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Electric Energy T&D MAGAZINE

JULY-AUGUST 2009 Issue 4 • Volume 13

2010 BUYERS GUIDE

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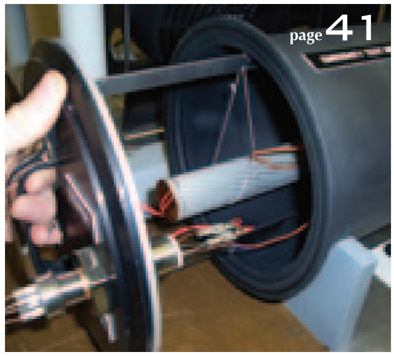

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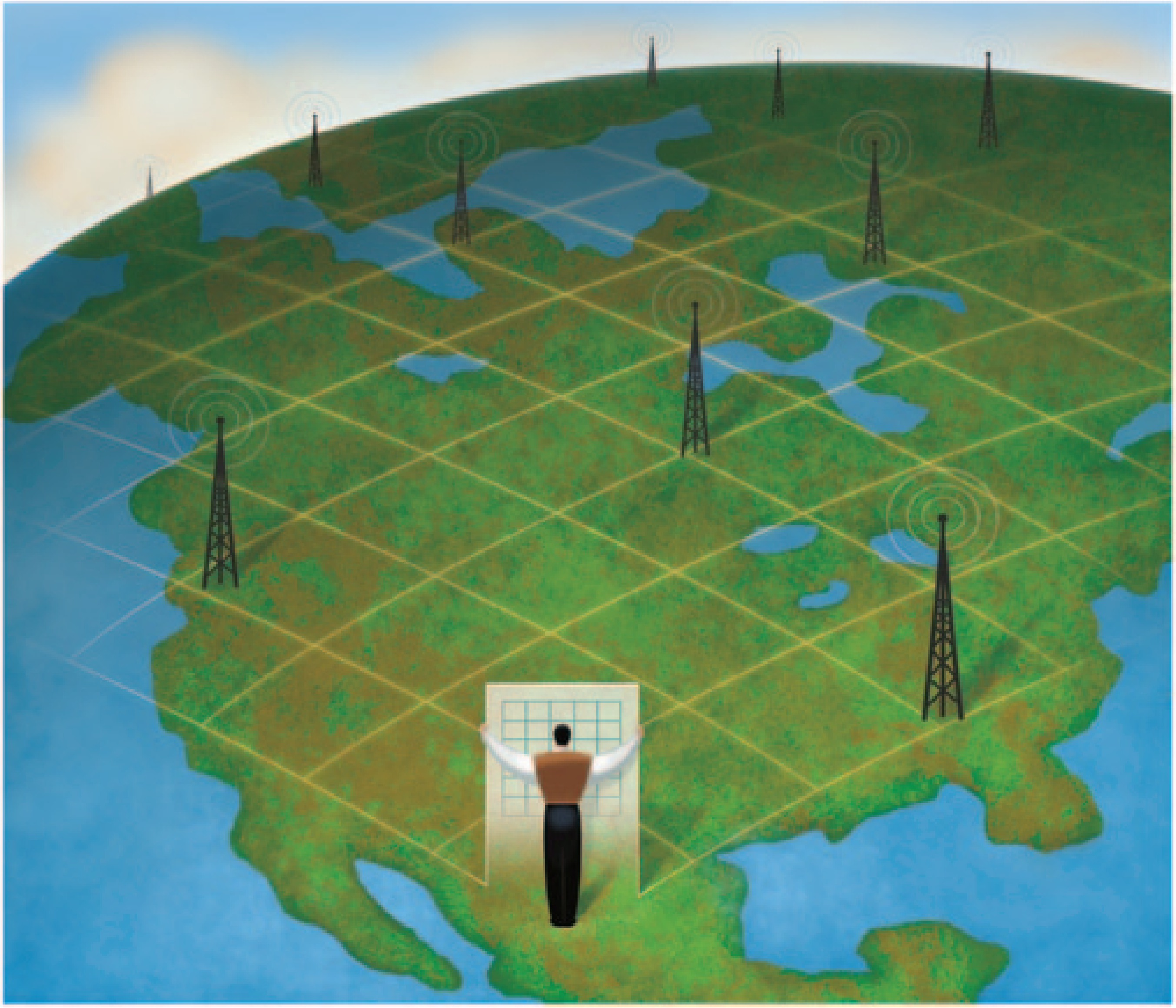
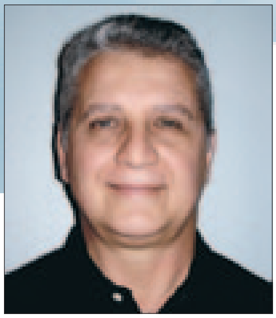


GRIDLINES

MICHAEL A. MARULLO, EDITOR IN CHIEF



The July-August *Annual Buyers Guide* issue is always well read and widely anticipated by users and suppliers alike. The supplier/resource information contained within these pages is a year-round reference tool that presents easy access to a vast array of information about T&D products, systems and services for everyone. Moreover, additional copies of this issue are also distributed at virtually every major power industry conference (including our own spring and fall *Smart Grid RoadShow* events) throughout the year, further extending its longevity and the tangible value it brings to an extended readership.

This year's mid-year issue is also special in another way; it marks the debut of two new features we have added to the line up that we are certain will deliver pertinent information and that rounds out our editorial coverage of the industry.

The first of these is ***Security Sessions***, a column focused on all facets of the security topic as it relates to the power industry. Authored by **Dr. W.T. (Tim) Shaw**, a 30-year industry veteran of automation and information technology for energy, utilities, government and various industrial process control, automation and instrumentation markets. ***Security Sessions*** will now appear in every issue, from this issue forward.

The second new installment making its debut in this issue is ***Washington Watch***, which monitors and reports on evolving regulatory and legislative energy- and utility-centric initiatives. **Gregory K. Lawrence**, a partner in the Energy & Derivatives Markets Group of global law firm McDermott Will & Emery, authors the column. ***Washington Watch*** will appear three times annually, alternating with our Executive Directions feature.

Our *Automation/IT Leadership Interview Series* interview is with Dr. Ed Schweitzer – a true industry icon and president of Schweitzer Engineering Labs – and SEL's Vice President of Research & Development, Dave Whitehead. In this interview we delve into two of the most intensive – and in many ways, controversial – topics of the day: Security and Reliability. A thorough understanding of the task at hand and a personal commitment to technology investments balance Dr. Schweitzer's ever-present optimism and enthusiasm for dealing with grid transformation challenges in a realistic and pragmatic way.

In the featured article for this issue, Guerry Waters shares the results of a comprehensive Smart Grid survey recently commissioned by Oracle Utilities. The results of this precedent-setting research reveal some of the grittier issues surrounding Smart Grid that are gradually making their way to the consciousness of utility customers.

Carlos Romero of Ventyx contributes our *LightsOn* feature, which casts a creative light on Alternative Energy and Renewables with a look at Virtual Power Plants. In another recent study – this one sponsored by Ventyx – the respondents viewed facilitating DR and seamlessly integrating distributed energy resources (DER) such as DG and renewable resources of strategic near-term importance.
Delving further into the customer side of evolving Smart Grid initiatives, Simon Reynolds with HP's Imaging and Printing Group explains how E.ON – the giant global utility – changed the face of customer communications by creating a new kind of bill, dubbed the OneBill. Find out how E.ON was able to not only improve customer communications, but also pro-actively attract new customers from what began as a simple bill redesign.

Bernie Clairmont of the Electric Power Research Institute and co-authors Ray Ferraro (PSE&G) and Dan Lawry (Pike Electric) explain how shiny power lines are more than just a cosmetic touch when it comes to the efficient transmission of electric power. The emmissivity testing instrument (ETI) and testing process described in the article will significantly help expand the knowledge base associated with high voltage power line performance and aging characteristics, which in turn, can lead to more accurate capacity and life cycle ratings for thousands of miles of aging power lines.

Showcasing yet another way to improve system performance and extend the useful life of aging infrastructure, Dr. Roy Hoffman of SNC-Lavalin presents new methods and various approaches to automated Fault Detection, Isolation and Restoration in the distribution environment. FDIR – long relegated to demonstration project status – is now ready for prime time and promises to forge new paths into customer service and reliability improvements.

Harry Valentine is a Canadian-based freelance writer who brings a fact-rich historical perspective to distributed generation – a class of energy resources that for many of us is perceived as something totally new and relatively unproven. On the contrary, Valentine shows us that DG is anything but new while also underscoring some of the salient advantages and disadvantages of various DG methods and the inherent value of diversity in contemporary and future energy supply strategies.

And finally, the article by J.N. Bérubé of Neoptix, together with co-authors B.L. Browoleit of Grant County PUD and consultant J. Aubin, provides an in depth discussion of how advanced fiber-optic instrumentation can be used to improve both dependability and the long-term performance of transformer cooling. The article describes precisely how more reliable and more accurate monitoring of transformer performance can be readily achieved through the use of modern fiber-optic sensors.

Of course, the Annual Buyers Guide content speaks for itself, so enjoy!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Industry News

Public Utility in Largest County of Washington State Selects TWACS Power-Line Communications Technology

ST LOUIS – The Okanogan County Public Utility District (PUD), which has served the largest county in Washington State for over 60 years, recently began a two-year advanced metering infrastructure (AMI) project to deploy the Aclara™ Two-Way Automatic Communications System (TWACS®), a leading Intelligent Infrastructure™ technology that works over power lines. The PUD, the 300th customer for TWACS technology, will use the system to collect interval data from 22,000 electric meters, perform outage management, and do engineering analysis.

The utility chose TWACS technology because of its reliability. "We focused on finding a solution that was mature and that had the bugs worked out of it," said Doug Adams, Manager of Operations for Okanogan County PUD.

"We were also constrained by our terrain, which consists of a series of peaks and valleys, to power-line technology," added Adams. "The TWACS technology worked flawlessly for us in a pilot project done with the help of Okanogan Electric Cooperative, a neighboring utility."

Okanogan County PUD shares a substation with Okanogan Electric Cooperative, a TWACS technology customer that serves about 3000 customers. The cooperative's positive experience with TWACS technology was also a factor in the PUD's decision.

The primary reason the PUD moved to AMI was to move from bi-monthly to monthly billing, which will improve the utilities cash flow and prevent the large two-month winter bills for customers as well as eliminate estimated reads.

TWACS technology will read meters remotely by communicating over power lines and the fiber-optic network that was developed by the PUD to provide high-speed telecommunications to its customers. In addition to providing regular meter reading, the system will offer immediate access to information about loads, voltages, meter tampering, and outages.

Okanogan is using TWACS PROasys™ software to pinpoint the extent of outages. The software works by signaling meters to determine which ones are working. The utility also will use iVUE software from the National Information Solutions Cooperative to help map the location of outages as well as to dispatch repair crews.

Utilizing TWACS' interval-data collection capability, each customer meter will be checked periodically for outages, which allows the utility to immediately identify meters that have stopped working, rather than waiting to find them when the meter is physically read. In addition, the system will provide customer service representatives with information that will allow them to better handle customer inquiries. TWACS technology also will make it easier for the utility to switch accounts from one person to another.

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Sensus opens Conservation Solutions office in Aurora, Canada

Location to offer local distribution network and utility customer support

Raleigh, NC - Raleigh, NC – Sensus, the time-tested technology and communications company that provides data collection and metering solutions for water, gas and electric utilities around the world, is adding an office in Aurora, Canada.

Sensus professionals at the new location focus on conservation solutions and make up the project management team assigned to work closely with our Canadian utility customers as they deploy FlexNet AMI and Smart Grid projects. The Canadian office, which sits just outside of Toronto, provides fast access to technical support and customer service as Sensus utility customers deploy and implement AMI, smart metering, demand response and time-of-use advanced Smart Grid applications.

