEP's 13.8-kV center phase was causing a customer's equipment to trip off at the same time each day.

American Electric Power

"Power quality is the system integrator," says Power Quality Engineer Harry Simpson, of American Electric Power (AEP). "Monitoring data can detect problems on either side of the meter, including customer variations and disturbances in voltage, current, and frequency. At AEP, we have developed techniques for using power quality data to assess the health of the distribution system.

"These techniques have helped us prevent safety issues and increase customer satisfaction. In one case, the data showed abnormal grounding of a substation, which was creating the dangerous situation of not allowing high-impedance faults to be cleared. In another case, the data allowed us to predict an insulator failure on a 345-kV circuit and abort a voltage sag on the system."

A third case involves a customer who had a 150-hp adjustable speed drive (ASD) that tripped off at a certain time each day. AEP installed power quality monitors at the customer's service entrance and on the 13.8-kV distribution substation serving the customer. The collected data confirmed that a 1200-kVar capacitor bank, three-quarters of a mile from the customer site, was switched daily. Waveform characteristics, time of day, and location of events all ruled out capacitor switching as the cause for the ASD tripping.

During the investigation, an unusual waveform characteristic prompted AEP to investigate further. Loose monitor connections, potential transformer problems, and load tap changer misoperation were ruled out. Inspection of the transmission line serving the distribution substation uncovered a broken connector on the 138-kV line serving the substation.

Salt River Project

"We have approximately 50 power quality monitors installed at substations throughout our distribution system," says Kris Koellner, who is a Power Quality Engineer for Salt River Project (SRP). "Now, to leverage our investment, we are turning the massive amounts of data we collect into information and acting on it.

"We have developed corporate power quality indices for the system as a whole as well as individual monitors, and have seen a direct correlation between customer satisfaction and the indices," says Koellner. "We are also working with EPRI PEAC to develop an algorithm and methodology to look at waveforms as they happen and then match them against a database to determine if problems may be occurring."

One such set of waveforms comes from a power quality monitor installed on an SRP 12-kV distribution feeder that detected high currents lasting for one to two cycles. These occurrences continued and became more frequent until the eventual failure of a lightning arrester. Upon review of the data, SRP could see a pattern of precursor events. High levels of current lasting for several cycles, along with a concurrent decrease in voltage, were occurring up to two months before the arrester failed. An algorithm will allow SRP to predict and prevent this type of occurrence in the future. ■

Charlie Williams can be reached at *charles.williams@pgnmail.com,* Harry Simpson at *hlsimpson@aep.com,* and Kris Koellner at *kmkoelln@srpnet.com*.

Standards Watch

By Mark McGranaghan

Power quality standards are becoming more and more critical as the utility industry throughout the world becomes deregulated and the technology level of electricity customers rises. More utilities and their customers are moving into the international arena, spurring a serious effort to use common approaches to assess power quality and electricity system performance. As this international standardization occurs, it is useful to examine various types of standards so that we can make the successful approaches more widespread, avoid mistakes, and recognize emerging trends.

Europe and the EuroNorms

The idea behind *compatibility levels* is that we can define a power quality level that is achievable by the power system and is also sufficient for equipment connected to the system.

This concept works great for all of the steady-state power quality characteristics—voltage regulation, unbalance, harmonic distortion, and flicker. As part of the deregulation of the power industry in Europe, a set of base requirements for the quality of power called the EuroNorms was developed. They are specified in EN 50160 and are based on the compatibility level concept.

For example, the voltage distortion level specified in EN 50160 on low-voltage systems is 8%. This means that the power system should be able to maintain a voltage distortion level of less than 8% for 95% of the time and that the equipment connected to the system should be able to operate properly with a voltage distortion level of 8%.

The greatest impact of this regulation on utilities in Europe is that they are required to monitor the performance of the system. This is creating a significant demand for monitoring equipment. Not all sites have to be monitored, but the suppliers must demonstrate compliance on a statistical basis.