"The proactive nature and forward thinking of the Canadian utilities has led to the adoption of Smart Grid and AMI technology throughout the country. Our FlexNet technology has proven a perfect fit for their goals: improving the end user experience, capital investment protection and reduction in the carbon footprint," said Doug McCall Director of Marketing at Sensus. "We at Sensus look forward to continuing our growth in the Canadian market and insuring our customer's success with this local presence."

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Industry News

Unemployment Rate for Electrical Engineers Soars to New Record, Engineering Jobless Rate Up for Second Consecutive Quarter

Washington - The unemployment rate for U.S. electrical and electronics engineers (EEs) hit a new record in the second quarter, while the rate for all engineers increased for a second straight quarter, according to data released by the Department of Labor's Bureau of Labor Statistics (BLS).

"Technology drives our economy, which means engineering unemployment is a bellwether for recovery and job creation," IEEE-USA President Gordon Day said. "These new data suggest we've got a long way to go as the United States attempts to regain its economic footing."

The news for EEs was particularly bad as the jobless rate more than doubled from 4.1 percent in the first quarter to a record-high 8.6 percent in the second. The previous quarterly record was 7 percent, in the first quarter of 2003.

For all engineers, the unemployment rate jumped from 3.9 percent in the first quarter to 5.5 percent in the second quarter. The rate for computer professionals steadied at 5.4 percent, after a significant jump in the first quarter. The second-quarter unemployment rate for all professional workers showed a modest uptick, from 3.7 percent to 4.3 percent.

The BLS reports that 29,000 EEs were unemployed in the second quarter, up from the first-quarter figure of 13,000. On a small positive note, the number of employed EEs seems to have stabilized, actually rising 2.3 percent quarter-to-quarter, but at levels well below those of the past decade.

"Taken together, these data may suggest that engineers laid off last year and early this year are having trouble securing the new engineering jobs being created," Day said.

IEEE members can find career enhancement resources at www.ieeeusa.org/careers. Help for unemployed and at-risk members is available at www.ieeeusa.org/careers/help.

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Hydro One invests more than $10 million for 230 kV wood pole structure replacements in Northwestern Ontario

Toronto - Hydro One has completed more than half of the pole and arm replacements scheduled on its 230 kV wood pole transmission structures in Northwestern Ontario for this year.

Forty Hydro One workers, with the help of about 15 apprentices, replaced poles and arms on 176 structures on the 230 kV power line from Atikokan to Manitoba. An additional 120 wood pole structures located between Kenora, Dryden and Fort Frances are also scheduled for replacement later this year.

Hydro One will invest approximately $10 million this year on the upgrades. This investment is just a portion of the replacements planned in Northwestern Ontario over the next five years.

"This project is part of an ongoing program to continually assess the condition of our power system and make significant upgrades to improve overall reliability," said Carmine Marcello, VP, Asset Management, Hydro One. "This work is a reflection of Hydro One's proactive approach to monitoring and improving the transmission system in the Province."

For this project, a new technique is being used to determine if replacement of the structure is necessary. Each pole is tested by drilling into an arm on the structure from a helicopter. A helicopter equipped with an Airstair, a framework that attaches to the undercarriage of the helicopter and allows for safe access to the transmission lines, is used to test and replace poles.

Work on the line from Atikokan to Manitoba started on January 26, 2009 and finished on March 9, 2009. Across the province, approximately $25 million is invested annually into replacing 115 and 230 kV wood pole power line structures. Two Ontario-based companies are supplying the wood poles and steel arms for this project.

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SEL Announces Intuitive, Economical Solutions for Grid Security

PULLMAN, WA — June 15, 2009 — As the utility industry continues to make the electric power grid smarter and less vulnerable to attack, Schweitzer Engineering Laboratories, Inc. (SEL) is committed to providing intuitive, economical cybersecurity solutions that help do both. Our expertise in critical communications system security improves grid security by tailoring solutions specifically to the smart grid's communications infrastructure requirements.

As part of these solutions, the new SEL-3620 Ethernet Security Gateway protects site-to-site Ethernet communications as well as private networks, allowing users to maximize the benefits of a smart grid while minimizing security risk.

Easy to use and tough enough for harsh environments, the SEL-3620 operates with existing IT and control systems, using an intuitive, menu-driven web interface.

SEL designed and built the Ethernet security gateway, available this November, as part of a research project with the U.S. Department of Energy (DOE), Tennessee Valley Authority, and Sandia National Laboratories, among other partners.

"The SEL-3620, an OPSAID-compliant device, can provide a synergistic solution that benefits specific needs in securing our critical infrastructure, including smart grid communications," said DOE Deputy Assistant Secretary Hank Kenchington. "This is a good example of the Department of Energy, a national laboratory, and a private company working together to provide useful solutions to critical needs in a timely fashion."

Another element of SEL's smart grid security solutions is the SEL-3021 Serial Encrypting Transceiver. It protects point-to-point and multidrop data links from attacks and eavesdropping, with advanced encryption validated to Federal Information Processing Standards (FIPS) 140-2 Level 2. For wireless applications, the SEL-3022 Wireless Encrypting Transceiver creates a cryptographically secure wireless link between a computer and remote IED serial communications port.

SEL's security solutions provide an effective means for reducing electronic vulnerabilities in critical communications systems ranging from serial to Ethernet and SCADA to engineering access. Securing systems ranging from water treatment facilities to electric power transmission infrastructure with SEL cybersecurity solutions ensures continued smart grid operation.

Celebrating 25 years of innovation in 2009, 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.

Circle **46** on Reader Service Card

Smart Grid Investment Grants Reflect NEMA Initiatives

Rosslyn - The U.S. Department of Energy (DOE) has finalized rules for its Smart Grid Investment Grant program, providing a total of $3.3B in grants of $500,000 to $200M, which is significant higher than the $20M cap originally proposed. The grants will come in the form of a 50 percent match from end users, utilities, or other non-government sources.

NEMA staff had previously compiled recommendations from the Smart Grid Advisory Panel and delivered them to Secretary Steven Chu in March. The announcement reflects deployment and demonstration recommendations from the NEMA Smart Grid Advisory Panel, including community energy storage, storage management systems, and transmission ratings.

Many projects will be utility-scale and NEMA companies may partner with or supply the utilities who will act as a project "host." In some instances, such as in California and Colorado, the state utility commissions plan to hold expedited hearings, which will demonstrate official support utilities seeking DOE funds. NEMA has compiled a list of state Smart Grid dockets or stimulus efforts, which is available to its members by going to **http://workspaces.nema.org/NEMA/Members%20Only%20Links/Stimulus_Contacts.pdf**.

The first round of applications will close July 29. Subsequent application due dates are anticipated in December 2009 and March 2010. Applicants, however, are encouraged to apply quickly as funds may not be reserved for future rounds.

The Smart Grid Investment Grant Program was authorized by the Energy Independence and Security Act of 2007 and funded by the American Reinvestment and Recovery Act of 2009. NEMA provided critical input for both bills, and continues to advocate for grid modernization as a path to the nation's climate, economic, and security policy goals. NEMA has also provided state officials with manufacturers' perspectives, including invited presentations to the California Public Utilities Commission and the Smart Grid Collaborative between the Federal Energy Regulatory Commission and the National Association of Regulatory Utility Commissioners.

Circle **47** on Reader Service Card

GE to Transform U.S. Military Base into Smart Grid Showcase

Awarded $2 Million in Federal Stimulus Funds for New, Smart Microgrid Demonstration Project That Will Serve as a Model for Maximizing Energy Security, Improving Efficiency, and Supplying Clean, Renewable Power for Military Bases

Niskayuna - With the goals of increasing energy security, energy efficiency, and promoting cleaner, alternative energy at U.S. military bases, GE announced on July 8 it has been awarded $2 million in Federal stimulus funding from the U.S. Department of Defense (DOD) for a smart microgrid demonstration project at Twentynine Palms Base, California.

Industry NEWS

The base is the world's largest Marine Corps Base and it is the premier training facility in the world for Marine operations, drawing military personnel from all over the world for Combined Arms Exercises. GE and the Environmental Security Technology Certification Program (ESTCP) office at DOD are in the process of finalizing a contract for the project.

GE will design and demonstrate a smart energy management system that enables installations to more optimally manage on-site power generation and energy storage, while interacting with the regional electrical grid in a more intelligent and efficient way. Additionally, GE's system will provide enhanced capabilities for installations to integrate renewable resources, such as solar energy, to help meet their electricity needs and reduce their carbon footprints.

According to the 2009 Defense Appropriations Act, U.S. military installations consumed 3.8 billion kilowatt-hours of electricity last year, enough electricity to power 350,000 households in the United States. In addition to high energy costs for these installations, critical defense facilities must operate seamlessly through a power outage or other infrastructure disturbance. These are two key challenges that a smarter, more intelligent grid management system will help to address.

"GE's smart microgrid demonstration project will show how a more intelligent energy management system can help military bases further safeguard the operation of their power systems while also reducing overall energy costs," said John Kern, Manager of GE's Smart Grid Research Lab. "This project will serve as a model for other bases and it also will demonstrate how similar types of facilities, such as industrial complexes and universities, can take advantage of a smarter grid."

U.S. military bases typically manage power in two ways: local power is generated on site for critical facility needs; and, the bases are connected to the larger U.S. electrical grid network. As part of the project, GE will provide an enhanced suite of microgrid control system technologies that will enable a military base to more effectively manage its local energy resources as well as the interaction with the larger electrical grid network.

To develop this new system, researchers at GE Global Research in Upstate New York will develop and incorporate advanced algorithms and computational decision engines into a microgrid controller built by GE Digital Energy. This microgrid controller will optimize the power generation and distribution within the microgrid. GE Fanuc Intelligent Platforms will also integrate many of these advanced technologies into a new supervisory control and software system that can span power generation and distribution as well as major power consumers within the microgrid.

GE has completed considerable research and development in microgrids in recent years for both the U.S. Department of Energy and the Canadian government. Because microgrids are essentially self-contained systems, they have great potential for enabling a higher penetration of clean, renewable power sources into the electrical distribution network. For contained complexes like a military base that can supplement their own power needs with power generation onsite, microgrids can be an attractive option for bringing more renewable power online.

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Duke Energy Announces Management Realignment

Charlotte - Duke Energy announced several changes in leadership responsibilities on July 2.

- Keith Trent, currently group executive and chief strategy, policy and regulatory officer, was named group executive and president of Duke's Commercial Businesses.

  The Commercial Businesses organization includes Duke Energy Generation Services, which houses the company's wind generation business, Midwest non-regulated generation, DukeNet, a telecommunications business, and Duke Energy International, with operations in Latin America.
- Jim Turner, currently group executive, president and chief operating officer for U.S. Franchised Electric & Gas (FE&G), is assuming expanded responsibilities in FE&G.

  Turner will take on responsibility for regulatory strategy and execution at the state and federal levels. These responsibilities will align with the existing customer-facing functions to provide a comprehensive approach to managing customer relationships. The state presidents for Duke Energy Carolinas, Duke Energy Ohio/Kentucky and Duke Energy Indiana will report to Turner.
- Dhiaa Jamil, currently group executive and chief nuclear officer, was named group executive and chief generation officer.

  In his expanded role, Jamil, who will also retain the title of chief nuclear officer, will have accountability for nuclear, fossil and hydro regulated generation.

"These changes in leadership responsibilities are designed to clarify accountabilities, streamline our decision making and strengthen relationships with our customers, regulators and shareholders," said James E. Rogers, Duke Energy chairman, president and chief executive officer. "We're able to make significant changes like these with confidence because of the strength and depth of our leadership team."

Keith Trent

Trent joined Duke Energy in 2002 as general counsel, litigation. He has more than 18 years of experience as an accomplished attorney.

Trent was named to his current role in September 2006 and has led the areas of strategy, state and federal policy and government affairs, corporate communications, community affairs, technology initiatives and environment, safety and health policy.

Jim Turner
Turner joined the company, in 1995. Before joining Duke, Turner was a principal in the Indianapolis law firm of Lewis & Kappes, P.C. Prior to the merger of Duke Energy and Cinergy, Turner served as president of Cinergy. He also served as the company's chief financial officer, where he was responsible for financial operations, investor relations, corporate development, and strategic planning.

Dhiaa Jamil
Jamil has more than 28 years of experience in the energy industry. He joined the company in 1981 as a design engineer and has served in significant leadership roles at all of Duke's nuclear stations, including serving as site vice president of Catawba Nuclear Station in 2003. Jamil is a registered professional engineer in North Carolina and South Carolina. He was named to his current role in January 2008.

Circle **49** on Reader Service Card

President Obama Announces New Light Bulb Standards

Biggest energy saver in history of Energy Department

Washington D.C - New national minimum energy efficiency requirements for light bulbs will save more energy than any other standard ever issued by any administration, according to a coalition representing environmental and consumer organizations, state government, and utilities. The new standards, announced by President Obama on June 29, will make the hundreds of millions of fluorescent tube lamps that light offices, stores, and factories more efficient. They also will phase out conventional incandescent reflector lamps, effectively extending the phase out of inefficient incandescent products initiated by Congress in 2007 to the common cone-shaped bulbs used in recessed light fixtures and track lighting.

"With our nation's birthday around the corner, President Obama has provided the nation an early gift in the form of big energy savings, dollar savings, and pollution cuts," said Andrew deLaski, Executive Director of the Appliance Standards Awareness Project (ASAP). "However, even bigger savings could have been achieved."

According to the Department of Energy (DOE), lighting uses nearly 40% of all electricity used in commercial buildings. The standards announced on June 29 affect the more than 500 million fluorescent tube lamps and 265 million reflector lamps sold each year in the United States.

"This final standard is a substantial improvement on the draft standard released by the Department of Energy in the closing days of the Bush Administration," said Steven Nadel, Executive Director of the American Council for an Energy-Efficient Economy (ACEEE). "We are heartened that President Obama himself chose to make the announcement and to focus on the importance of energy efficiency."

According to DOE, the new standards announced will save up to 1.2 trillion kilowatt-hours over thirty years, an amount about equal to the total consumption of all homes in the U.S. in one year.Businesses and consumers will gain up to $35 billion in net savings and global warming carbon dioxide emissions will be cut by up to 594 million metric tons, an amount equal to the annual emissions of nearly 110 million cars.

The maximum levels analyzed by DOE would have increased energy savings by another 230 billion kilowatt-hours over thirty years, or roughly enough to meet the power needs of 22 million more U.S. households for a year. The higher standards would have saved businesses and consumers as much as another $11 billion, according to DOE.

"A flip of the switch may seem mundane but the way we light our homes and offices is a big chunk of our nation's energy use," said Lane Burt, Policy Analyst with the Natural Resources Defense Council (NRDC). "This standard starts cutting the huge energy and pollution costs that come with keeping the lights on. The DOE rule is literally lighting the way toward a brighter energy future and along with future standards will serve as a cornerstone of our energy policy that we will build upon in years to come."

DOE is slated to set a total of 25 new standards during the current presidential term.

The new lamp standards, which will take effect in 2012, will have little effect on the outward appearance or lighting performance of the affected light bulbs. For fluorescent lamps, highly efficient "T8" lamps (lamps with a 1 inch diameter) will replace "T12" lamps (which have a 1.5 inch diameter). For reflector lamps, standard incandescent and halogen technology will be replaced with highly efficient halogen infrared reflector technology, a change that will save consumers energy, but not result in any outward change to reflector lamp appearance. In 2007, Congress enacted a phase out of standard incandescent light bulbs in favor of advanced incandescent technology and other high efficiency products starting in 2012. ■

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The 2009 Automation/IT Leadership Series

Edmund O. Schweitzer, III PhD.
President

Dave Whitehead
Vice President R&D

Schweitzer Engineering Laboratories, Inc.

> “I have personally stressed the importance of security for SEL relays, communications processors, meters, and other equipment from the very beginning of the company.” – **Dr. Ed Schweitzer**, President

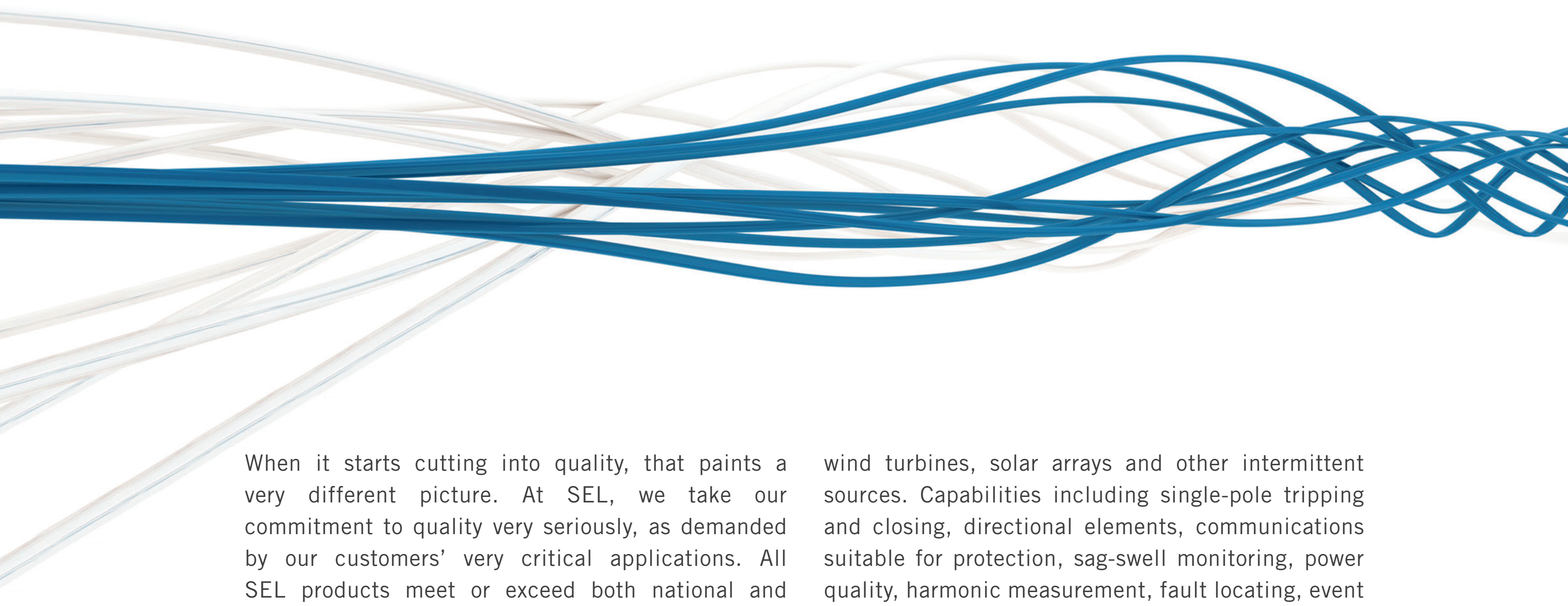
Schweitzer Engineering Laboratories, Inc. (**SEL**) introduced the world’s first digital relay in 1984, revolutionizing the power protection industry by offering fault locating and other features for a fraction of the cost of earlier systems. Twenty-five years later, SEL offers a complete line of products and services for the protection, monitoring, control, automation and metering of electric power systems. Yet despite its launch as a low-cost provider, this icon of modern-day power engineering is today most often characterized by trend-setting innovation, consistent performance and an unwavering commitment to product quality and customer service.

EET&D: First of all, congratulations on SEL’s 25th anniversary! Having been at the forefront of power system protection innovation twenty-five years ago this must be an exciting time for you given all of the new challenges our industry is facing. How would you characterize your posture as a company that is probably going to play an integral role in transforming the grid for the next quarter century and beyond?

Dr. Schweitzer: Creativity, extensive research, attention to customer needs, and a wealth of power system automation, communications, and cybersecurity expertise drive our research and development processes. Our multidisciplinary teams of power, communications, automation, software, mechanical, and electronic design engineers develop products that meet or exceed customer needs for features, functionality, and robustness. These principles remain firmly in place at SEL, so I don’t foresee any major changes in that regard. What I do see, however, is an urgent industry need to invest in the future – something that has been lacking in recent years as the industry struggled with deregulation, fiscal uncertainties, rate reviews, market design, security and other distractions from the fundamentals of power engineering.

EET&D: We’re in difficult economic times right now, and as a result, a lot of companies – suppliers and users alike – are looking for ways to cut corners and trim costs as much as possible. What is your view of how the recession is impacting the electric power industry and whether the result will be temporary or longer lasting?

Dr. Schweitzer: There’s always a legitimate incentive to cost-engineer goods and services for maximum efficiency and, of course, profitability, but that only pays off in terms of cutting waste and improving the process.



When it starts cutting into quality, that paints a very different picture. At SEL, we take our commitment to quality very seriously, as demanded by our customers' very critical applications. All SEL products meet or exceed both national and international testing standards, which we feel is one of the best investments any company can make in their future, especially in tumultuous times like these. And, we back that up with a 10-year worldwide warranty. Fortunately, our pursuit of quality almost always leads to cost savings that we can pass along to our customers, allowing them to benefit not just from lower costs, but also from the improved power reliability that results.

EET&D: Clearly, there is a lot to do if we're going to transform the grid in ways that will allow it to serve us at least as well as it has thus far. What do you feel needs to happen for the so-called "Grid of the Future" to become reality?

Dr. Schweitzer: The fact is that we and our customers have already been building the grid of the future for a long time. One example is the International Drive project with Progress Energy in Florida, which is a looped distribution system. That is, power can flow in either direction, and we're tripping and restoring service in just six cycles. That system has already been in service for about a decade. It's distribution working at transmission speeds – I think that's pretty smart, so perhaps it would be better to refer to the challenge at hand as enhancing the grid of the future, rather than "creating" it, per se.

EET&D: That brings up another interesting point regarding distributed resources and 2-way power flows. With all the talk about wind, solar and other renewables these days, can you perhaps comment on how these new energy sources will be accommodated?

Dr. Schweitzer: Today, we can integrate, protect, control and monitor distributed energy resources like wind turbines, solar arrays and other intermittent sources. Capabilities including single-pole tripping and closing, directional elements, communications suitable for protection, sag-swell monitoring, power quality, harmonic measurement, fault locating, event reporting, secure communications, precision time, oscillography and more are ready to address the challenges of today and the future.

EET&D: Let's turn now to a topic that is on everyone's mind lately and one that is still in a steep climb toward maximum mindshare among utilities of all types, sizes and locations: Security.

Dr. Schweitzer: I have personally stressed the importance of security for SEL relays, communications processors, meters, and other equipment from the very beginning of the company. From our very first products, we have provided two levels of access with separate passwords and alarm contacts, which signal access failures. Security is a way of thinking, a continuous process as important as product features and system architectures. Security awareness, security-in-depth, and good security must be taught and learned for us to succeed. After that, the technology comes in.

Whitehead: Let me be very clear in saying that although technology has a prominent role in threat mitigation, technology alone can't – and won't –fix this problem unilaterally. The security picture is much bigger than that. As Dr. Schweitzer pointed out, we have routinely emphasized the importance of security in integrated systems and have published many papers describing the threats, vulnerabilities, and practical mitigation measures. And, as an ongoing priority, SEL University offers a cybersecurity course to educate users about our secure-communications products to improve security awareness at the customer level as well.

Do we design security into our products? Yes, of course, but education about security and heightened awareness is at least equally important.

EET&D: Security is an issue that affects us all in many different ways – both personally and professionally – but overall, in many of the same ways. What, in your opinion, is the most likely path toward effective security threat mitigation?