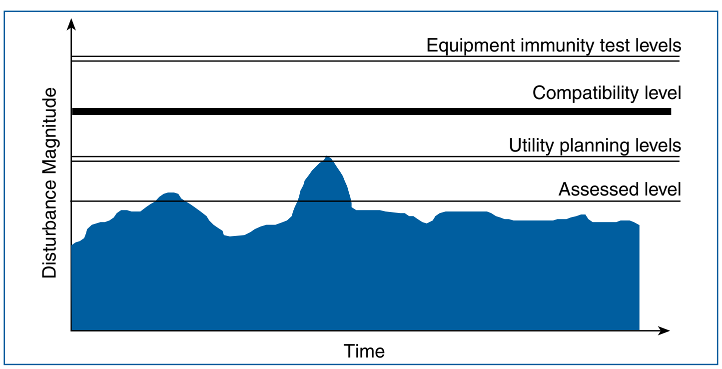
Economic Penalties for Noncompliance

The EuroNorms provide an example of power quality limits for the supply system that could be applied around the world. They don't, however, specify penalties for exceeding the limits. Argentina used the concept of compatibility levels in a similar manner, but it went one step further and included penalties for noncompliance.

The concept of the cost of *unserved energy* is used to apply penalties when power quality levels are unacceptable. This refers to the cost incurred by customers when their energy is not being supplied. In Argentina, the general penalties are based on the interruption cost for residential customers. This is the lowest cost of all customer categories, but still much higher than the cost of the electricity itself.

Again, using harmonics as the example, if the voltage distortion exceeds 8% for some period of time, the utility must provide a payment to the customer for that period of time equivalent to the interruption cost. For instance, the cost of electricity might be 8 cents per kilowatt-hour, but the penalty could be 30 cents per kilowatt-hour if the quality was unacceptable.

This type of penalty structure can be applied to all of the steady-state power quality characteristics, although it is important to point out that it results in a tremendous monitoring and evaluation burden. Quality characteristics like harmonic distortion can also be dealt with on an exception basis; since the number of problems associated with harmonics is small, it may be more cost-effective to just focus on solving problems when they come up rather than relying on monitoring and assessment throughout the system.



The concept of compatibility levels provides a basis for determining limits on such power quality characteristics as unbalance, harmonic distortion, and flicker.

Sags and Disturbances Are More Difficult

Sag performance and reliability are very dependent on specific

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and more capacitors can result in significant voltage collapse over a wide area if certain fault conditions occur. Thanks to intensive research and development in power electronics and energy storage devices over the last decade, proven solutions have arrived on the custom power landscape. The most significant developments in this arena have been Flexible AC Transmission System (FACTS) devices, Dynamic Voltage Restorer (DVR) and Distribution Static Compensator (DSTATCOM) systems, plus larger-scale, low- and medium-voltage UPS systems. In addition, medium-voltage solid-state transfer switches (STSs) have been fielded to allow virtually "seamless" transfer of large loads from one feeder to another in response to a voltage sag.

FACTS by definition is targeted at providing improved power transfer and voltage stability for large bulk transmission applications along with static VAR compensators (SVCs) for loads typically greater than 50 MVA and 69 kV. These are proven systems and will continue to be implemented for large critical loads, such as arc furnace applications, to reduce voltage flicker.

The greatest opportunity for improving voltage stability in this decade will be at the distribution voltage level, where voltage disturbances are generally greater in magnitude and more frequent, and where all transmission-oriented dips are seen as well. The semiconductor wafer fabrication industry has led the way in adapting large-scale voltage stabilization systems to protect critical processes from sags, swells, and outages. DVRs have been installed around the world to protect a variety of critical loads ranging from wafer fabricators to paper mills and food processing plants.

Successful DVR installations are now protecting loads in excess of 50 MVA, compensating for voltage sags as low as 50% of nominal voltage. The DVR concept will continue to be perfected in this decade. The concept of a "sag-proof" distribution transformer offers real promise in the very near future. Combining DVR electronics with the transformer windings of conventional oil-filled, pad-mount service transformers could finally give utility companies a cost-effective option for customers with sensitive loads.

Service Entrance UPS

Another program that has gained acceptance in the premium service entrance arena is low- and medium-voltage UPS. Critical process users with a goal of 100% disturbance mitigation are protecting entire loads, particularly in retrofit applications where downtime must be kept to a minimum.

The development of higher-voltage power electronic devices has permitted UPS systems to be scaled up for medium-voltage application. One project in Arizona—in which a 12.5-MVA, 12.47-kV, 10-MW off-line UPS applied in a substation protects an entire semiconductor plant—demonstrates that customers and utilities can work together to solve power quality problems.

More utilities will launch premium power programs in this decade as the variety of solutions grows and their field performances show the desired results.

Courtesy of S&C Electric Company

An off-line UPS in a utility substation protects the entire ST Microelectronics semiconductor wafer plant in Arizona, demonstrating how customers and utilities can work together.