Dr. Schweitzer: The many security threats today include hackers, disgruntled employees, terrorists and countries with sophisticated information warfare plans and capabilities. We all must recognize our own role and responsibilities in mitigating these threats. As manufacturers, we need to provide safe and secure solutions. Asset owners need to meet their obligations to shareholders and customers. I believe government can help by sharing knowledge of threats and good security practices. Fortunately, there are many simple and low-cost steps that one can take to quickly reduce the threats to the vital assets of our power systems.

EET&D: Can you perhaps give our readers a few examples of what you mean by that?

Dr. Schweitzer: Sure. We've developed a list of twelve tips for threat mitigation. I won't go over all of them here, but one of the most important is knowing all of the paths to your assets That is, making a list of all the ways you normally access them – which includes both physical access as well as electronic or cyber access, where applicable – and then making sure that each path is appropriately monitored and/or restricted to key personnel only. Dave, what is another one that you feel is important to mention here?

Whitehead: Use security features that are present in the equipment, like strong passwords. Password management, of course, goes hand-in-hand with the use of good passwords. Limit access to the assets on a need-to-know basis. Sound security policies should be practiced as a matter of course. Again, a lot of this is common sense and procedural.

EET&D: What about the technical side? Certainly there is a technical dimension to all of this that will help improve security…

Whitehead: Well, naturally there are a lot of technical measures available to support procedural methods. There's no silver bullet. Different threats call for different kinds of protection: solutions must be designed holistically, not individually. Our solutions scale with applications. For some applications, passwords may provide sufficient security. For other applications where data security is critical, we've developed NSA-recognized encryption designed for protection and SCADA communications links.

EET&D: I want to take the last few minutes we have together to ask you about synchrophasors and Phasor Measurement Units – or PMUs as they are often called. PMUs are a relatively new addition to the power engineering toolbox that hold great promise for improving our ability to predict, and hopefully, prevent faults that can lead to major outages, especially those of the kind that caused the Northeast blackout in August of 2004. What can you tell us about how PMUs fit into grid transformation and Smart Grid?

Dr. Schweitzer: We're at the tipping point for synchrophasors. The result is that we and many of our customers are already transforming the grid. For example, Comision Federal de Electricidad (CFE) in Mexico is using synchrophasors for the real-time control of generation to respond quickly to line outages. Several utilities and industrials are not only using the protection but also the programming and control capabilities these devices contain to automatically reconfigure their systems, locally and quickly. I like to say we should communicate more and depend on it less, which in turn, drives more localized and automated decision-making.

EET&D: You mentioned CFE in Mexico as one example of where PMUs are already being deployed, but can we assume that we will start seeing these in more projects going forward?

Dr. Schweitzer: Until recently, synchronized phasor measurements were available only from laboratory equipment or from expensive stand-alone phasor measurement units. The expense and need for separate equipment had limited the use of synchrophasors. Today, however, you can get built-in synchronous phasor measurement capabilities when you buy meters and a growing number of relay models. You can even get firmware upgrades that will further extend the reach of the synchrophasors.

Whitehead: I'd like to also add that thanks to microsecond-accurate GPS clocks, precise time is available everywhere today. One reason our R&D engineers have worked so hard to make synchrophasors ubiquitous is because there are so many things you can do when voltage and current measurements are precisely time-synced. One microsecond corresponds to only about 0.02 electrical degree at 60 Hz, so phase errors in the measurements come primarily from instrument transformers.

EET&D: What kinds of things can we do by migrating to broader use of synchrophasors in the future?

Dr. Schweitzer: These devices have a multitude of applications, some of which are fairly traditional and others of which represent relatively new frontiers. But whether you test or commission protective systems, manage assets, operate control centers, develop models, or analyze power system events, you will find these units to be immensely useful.

One straightforward application is the use of synchronized phasor measurements from your meters and relays to check the instrument transformers within your substation. When the breakers are closed, all line and bus voltage transformers should agree in magnitude and phase.

Another common use is to check CT polarities, phasing and ratio. With a little load on the system and all your relays synchronized, perform Kirchoff's Current Law around the bus, phase by phase, and you will be able to see any phasing, polarity or ratio errors. And, since synchrophasors are available everywhere today, we can now directly measure the power-system state – and do so quickly. Knowledge of the state is vital in preventing blackouts, and adapting to rapid changes in wind generation, for instance.

EET&D: In closing, what are some of the broader changes you expect to see in the electric power industry over the next few years?

Dr. Schweitzer: One of the changes I think we will see is a move towards distribution systems that can accept load or generation virtually anywhere along the network. One rather creative idea is to integrate idling locomotives as spinning reserves. On a more conventional basis, however, I think we will see a rebirth of nuclear generation and probably more hydro as well, since hydro goes hand-in-hand with wind as what you might call complementary renewables.

Synchronized measurement and operations of the power system including switching events at multiple substations that are precisely controlled in time is another example. Distributed control that intelligently islands – instead of "anti-islanding" – and faster clearing of faults, will result in less reliance on time coordination except for back-up. Customer service and safety will demand this!

I also see more transmission lines being built, and many existing ones upgraded – something that we have desperately needed for a long time. And new tailor-made, wide-area communications solutions that are fast, secure and flexible and that support the need for synchronized control and protection are needed for all of this to come together in a cohesive and efficient way. I realize that's a pretty tall order, but I have every confidence that we can and will do it. Meanwhile, utilities and industry need to keep educating, training and hiring engineers to create, design and build these systems. I'm sure that many other creative new solutions will arise as we go forward. It's truly an exciting time to be in the power business! ■

Preparing Customers for Smart Grid Costs

By Guerry Waters, Vice President, Industry Strategy, Oracle Utilities

It's impossible these days to open a newspaper or turn on the TV without hearing stories about the negative effects of energy use. North Americans are increasingly seeing a connection between fossil fuels and climate change.

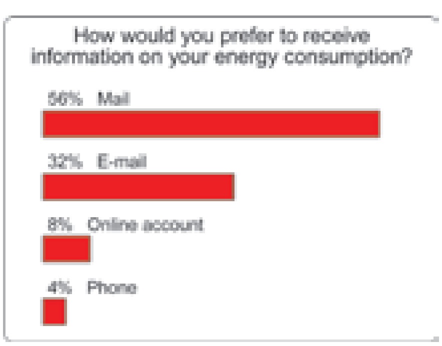
The Obama Administration's 2009 Stimulus Bill brought the Smart Grid to public attention as a partial solution to the problem. The federal government's willingness to fund projects and the view that at least some were "shovel ready" encouraged consumers to see the utility industry as a source of solutions to issues like replacing fossil fuels with wind and solar energy.

Many industry executives, however, worry that the image of the Smart Grid is too positive. Once customers understand the full costs of a Smart Grid, they ask, will the glow continue? And what happens if it fades?

Cost Expectations

Oracle found in its survey of 604 U.S. consumers and 200 U.S. utility managers, "Turning Information into Power," that there are grounds for concern. The survey found, for instance, that although U.S. gas and electricity costs remain modest by global standards, 94 percent of respondents were concerned about the energy costs of their primary residence. Almost as many – 93 percent – rated "saving money" as a 'Somewhat Important' or 'Very Important' motivator to conserve energy. As proof of that importance, 88 percent said that in the previous 12 months they had actually taken steps – adding insulation, switching to compact fluorescents, and the like – to lower their energy costs.

Every bill received, payment made, or visit to the company website should be used as a valuable opportunity for companies to promote strategic adoption of the online channel. A positive payment experience strengthens a company's brand and increases the potential to transition customers to paperless billing.



Oracle's "Turning Information into Power" study revealed that, despite the many communication advances of the past decade, most customers would prefer to receive information from their utility via mail.

Costs and Renewables

Most startling on the cost front were the slightly more than half of the survey respondents who said that one of the most important benefits of renewable energy use is that it will reduce personal energy costs[1] – an idea few in the utility industry support.

Is this an idea left over from mid-Twentieth Century sci-fi projections? Possibly not. Many media stories on renewables highlight the falling cost of renewables technology. One search engine shows 264,000 hits on the exact phrase "low cost solar" and millions more where the words are in close proximity.[2]

These reports are not intended to deceive. They use "low cost" in the sense of "lower in cost than a similar item was in previous years" – a concept clear within the energy industry. It is also the case that new cap-and-trade systems or carbon taxes could, in a foreseeable future, easily make renewables less expensive than fossil fuel generation.

Still, it appears that a substantial number of consumers interpret "lower cost" as meaning "lower than I currently pay."

Costs and Information

Consumer concern with cost is also clear in the survey results on information usage.

On one hand, consumers have a desire for more information on energy consumption. Nearly all those surveyed (95 percent) said they were interested in receiving consumption information.

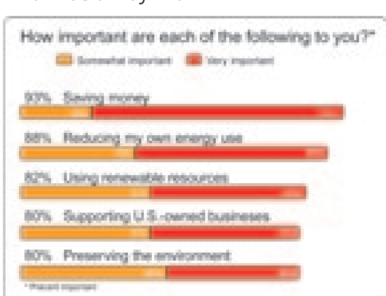
[1] Based on percentage of respondents that rated the benefit an 8-10 on a scale of 1-10, where one is "not at all important" and 10 is "extremely important."
[2] Such casual searches are merely suggestive, of course, but results are similar using "wind" as the criterion. And "low cost" hits for both wind and solar outnumber similar "high cost" hits by more than six to one.

And most saw room for improvement in the amount and quality of information utilities currently offer.[3]

Also demonstrating the value consumers place on information is the fact that 69 percent of them said they would review detailed "real-time" usage data if it were available. Most of those saw information as leading to lower personal consumption.

Does that mean consumers would value the near-real-time information a Smart Grid can provide? For some consumers, "value" may not equal "money." When asked if they would be willing to pay an upfront cost for the ability to see detailed and/or real-time consumption data, only 20 percent said yes.

Expenditures for customer portals via which utilities plan to deliver Smart Grid information could also be problematic. The survey revealed that such portals were not high on the priority list for the more than half of all consumers who would prefer to receive their energy information by mail.



Consumer emphasis on saving money could challenge utilities looking at rising commodity prices and high costs to develop a Smart Grid.

Costs versus Benefits

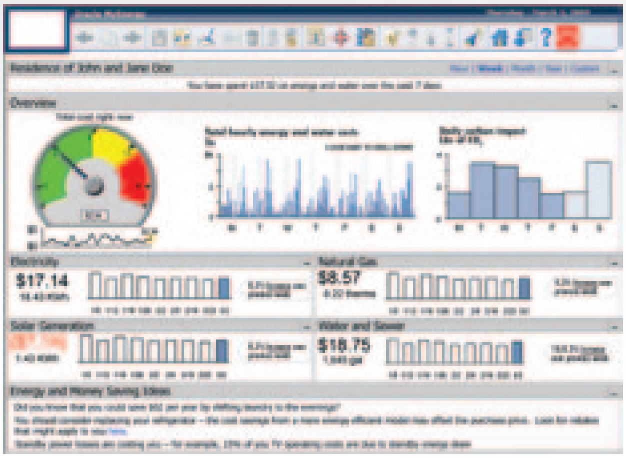
Total Smart Grid cost estimates vary widely. KEMA has estimated U.S. costs for the Advanced Metering Infrastructure (AMI or "Smart Metering") portion of the Smart Grid at slightly more than $63 billion.[4] A study from U.S. regional transmission operators,[5] suggests the grid needs $100 billion in improvements to substantially raise the percentage of generation from renewables. A widely circulating number for total Smart Grid cost is "up to $2 trillion."[6]

The thick technical reports backing up these estimates do not lead easily to consumer-oriented explanations. And few bother to point out that, even without the Smart Metering and renewables associated with the Smart Grid, ongoing transmission and distribution investments have been – and will continue to be – substantial.

From the consumer's point of view, it is equally difficult to assess benefits. A 2003 U.S. Department of Energy study suggests Smart Grid-related benefits of $46-$117 billion by 2023.[7] Estimates since then have risen considerably. The Electric Power Research Institute, for instance, estimates[8] that reducing power interruptions and fluctuations – an almost certain Smart Grid benefit – could save up to $100 billion each year in damages and lost business.

Few, however, venture to guess at how total benefits might approach the costs without positing carbon taxes or CO_2 cap-and-trade permits.

[3] When asked to give their utility supplier a grade on their "current ability to provide detailed, useful information on energy consumption," only 14% of consumers gave their utility supplier an "A."
[4] KEMA, Inc., The U.S. Smart Grid Revolution – KEMA's Perspectives on Job Creation, prepared for the GridWise Alliance, December 2008.
[5] Cited in Rebecca Smith, "New Grid for Renewable Energy Could Be Costly," Wall Street Journal, February 9, 2009.
[6] National Public Radio, "Putting a Price on Smart Power," Power Hungry: Reinventing The U.S. Electric Grid, April 2009.
[7] [[L. D. Kannberg]]; M. C. Kintner-Meyer, D. P. Chassin, R. G. Pratt, J. G. DeSteese, L. A. Schienbein, S. G. Hauser, W. M. Warwick (2003-11) (pdf). GridWise: The Benefits of a Transformed Energy System. Pacific Northwest National Laboratory under contract with the United States Department of Energy.
[8] Cited in [8] National Public Radio, "Putting a Price on Smart Power," Power Hungry: Reinventing The U.S. Electric Grid, April 2009.



Many utilities are developing Web portals to provide detailed information to customers. Encouraging customer use and assessing results remains a challenge for the future.

Other Studies

The Oracle study is not the only one detecting a gap between customer expectations of future energy costs and experts' estimates of likely costs.

A Deloitte study found that "Sixty-two percent of consumers would be willing to pay five percent more on their electric bills to stop greenhouse gas emissions."[9] Applied to consumers alone, that would produce about $7.8 billion annually; applying that percentage uniformly across all sectors would produce about $18.2 billion.[10]

Similarly, the Distributed Energy Financial Group[11] found: Nearly one-third of Americans believes that no utility bill increase is necessary to manage climate change, and another 44 percent say less than 10 percent… One third of Americans… would be very dissatisfied if they had to pay 10 percent more for electricity to address climate change.

While cost estimates are vague and implementation schedules highly uncertain, a 5-10 percent rise in bills seems unlikely to generate revenue quickly enough for a pay-as-you-go rollout. Such utility capital projects are rarely, however, financed through current revenue; bonds could make payment far more manageable, especially for investments made gradually over time. Given ongoing inflation rates and projected pricing for the renewable energy to put onto an improved grid, however, consumers are almost certain to notice the added costs.

Promoting Support

Education

One approach to encouraging customer acceptance of Smart Grid costs is to demonstrate their need. That begins with putting national abstractions into local terms.

"Reducing peak consumption" is a vague concept, at best. Consumers need something clearer: Unless we reduce consumption during X time periods by Y amount, we are going to have to spend Z dollars to build a new distribution line.

Clarity permits all stakeholders to examine options for reaching a goal. In this example, discussions might involve:

- Monthly rather than seasonal rate adjustments. Some studies suggest that varying flat rates monthly rather than annually[12] could produce 30 percent of the peak-shaving gains anticipated through real-time pricing.
- Critical peak pricing programs for very large customers or volunteers only.
- Customer-owned generation strategically positioned to reduce use of specific lines.
- Direct load control devices on customer-premises equipment like air conditioning units. These devices proved workable in the 1980s and 1990s but lost favor, in part because utilities could not detect which units were still operational or which households overrode their use. Comparing direct load control with the cost of more sophisticated equipment could help customers understand the pay-off for investments in such single-use devices versus the potential of more flexible, multi-purpose advanced metering systems.

The customer may also respond positively to information on lessons learned from previous local or national programs aimed at solving the problem, such as:

- Weatherization.
- Use of an existing automatic meter reading (AMR) system, read daily and using 24 hours as an "interval" to gain at least some of the benefits available from Smart Metering.
- Rewards for specific percentages of use reductions maintained over specific time periods.
- Intensive education programs delivered more aggressively using not merely the bill stuffer but (with the customer's permission) more aggressive channels such as e-mail or short message service (SMS).
- Low-cost loans, collected as part of the normal energy bill, for energy-saving equipment and weatherization services.

[9] Cited in International Consumer Research, "Rising electricity rates, global warming top concerns for consumers and regulators: Deloitte study," May 22,2008.
[10] Using 2008 consumption figures from the Energy Information Administration, U.S. Department of Energy.
[11] Cited in Warren B. Causey, *Tracking The Rise Of The Intelligent Enterprise*, Sierra Energy Group, January 2009.
[12] For instance, in "The Short-Run Effects of Time-Varying Prices in Competitive Electricity Markets," (University of California Energy Institute, CSEM WP-143R), Stephen P. Holland and Erin T. Mansur suggest that goals could be realized through setting flat rates monthly rather than annually. "Monthly flat rate adjustment has many of the same effects as RTP adoption, captures more of the deadweight loss than time of use (TOU) rates, and requires no new metering technology," they find.

Helping consumers understand the grid improvements essential to meeting state Renewable Portfolio Standards should also ease customer acceptance of Smart Grid costs – or possibly direct the backlash, if one remains, at an appropriate target.

Reducing Costs

The Smart Grid is not a single package of specific hardware and software. Despite the claims of some vendors, it does not arrive in a box. The shape of the Smart Grid will vary from region to region; so will its costs.

Technologies and customer programs designed to reduce peaks, for instance, will not be a part of the Smart Grid in regions with transmission and distribution overcapacity. Utilities developing local run-of-river hydro or biomass generation to fill Renewable Portfolio Mandates may ignore the sophisticated grid improvements associated with using "non-dispatchable" wind and solar.

The Smart Grid is a vision we will realize through evolution. And Smart Grid costs could plummet over time. Economies of scale and innovation will likely reduce manufacturing costs, as they have in virtually every other high-tech venture. Experience with business processes and customer programs will likely lead to the emergence of best practices that will increase efficiency and reduce investments in dead-end approaches.

Non-Rate Funding

Customer revenue is not the only source of funding for Smart Grid projects. The $11 billion in Smart Grid grants available under the U.S. fiscal Stimulus package may be, as some describe it, a drop in the bucket of overall Smart Grid funding. But it is a valuable drop in kicking off projects. Additionally, the Department of Energy has about $3 billion available for Smart Grid grants.

Reducing utility risk profiles may be another source of funding. Standard and Poor's numeric business risk profile categories significantly affect utilities' cost of capital. Lowering risk reduces the cost of capital in quantifiable ways. Utilities and regulators could – should they choose to do so – apply the savings to various Smart Grid improvements.[13]

Working with the Media

Television, radio, and newspapers can be invaluable allies in getting clear and realistic Smart Grid information in front of customers. Many utilities already have a significant media presence and excellent contacts. But reality is that only the largest media outlets have full-time energy reporters. Most use generalists who cover little beyond commodity price changes and do-it-yourself home weatherization.

That suggests significant risk concerning potential media portrayal of the Smart Grid. Once the rust of media "hype" subsides, a generalist reporter might, for instance, take a $2 trillion Smart Grid cost estimate, assign half to business and half to residential customers, and denounce the Smart Grid as saddling households and small businesses with an astounding $7,000 bill.

Utilities can help head off such incidents by providing the media with not just a community-outreach professional but also with a technical expert who can, on an ongoing basis, localize costs and benefits, explain utility plans, answer customer questions via a blog, and generally help fill the information gap.

Conclusion

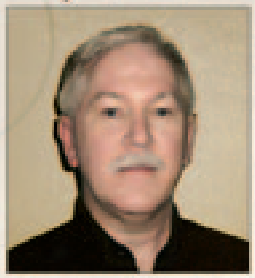
Consumers today are coping with continuing bad financial and environmental news. For many, positive media stories and federal support have turned the Smart Grid into a much-needed beacon of hope for addressing some major environmental issues in a positive and meaningful way.

Studies like Oracle's "Turning Information into Power" suggest, however, a gap in consumer understanding about likely future energy costs. Most utilities will want to turn that lack of understanding into support and avoid a backlash against Smart Grid costs. To do so, utilities may want to step up media contacts and customer communication initiatives regarding the costs, benefits, and alternative paths to a cleaner and more secure energy future. ■

About the Author

Guerry Waters joined the Oracle Utilities Global Business Unit (previously SPL WorldGroup) in 2000. Previous positions include Vice President of Energy Information Strategy at META Group (now Gartner) and CTO and Director of Technology Strategy and Engineering at Southern Company. He focuses on IT strategies that help utilities meet their goals amidst changing customer demands, regulations, and market structures.

[13] Use of a lower cost of capital as a revenue source is playing a role in current discussions of rate structures like decoupling. It is far too complex, however, for complete discussion in this article. There is a particularly lucid description of the issue in The Regulatory Assistance Project's (RAP's) Revenue Decoupling Standards And Criteria, A Report to the Minnesota Public Utilities Commission (30 June 2008). RAP also publishes a number of other documents on this issue.



SECURITY SESSIONS

By William T. (Tim) Shaw, PhD, CISSP

Welcome to the first installment of *Security Sessions*, a new feature focused on security-related issues, policies and procedures. I want to thank Jaguar Media and the editorial staff of *Electric Energy T&D magazine* for this opportunity to communicate with EET&D readers across the industry and around the world on this increasingly important topic. Let me start off by saying that I like to think of myself as an educator. As such, I hope to use this column to help convey the various aspects of security and how evolving security measures impact those involved electric power T&D in a way that is informative and easy to apply to your own situation, regardless of how complex the core issues may be. In this first installment, I will address a few of the many misconceptions about security and also lay some groundwork for a common understanding of security fundamentals going forward.

Lately, the news has been full of headlines and warnings about nebulous cyber threats to the power grid. We hear that hackers from other countries have "embedded software" into critical systems that monitor and control various aspects of the grid and that we are vulnerable to blackouts precipitated by these evil forces. No one who is knowledgeable about cyber crime disagrees that there are myriad hacker groups constantly looking for ways to make a dishonest buck, and there is ample evidence of foreign governments that would like to inflict harm on our industry and innocent people the world over. Yet often the people making these pronouncements – although presumably well intended – are less technically informed than might otherwise be appropriate for issuing such sweeping alarms.

For example, the notion that someone hacking into a company's web server is equivalent to having a control system 'hacked' is simply not true in the vast majority of cases. Indeed, industrial automation experts have always distrusted the reliability of computers. And despite the fact that computer reliability is extremely high compared to most manual methods, the vast majority of mission-critical systems are designed to be exceedingly fault-tolerant. This can be accomplished by various methods and practices including measures ranging from full redundancy (often with automatic failover software) to totally replicated equipment at alternate facilities and/or back up by one or more layers of independent safety equipment.

The reason for this protective stance being initially developed was quite basic: Industrial processes – whether generating or transmitting electric power, processing hydrocarbons or a part of countless other activities – can result in valuable equipment being damaged or entirely destroyed and people can be harmed or even killed should things go badly wrong. And although fault tolerance isn't in itself a sufficient security blanket, it is often an effective first line of defense and an indicator that there are problems requiring further attention. This is not to say that we shouldn't be concerned enough to take steps to strengthen our critical systems and infrastructure – naturally, we must. But such actions should be focused on the areas of greatest vulnerability and risk, initially targeting cyber assets whose compromise would yield unacceptable consequences that may not be readily preventable by routine fault detection and operator vigilance.