Making Electricity Storage Practical

One of the areas of greatest challenge this decade will be making electricity storage work on a larger scale. Not just megawatts in large applications, but kilowatts in distributed generation systems that need stabilization to be effectively connected to the utility grid. Microturbines and fuel cells are growing in acceptance, but they lack the power to respond to load fluctuations. Adding "power packs" of flywheels or supercapacitors will make these devices respond better and become power quality solutions as well as distributed generation sources.

Development of larger-scale battery systems is showing promise for storage of megawatt-hours of power for true peak-shaving applications. These systems, combined with large-scale wind farms, could provide power when "needed most," not only when it is available. Storage could provide a "balanced flow" of energy and greatly improve the economics of wind power. Significant demonstration projects are under way to show how large-scale storage systems perform in applications up to 120 MWh. Projects in the United States—funded by the Tennessee Valley Authority in Mississippi—and Great Britain are under construction.

Since small, distributed generation systems will most likely incorporate some form of energy storage in the future, it makes more sense to distribute greater amounts of storage at numerous small sites rather than at larger megawatt installations. The economics of this issue will be tested in this decade. Renewable sources such as solar or wind power need to capture and store as much energy as possible when available.

Premium Power Parks

The variety of products discussed so far show how specific technologies can be tailored to solve specific power quality and reliability problems. As the use of custom power systems grows, their overall interaction with the utility grid will be studied. Perhaps the greatest opportunity for custom power to benefit critical-process users will be realized in the form of premium power parks. Fifty years ago, the leading industries that developed the computer age flourished in the downtown areas of major cities, where power quality was generally very good due to reliable underground networks laced with multiple feeders and rapid switching capabilities. Today, as sensitive loads are located virtually everywhere, the luxury of a downtown grid is neither practical nor affordable. The focus will finally shift to implementation of premium power sources where needed and when needed or parks with enhanced services. In Ohio, EPRI and American Electric Power have undertaken a 2- to 3-year project to analyze and implement a demonstration of the premium power park concept.

Protected power services will evolve as commonplace service offerings in this decade. Locating critical-load customers near each other in power quality parks or campuses will improve the economies of scale, resulting in a higher level of service reliability and lowering the cost per kVA of critical load served.

Smart Distribution Improves Reliability

Higher reliability of utility power is being made possible with the latest in distribution automation (DA) devices designed to ensure that a cable or equipment fault is sensed and isolated in cycles, not in seconds or minutes. Theoretically, a power quality park feed from two separate transmission systems and dual-feed distribution lines, coupled with the latest DA equipment, would all but eliminate the need for UPS systems requiring long-term batteries. Only the most critical loads would need UPS or backup generation to respond to only the most remote power distribution malfunction.

An excellent example of this type of distribution system is the International Drive Project in Orlando, Florida. The complex consists of a very large convention center plus numerous hotel and commercial facilities, which were being impacted by power interruptions. Implementation of DA sensors and controllers connected by fiber-optic lines eliminated the problems and reduced the short outages to voltage sags only. Taking this concept to the next level and curing sags at the points of most-critical load will be utilized more and more in the next few years.

Best Use of Custom Power

All EPRI custom power projects stress modularity and transportability in accordance with a traditional utility equipment deployment strategy. Critical-load customers who construct facilities in areas that experience sags or outages can be protected with the proper custom power device until the transmission and/or distribution systems are upgraded in the area, allowing the solution to be redeployed to another site. Making this strategy work has many regulatory and financial hurdles. However, efforts are under way by several utilities to develop and test some type of premium power offering. Numerous programs should produce results in this decade and provide the template for other utilities.

Working Together Toward Success

Concern over power quality stems from the "perception" that power quality has become worse over the last two decades. In some areas of the United States, this may be true. However, in general it has steadily improved. The real problem is that the level of voltage stability required by newer technologies has become more precise as high-tech devices push the limits of precision.

Utilities and critical-load customers do have a greater understanding of the issues and are working closer together to solve the problems. The advances in custom power devices over the last 10 years have provided a foundation for innovation in the delivery of these solutions on a

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EPRI R&D Corner

New Directions for 2003

Responding to current and future needs to boost competitiveness in a deregulated market, the 2003 EPRI Power Quality Solutions for Transmission and Distribution Program has a new focus: cost-effectively maintaining grid power quality and reliability while maximizing the utilization of existing assets. Meeting the more demanding power quality and reliability requirements of future loads will become an increasingly important aspect of the utility business, and this program will provide the necessary knowledge base and tools.