When discussing cyber threats to critical (cyber) assets, we must first understand the characteristics of – and especially the differences across – various classes of cyber assets. My definition of a vulnerable cyber asset is any intelligent system or device that has remote communications capabilities enabled (e.g., a DCS or SCADA system, a protective relay, an RTU, a smart meter, etc.). Communications may be via wireless technologies, LAN or WAN technologies or even conventional analog telephone lines. (Any such device that does not have a communications interface cannot be attacked without physical access to that device, so I will not consider them in this instance.)

We can further break these assets down into three (3) classes: 1. Devices having a fixed set of executable commands; 2. devices that also have some capacity for remotely configurable settings and functions; and 3. devices that also can be remotely reprogrammed to some degree.

The first class of devices cannot be infected with malware because it is not possible to alter their programming remotely.

The most that can happen in those cases is that unauthorized commands are sent to, and executed by, the device(s), which could ostensibly have dangerous results. The same is generally true for the second class of assets, but those types of devices may have remotely alterable configuration settings that significantly change the operation. A good example would be changing or disabling the protective functions of a relay. The third class of assets does support – or can at least be tricked into allowing – remotely alterable programming (e.g., a 'server', a router, a smart printer, etc.), and thus, can be infected by changing its programming.

Also, one must be careful about making sweeping judgments about which class a particular asset falls into. For example, RTUs can fall into any or all of these classifications. Unfortunately, however, most devices in the first two classes (and some in the third) have simple communication protocols that do not incorporate any facility for mutual authentication or encryption. That means that they can't tell where a message actually comes from, so anyone who taps into their communication channel can potentially send fraudulent messages to those devices.

Encryption allows a sender and receiver to 'scramble' their messages so that an attacker can't generate valid-looking fake messages unless they can decipher the encryption scheme. Today a range of products exists that can be placed into the communications channel – be it a phone line or a LAN – to add both authentication and encryption capabilities. (Authentication is a process that lets the device verify the sender of a received message, thus, allowing it to reject those from unauthorized sources.)

For IP-based LANs and WANs there are a range of network devices, such as switches and routers, which can be configured to perform both authentication and encryption and, in some cases, even act as a firewall. For utilities that have pushed IP networking out to the field (e.g., to substations and generating facilities) these devices can add another layer of security.

Many utilities have potentially dangerous remote dial-up telephone access into their substations that enables communications between the IEDs and remote users who need to access those devices. Ordinarily, dial-up circuits create a minimally secure or, in many cases, totally insecure "back door" into any subsystem having such remote access ports. One way to eliminate this security hole is to implement a VPN (virtual private network) connection between the remote users and the substation equipment.

Creating a VPN implicitly adds authentication and encryption, essentially eliminating unauthorized access. There are "substation automation" products designed to provide this capability for either dial-up phone circuits or actual IP network connections – the latter for utilities that have extended IP networking to their substations. To further enhance security, some utilities have also incorporated link encryptors (sometimes referred to as "bump-in-the-wire" devices) on their RTU polling channels as well, thus, eliminating the possibility of attackers tapping into the communications paths and sending fake commands to the RTUs.

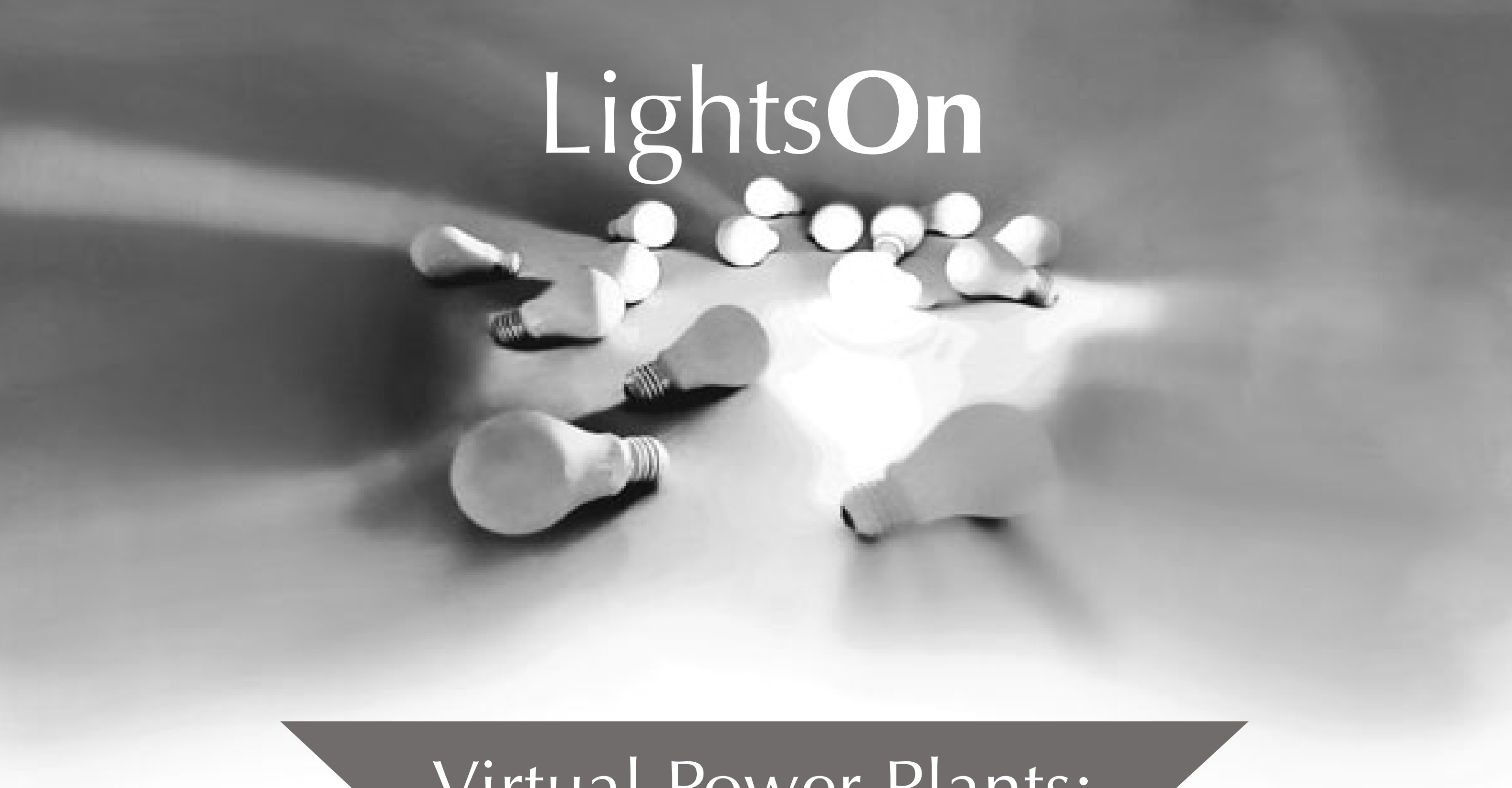
One area of serious concern is the microcomputer-based components being used to develop and build what is now commonly called the Smart Grid. For the concept of a smart grid to be ultimately successful, there must be communications from the generation management and scheduling levels all the way through the power delivery network to electric appliances at the customer premise. These distributed intelligence devices are also placed in communication networks at various levels along the grid in a variety of applications ranging from distribution automation to advanced metering infrastructure and many others. All of this implies a growing need for security equipment that is inherently secure and resistant to compromise to be installed on communications networks.

Although most control system providers – manufacturers and integrators alike – insist that they are addressing the vast majority of these issues, many existing hardware, software and communications weaknesses persist. Indeed, new vulnerabilities are constantly being identified and many questions about the application, adequacy and costs of security remain. The technologies required to address these concerns do exist, and NIST (National Institute of Science & Technology) has made an initial recommendation for possible standards, the latter of which will be examined and discussed in a future column. ■

About the Author

Dr. Shaw is a Certified Information Systems Security Professional (CISSP) and has been active in industrial automation for more than 30 years. He has authored two books ("Computer Control of Batch Processes" and "CYBERSECURITY for SCADA Systems") and continues to write extensively on a wide range of technical topics, issues and tends. He is currently Principal & Senior Consultant for Cyber SECurity Consulting, an industrial automation, security and technology firm. Inquiries, comments or questions regarding the contents of this column and/or other security-related topics can be emailed to *timshaw@ industryconsulting.org.*

LightsOn



Virtual Power Plants: Making Distributed Energy Resources Actionable in Smart Grid Commercial Operations

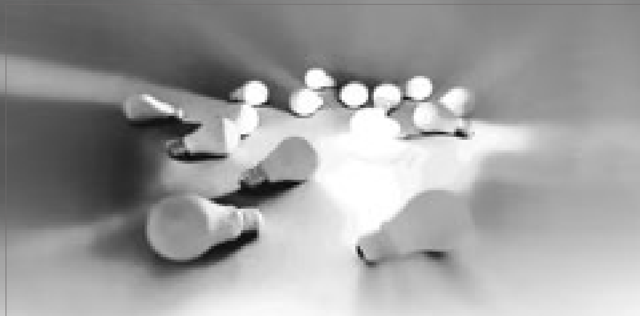
The vast complexity of resources that must be managed and integrated in advanced Smart Grid deployments can seem intimidating for almost any utility. For large commercial operations with hundreds of thousands – or even millions – of customers, it can seem like an impossibility. In this article, Smart Grid solutions expert Carlos Romero unveils a new mechanism for aggregating distributed energy resources and making them actionable in Smart Grid commercial operations as *Virtual Power Plants*.

In a recent survey, executives at leading global utilities indicated that a growing number of them have embraced Smart Grid strategy. No surprise there. But, what is new is the desire to drive the strategy not just in discrete areas like smart metering, load management and distributed generation, but "as a platform for fundamental business process transformation initiatives that span the entire energy value chain across generation, T&D, and customer service operations."[1]

The executives interviewed for the study see this strategy as an opportunity to fundamentally realign the relationship between supply, demand, economic efficiency, and environmental objectives to create new operating models that support intelligent utility enterprises. And, they see it as an opportunity that comes with many potential benefits; namely the facilitation of energy efficiency and customer choice for demand response (DR) programs, as well as maximizing the benefits of renewable resources and distributed generation (DG) as part of the complete utility's portfolio.

As a whole, the respondents viewed facilitating DR and seamlessly integrating distributed energy resources (DER) such as DG and renewable resources of strategic near-term importance. However, most perceived their readiness to implement DR and DER to be low. As a result, while many utilities are beginning to implement standalone programs, few are actually connecting the customer to the wholesale side of the utility (i.e., commercial operations).

[1] Transforming the Energy Value Chain: Smart Grid Strategy of Leading Global Utilities," January 2009; The McDonnell Group.

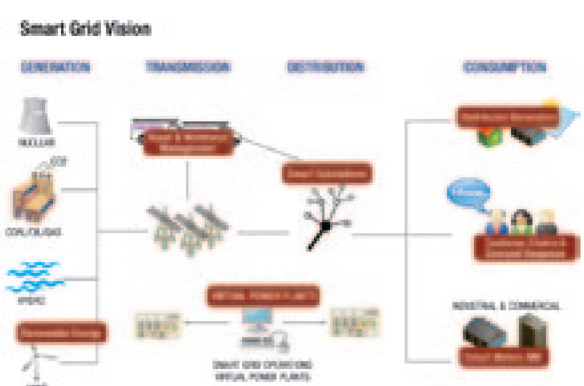


Providing this link would represent a major step in implementing a true Smart Grid. It would enable customers to receive price or environmental signals, understand their energy consumption and even predict what their bill is going to look like. It could even enable customers to understand and affect their carbon footprint by adjusting their energy usage without diminishing their quality of life. Furthermore, it could help utilities make better use of existing infrastructure – even defer investments in new infrastructure for fuels, transmission, distribution, transformation, and generation.

If so many utilities understand the benefits of DR and DER as part of a comprehensive Smart Grid initiative, why are they not making more progress in implementation? Because they also understand the many challenges inherent in implementing effective Smart Grid programs and because the wholesale market and local tariff structures that support these approaches are just now emerging into the mainstream.

A Complicated Future

As complex and unwieldy as the electric network can be today, just imagine how complex it will be in the future, as we continue the growth of DG; as renewable resources such as wind generation – with intermittent availability – are integrated into the grid; as customers begin to plug in their electric vehicles, frequently connecting and disconnecting them from the network; and as smart appliances in homes begin responding to price and environmental signals. Imagine all your customers with different kinds of DR and DG programs, different types of resources and constraints on the utilization of these resources, and energy storage in their garage and/or at their business and how this storage will impact the distribution network.



The system gets even more complex as DR programs continue to evolve to provide more advanced controls based on time of use and real-time and dynamic pricing with the advent of smart meters. In some cases, customers can get information regarding prices (day-ahead or even real-time) and make decisions, or let intelligent devices make decisions, about their consumption based on that information.

DR programs will present even greater complexity as they begin to incorporate price-sensitivity. Utilities and service providers will have to understand and manage whatever kind of pricing structure is used for customer billing, how to calculate that price, and how fast those prices can be accurately calculated and communicated to the various control devices so that they can act/react in real time. And, how dynamic is the price to which they are expected to respond?

We must also take into account the reality that consumers can be price-sensitive, not only when the prices are high, but also when the prices are low. If large percentages of the market respond to prices on the demand side, the prices are going to come down rather than having demand resources function as a stop-gap reliability measure or critical peak resource, as they typically do today. Likewise people will connect because prices have come down, and a price-elastic market cycling process will ensue. Demand response is not only about shedding load; it is also about how the load is going to react, depending on where prices are headed at any given time.

DR programs need to be scalable and adaptable to manage these new complexities. For example, we expect customers to eventually react not only to pricing signals, but also environmental signals, as more renewable generation sources are integrated into the mix.

As all these changes come online, we will see a major impact on how utilities manage their electric networks. For many utilities there will be a major impact around the commercial operations of the Smart Grid. Traditionally, many components of the grid have been exclusively consumers of energy, such as the components on the right side of **Figure 1**. But now, not only can they contribute negative consumption by disconnecting from the network; they can also contribute power to the network with distributed generation, electric vehicles and other kinds of devices such as storage devices and smart appliances in their homes.

LightsOn

Once all of these things are in place, one can only imagine the complexity of managing all of that data and managing the interactions between the various devices. But, even more importantly, managing the optimal economic interactions between these devices and the different agents of the energy markets presents even greater challenges. How can a utility overcome the numerous hurdles and get through to the wealth of benefits? That's where "Virtual Power Plants" come in…

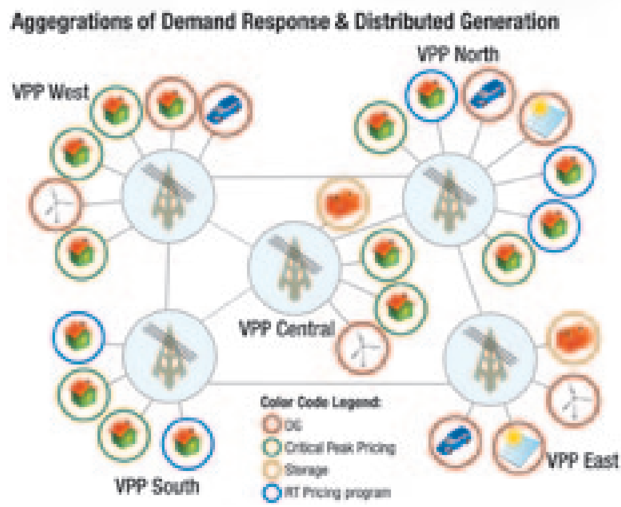
Virtual Power Plants: Doing More with Fewer Customers

So, how does a utility manage the complex systems associated with DR and DER to achieve their vision of a true Smart Grid? The first thing to realize is that we need better optimization of the various interactions along the energy value chain in order to manage this complex array of devices. We not only have a large number of them, but also a vast diversity of types of devices across the distribution network.

Households with smart appliances; electric vehicles plugged in at the home and/or the office, alternatively consuming and contributing energy; wind generation, distributed generation and other types of distributed resources must all be accommodated. Trying to manage all of these individual points would be very difficult and practically meaningless in terms of the actual kilowatts that can be extracted from each customer.

But, what if we aggregate large numbers of points on the network, in a meaningful way, as a single entity? That would certainly make things less complicated.

Say, for example, you have 300,000 customers consuming 1.5 kW each. And, you have to take into account the various DG and DR programs outlined above. At first this might seem like a nightmare, but what if you could group or otherwise aggregate these customers by program type and/or location on the distribution network? Then, instead of 300,000 customers consuming 1.5 KW each, you need only manage 15 customers each representing 30 MW. In the end, you not only have fewer customer programs to handle, but you have more capability and portfolio-level agility under each one of these programs. And, you don't lose the geographic location element of the groups (see **Figure 2**), which allows for managing the flows and constraints in the distribution topology. This is precisely what Virtual Power Plants are intended to do.



Basically, a Virtual Power Plant (VPP) is an aggregation of DR and DER programs (i.e., residential, commercial, or industrial) that enables the operator to model them as generation-quality resources. VPPs allow utilities to aggregate these programs by program type and by location in the distribution topology. This means that the utility can manage a meaningful number of customers in large volumes to affect their portfolio of options for commercial operations. In this way, using Virtual Power Plants provides a much tighter link between what is happening in the wholesale market with what is happening on the retail side with management of the transmission system and the distribution system. So, there is a complete, bidirectional flow of electrons (and money) that provides the tightly integrated optimization system that is needed to more efficiently manage the complexity of the Smart Grid.

Why "Virtual Power Plants?"

At first, Virtual Power Plants might seem a strange name, but it actually makes a lot of sense. Indeed, the characteristics of DR programs can actually mimic what traditional generation looks like, as depicted in **Figure 3**, below.

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Virual Power Plants Characteristics

For instance, a customer on a DR program might stipulate that the utility cannot shed his/her air conditioning unit more than once a day.

Otherwise, more frequent interruptions may cause customers to opt out of such programs altogether. Collectively these constraints mimic the startup constraints placed on a power plant unit. Alternatively, a customer might want to limit the minimum time between events.

For example, the customer might only allow the utility to call the dishwasher every two hours. Once again, that limitation mimics minimum downtime on a generation unit. Thus, we can readily see that many characteristics of a DR program can mimic how a conventional power plant operates. That is why we can make Virtual Power Plant programs a meaningful and tangible part of commercial operations. We can use them to incorporate an asset – or a group of assets – that can be dispatched based on pricing or environmental constraints to be part of the utility's entire generation portfolio.

In that respect, Virtual Power Plants represent the next generation of DR as integrated strategic resources for a utility company. As these programs have evolved from manual demand response for industrial loads to direct load control for A/C and heating units to advanced load management with dynamic pricing, the customer's demands have become more tightly linked with the utility's ability to meet them in real time. Now, Virtual Power Plants can help to create an even tighter link between the customer and commercial operations so that there is a two-way sharing of information, and the customers and all utility stakeholders can see tangible benefits from their participation in these programs.

This tighter link between the wholesale and retail sides of utility commercial operations is critical. At the end of the day, you don't manage two different utilities—a retail utility and a wholesale utility. If you are just a retailer and you don't have generation, you have to buy contracts, and you need to be able to optimize that as well. If you are an integrated utility, you have all of these businesses as part of a single company. They are not islands; everything is part of a single initiative and for many utilities the days of outsourcing this function to aggregators will give way to a reclaiming of these opportunities into the integrated portfolio. Using the Virtual Power Plant model, they can be more easily managed as a single initiative.

Additionally, there is enormous value that can be extracted from other resources such as renewable generation. Their intermittency and operational complexities can be minimized when these resources are optimized together with DR, storage and traditional generating resources.

Case Study: Xcel Energy's SmartGridCity

As a founding partner in Xcel Energy's Smart Grid Consortium, Ventyx has tested its Virtual Power Plant model as part of the utility's SmartGridCity™ initiative in Boulder, CO. Working with the initiative's various partners, Ventyx is providing – among other capabilities – the generation portfolio optimization and scheduling and customer program management solutions required to deploy and manage the Boulder-area Smart Grid.

By aggregating customer-level DR and DER into commercially actionable Virtual Power Plants, Ventyx solutions are helping Xcel Energy manage:

- Customer DR enrollments and device tracking
- More economic and environmental generation operations through the incorporated planning and dispatch of DR and DER
- Calculation and communication of real-time price and environmental signals
- Reporting of realized program and customer-level economic and environmental benefits

As a result, Xcel Energy's SmartGridCity is using Ventyx solutions to transform diverse data from the Smart Grid into more accurate price and load forecasts and connect customer actions to Xcel's trading portfolio operations and investment decisions via Virtual Power Plants. The resulting programs are giving SmartGridCity customers greater insight and control over their energy use, environmental footprint, and overall energy economics.

Summary

Virtual Power Plants are a key mechanism for making distributed energy resources actionable in commercial operations. The VPP model can enable complete portfolio optimization, helping to maximize the benefits of renewable resources, such as wind and solar generation, and acting as a local peaking resource to augment resource adequacy in real time.

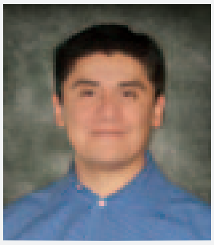
And, there are many additional benefits to implementing this model, not the least of which is improved customer satisfaction. As customers have more information regarding energy prices and their own consumption, they will feel more in control of their budget and their impact on the environment. And, the Virtual Power Plant model provides real economic benefits beyond responding to emergency reliability issues, including the deferment of new investment in infrastructure.

Based on the aforementioned utility survey, leading global utility executives are beginning to recognize the opportunities as well. This is perhaps best captured by the author of the report, who concluded:

"As utilities begin to consider the potentially new business operating models presented by two-way connectivity with customers, the potential for entirely new operating models has emerged according to the interviews. While AMI is seen by those interviewed as the foundation for the Smart Grid of the future, the panel discussed a range of new business model opportunities including the ability to deploy increasing levels of distributed resources through significant expansions of energy efficiency and demand response. The potential to physically and financially optimize both planning and day-to-day utility operations for distributed generation and renewable resources, expanding custom choice, and integrating utility commercial operations with demand response programs were also cited as high priorities."

Of course, there will be challenges associated with implementing these new operating models (e.g., obtaining rate recovery for investments, change management and system integration issues, consumer economic stress, etc.). However, if utilities can overcome these challenges, the payoff can be enormous.

About the Author



Carlos Romero, Industry Solutions Executive at Ventyx, has 15 years experience in the energy industry providing expertise in consulting, design and implementation of information technology products and solutions for business strategies surrounding resource planning, portfolio optimization, generation operations, load and price forecasting, ISO/RTO bidding and settlements. Carlos has worked with more than 30 utilities and generation companies around the world helping them implement best practices for short-term operations management.

Personalized Customer Communications and Greater Energy Efficiency Put E.ON Ahead of the Competition

By Simon Reynolds, Group Manager United Kingdom and Ireland, HP Imaging and Printing Group (IPG) Enterprise Software

With a growing industry interest in the adoption of Smart Grid technologies, utility providers are now seeing a subsequent increase in the demand for more personalized customer communications. Furthermore, the continued push for utility companies to be more energy-efficient and environmentally conscientious remains strong. In response to this new competitive market, E.ON – based in the United Kingdom as the world's largest investor-owned energy company – produced the "OneBill" in an effort to create more efficient and tailored communications for its more than nine million electricity and gas customers.