Power Quality Solutions for Transmission and Distribution offers six projects in 2003, including three that are multi-year. This multi-year vision is key to developing a long-term plan specifically designed to help customers upgrade their performance and boost their competitiveness by improving the power quality of the electricity they deliver. General goals for the program include:

- Providing knowledge of transmission and distribution construction standards and practices as they relate to power quality
- Establishing a technical foundation for developing power quality performance-based rates
- Minimizing distributed generation-related operational problems on transmission and distribution systems while enhancing system reliability
- Increasing asset utilization by evaluating power quality monitoring functionalities of substation-based integrated automation devices
- Developing add-on capabilities to power quality monitors so they can evaluate low-level current pulses, which are often an indication of common distribution and transmission system problems
- Predicting network power quality levels based on network topology and variables such as lightning flash density

For more information on these exciting research initiatives for 2003, contact Ashok Sundaram at 650-855-2304 or at *asundara@epri.com.*

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users, standards bodies, and research organizations.

Today high-quality power is quite simply the prerequisite for a universal transformation to the next level of automation. Transmission and distribution, as the delivery sectors of the energy industry, are the backbone of this technological revolution, and the quality of power delivered by transmission and distribution companies will always be a key metric that differentiates one organization from another. The energy industry's challenge will be to develop and integrate advanced technologies to balance the business pressure of cost optimization with customer power quality requirements.

This *Signature* focuses on that balancing act as it applies to transmission and distribution companies. Innovation flourishes when there are challenges. Together we can transform the power quality challenge faced by transmission and distribution companies into opportunities that ultimately benefit electricity customers.

Ashok Sundaram
EPRI Distribution and Power Quality

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cost-effective basis. Greater utility involvement in engineering and supplying these solutions will be a major factor for success in the custom power decade. ■

Brad Roberts is a registered professional engineer and Director of Marketing for the Power Electronics Division of S&C Electric Company in East Troy, Wisconsin. He can be reached at *broberts@sandc.com.*

Impacts of DG: Continued from page 3

There is a common misperception in the energy industry these days that DGs do not affect the distribution voltage. They can—and they do. Understanding the fundamentals of DG power flow and its impact on the distribution voltage profile is key to integrating DGs onto the distribution grid. ■

Reginald Comfort is Manager of Electric Distribution Engineering at Reliant Energy in Houston, Texas. He can be reached at *reginaldcomfort@reliantenergy.com.*

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characteristics within a power system (lightning flash density, overhead versus underground, trees, construction, animals), and it is not realistic or even useful to define a level that must be met throughout the system. Actual limits were developed for voltage sags in South Africa (Standard NRS 048), but it really doesn't provide any benefit to the customer because the limits are based on the worst-performing parts of the system. The most important use of the reliability and voltage sag indices, such as System Average Reliability Frequency Index (SARFI), is to describe the system performance so that customers know what to expect.

This approach was taken in Singapore, where voltage sags are critical because of the large semiconductor and electronics industries. There, the utility company, PowerGrid, developed a profile of expected voltage sag performance throughout Singapore and published the results as a "SARFI Map." This tells customers how many voltage sags per year they can expect based on historical performance at different locations throughout the system. At the same time, PowerGrid is continually striving to reduce the number of voltage sags.

With the information on the SARFI Map, customers can easily evaluate the cost of power conditioning options as compared to that of the voltage sags.

This will most likely be the wave of the future. Utilities will be required to provide information about expected voltage sag performance in a similar manner to reliability performance information. This will provide a means for the utilities and regulators to evaluate the ongoing performance of the overall system. At the same time, customers will have the information needed to optimize the design of their facilities. ■

Mark McGranaghan is Vice President of Marketing at Electrotek Concepts in Knoxville, Tennessee. This column serves as an open forum on power quality standards activities and developments. Please send your comments to Mark at *markm@electrotek.com.*

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Guest Editor
Ashok Sundaram, EPRI Distribution and Power Quality

Contributing Editors
Arshad Mansoor, EPRI PEAC Corporation
Mark McGranahan, Electrotek Concepts

Managing Editor
Krista Jacobsen Vigouroux, The J.A.K.E. Group

Project Manager
Marsha Grossman, EPRI Power Delivery and Markets

Senior Writer
Michaela Jarvis, The J.A.K.E. Group

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