Like most utility providers, E.ON initially looked at its customers' monthly statements as nothing more than an operational document with a list of transactional information (i.e., how much energy the customer consumed and how much they owed as a result). In fact, most of the company's efforts to promote, cross sell and up sell additional services or products were achieved through inserts within the monthly statement, as well as completely separate direct mail pieces. However, with an increasingly crowded market, E.ON also saw that it needed to differentiate itself from the competition if it was going to gain a competitive advantage and be able to pro-actively attract new customers.

Through the implementation of industry-leading document automation software, E.ON gradually began to see the monthly statement as much more than an operational document, but additionally an opportunistic, regular touch point with its customers. With the billing statement being the only regularly scheduled communication with its customers, E.ON began to see customers' bills as a streamlined vehicle for announcing new services and providing customized communications. And, in light of this more holistic view between the utility and its customers, the value in focusing on customer retention as a means of not only building positive relationships with its existing customers, but also as a means of acquiring new customers through modeling best practices with its customer communications became increasingly apparent.

Moreover, E.ON found that many customers were ignoring and immediately disposing of its statement inserts without reading them at all. To assess how to best address the problem, E.ON decided to commission a research project. Within the project, the company held focus groups with 80 customers from a broad demographic as well as all service process segments. This outreach also included mobile phone companies and mortgage providers to learn what kind of fulfillment document each of the customer groups liked best. Two options were offered – the traditional black and white statement (including an insert or pamphlet) or a four-color, composite document. The survey results found that overwhelmingly, consumers preferred the information in a single document instead of separate billing statements with multiple inserts.

Consolidating the Statement for a Greater and Greener Impact

In response to the research findings, E.ON used the document automation software to consolidate approximately 32 million statements (based on 2006 data) to create its "OneBill" program. This program combines all utility charges for a customer into a single statement for greater clarity and makes use of the white space on the "OneBill" statement to directly provide targeted messaging and information. This includes promotional offers, variable graphics showing energy usage, seasonally appropriate energy-saving tips and more – all of which is personalized for each customer.

By including relevant and promotional messaging within the customers' monthly statements, E.ON was able to maximize the potential for its customers to read the messages on the monthly statement in several ways. First, the billing statement is one of the few pieces of mail that a customer is likely to actually read. Second, E.ON was able to extend the life of the document and the messaging contained therein because most customers file away billing statements rather than discarding them on receipt.

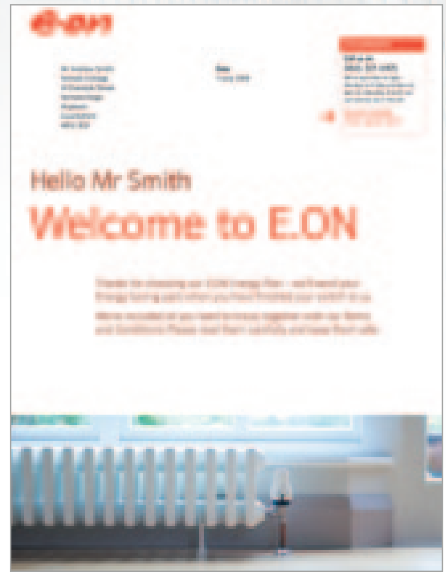
Furthermore, most customers usually look at their statement more than once (e.g., when they first open the mail and later when they are ready to pay the bill), which increases the number of impressions for the utility provider's advertisement or promotional campaign.

The effectiveness of this process became evident last year when E.ON ran a promotion to sell boiler covers to its customers on a continuation page of the bill. Traditionally, the company would have used a separate direct mail piece or included an insert with the monthly billing statement. However, when E.ON compared the continuation page method to a glossy booklet insert, the results were astonishing; the new method generated seven times more the sales than ads in either a booklet or using an insert with the bill.

Furthermore, prior to implementation of "OneBill," E.ON had approximately 40 different inserts that had to be split into separate print streams and several different postal runs. Now, E.ON has a single print stream that can be pre-sorted (i.e., instead of using the standard postal tariff), reducing the time to market and saving the company more than $735,000 a year in postage costs. Even more beneficial, by using the white space on the bill and consolidating multiple inserts into a single document, E.ON was able to reduce its overall paper usage and become more environmentally friendly in the process.

Moving forward, E.ON is looking to further leverage the document automation software to eliminate any pre-printed stock by printing directly on plain paper. Once implemented, the advantages are several. These include easily handling future changes to the company's address or logo and being able to readily accommodate a customer's change of address as well as any adjustments to the format of the bill itself. As a result, E.ON will no longer be forced to dispose of pre-printed stock each time changes become necessary, consequently making the utility more environmentally responsible.

A More Proper Welcoming



Traditionally, new E.ON customers received a black-and-white welcome letter with a colored leaflet insert. The communication was generic, so customers would sometimes receive information on products and services that they already had and/or that were not relevant. Following its research findings, E.ON redesigned the fulfillment document it sends to new customers and has created a customized, full-color communication piece.

Now, the new order fulfillment form – or Welcome Pack – walks E.ON customers through the entire transfer process. Unlike the impersonal generic form letter, it uses the customer's name throughout and provides detailed individual pricing and payment structures, as well as flow charts, diagrams and images to better explain the process. Moreover, the documents are customized to respond directly with the products and services each customer requested using rules-driven targeted messaging, all of which increases customer service efficiency while also providing a flexible platform for future marketing initiatives.

This notably more concise and easier to read fulfillment form is designed to help customers become more knowledgeable about the services they are buying and keep them informed about any upcoming changes in service. The new forms also help manage customer expectations which, in turn, reduces the number and frequency of customer questions and calls to E.ON's contact center as customer knowledge advances. In fact, E.ON found that by producing more effective statements and fulfillment documents that clearly detail the most important aspects of the bill (e.g., the amount due, the date due, account number, etc.) and using highlighted color and explanatory messages, E.ON could not only save money but also reduce call volume and call duration for both E.ON and its customers.


Switching

it's as easy as...

Mr Sample

When you spoke to our Home Energy Consultant, you chose EnergySavingPlan for electricity and gas - thank you.

1 We've started your switch

2 You'll need to give us your opening readings

3 We'll finish your switch

What you need to do

As an added benefit, E.ON can now spend more time focused on reacting to customer requests and getting key messages to market faster with its document production lead times being reduced from up to 10 weeks to just a matter of days.

Personalized Delivery Methods

Responding to customer requests goes beyond the contents and layout of the billing statement. It's also about the way customers receive their statements. Knowing, understanding and responding to customers' preferred channel of delivery is of equal importance when considering customer retention and acquisition.

At E.ON, customers can choose between standard print and mail or paperless billing. Each month, customers that choose paperless billing receive an e-mail stating, "Your new bill is ready," and directing them to a Web self-service portal site hosted by E.ON where customers can log-on any time to directly view their monthly bill as well as their usage chart(s) and other personalized data. And, as the utility industry continues to evolve, E.ON already has the flexibility to quickly and easily respond to any future trends and customer-preferred delivery channels (e.g., text messages, Web TV, etc.) by keeping the design of its "OneBill" document completely independent of delivery and channel restrictions.

Looking Ahead and Doing Things the "Smart" Way

For many utilities, Advanced Metering Infrastructure (AMI) is already a critical component of their evolving Smart Grid strategy. Among other benefits, AMI allows utility companies to measure, collect and analyze meter data on-demand through two-way communication with the meter, which also opens the door to two-way communication between the utility and its customers.

And, with the rapidly advancing deployment of Smart Grid technology comes the necessity for utility providers to develop a strategy to manage and successfully utilize the massive amounts of data they will now be receiving at daily, hourly or even more frequent intervals, reporting on the energy usage of each customer. Going forward, the challenge of dealing with monitoring and communicating the benefits of better, faster and more accurate information as a means of driving customer behavior looms large.

Lessons Learned

Through the research and successful implementation of the "OneBill" and new customer Welcome Pack, E.ON has positioned itself as an industry-leader. But with technology advancing at an unprecedented rate, staying both competitive and forward thinking is more critical than ever for utilities and providers alike. One way to do that is the early implementation of an automated customer communications strategy that enables effective and direct interaction with customers; ensures an efficient, informed and rapid response to problems; and provides better, faster and more accurate customer information.

Document automation software can help utilities to not only streamline their customer and operational documents, but can also reduce paper and postage costs and improve customer communications with fewer staff needed to handle call center inquiries and trouble calls. Moreover, utility providers can better position themselves for success by personalizing customer communications and becoming more conscientious and proactive about both the environment and the rapid technological evolution of the industry. ■

About the Author

Simon Reynolds is Group Manager for the United Kingdom and Ireland (UK&I) region of the HP Imaging and Printing Group (IPG) Enterprise Software division. With more than 25 years of experience within the IT sector, he has broad experience across sales, professional services, marketing and general management. Additionally, Reynolds played a key role during the UK's transformation to a deregulated, open market, working on several key utility client projects. Simon can be reached at simon.reynolds@hp.com.

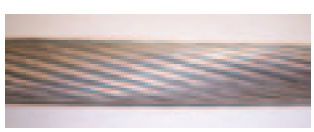
Optimize Capacity of Overhead Lines by Conductor Surface Test

by Ray Ferraro, PSE&G; Bernie Clairmont, EPRI; and Dan Lawry, Pike Electric

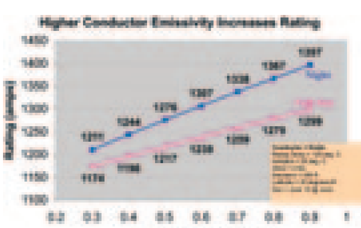
The amount of power that an overhead transmission line can transfer is affected by the conductor's ability to radiate thermal energy. This is determined by the conductor's surface "darkness," called its emissivity. An old, weathered conductor cools itself by thermal radiation much better than a new, shiny conductor. You can see this effect when working on a car exhaust system. With a shiny stainless steel muffler and tailpipe, you'll not be able to detect its hot temperature by putting your hand near it as well as if the metal had a darker rusted surface. Similarly, you can see the emissivity effect after taking a stainless steel brownie pan out of the oven. When putting your hand near its side, you will not be able to sense its hot temperature nearly as well as if the pan had a darker steel or cast iron surface. (Of course if you touch it, all doubt will be removed that it's truly hot.)

Determining a transmission line's emissivity improves the accuracy of the thermal rating, regardless of whether the rating is a static rating or is determined in real-time using sag, line temperature, weather or any other technique. Accurate emissivity improves the accuracy of both normal and emergency ratings. Since it is has been difficult to measure conductor emissivity, guesses of conservative values are often used by transmission owners. Measuring emissivity allows eliminating this unnecessary conservatism and allows harnessing more of the conductor's true ampacity (i.e., current-carrying capacity).


PSEG's 15-year-old weathered conductor


Nearly new conductor

The emissivity of a heated surface is the ratio of the radiant energy emitted by that surface to the radiant energy emitted by an ideal emitter. Emissivity is like emission efficiency, with 0.0 representing a surface that emits no radiation and 1.0 representing a perfect emitter (the so-called 'blackbody"). The following figure shows that the rating of a Drake conductor increases with increasing emissivity.



The numbers were calculated using IEEE Standard 738, "*IEEE Standard for Calculating the Current-Temperature Relationship of Bare Overhead Conductors*[1]."

If the conductor's emissivity were assumed to be 0.5 – a very common assumption – while the actual emissivity were 0.8 – a realistic number for an older line – the rating would be boosted by 5%. Not a bad increase considering the minimal effort and expense. Consider how valuable it could be if all your transmission lines increased their power transfer capability by 5%!

Older lines have the most to gain by determining the actual emissivity. This is useful since older lines are more apt to run up against their thermal limits. As a line is energized for years exposed to the environment, its surface darkens and its emissivity increases due to oxidation and contamination. That's a good thing for cooling and line rating purposes; older lines can easily have an emissivity above 0.8. House and Taylor[2] did some work, which is often cited for estimating conductor emissivity as a function of years in service and operating voltage. The data, however, has a large spread of emissivity values, so it is hard to make definitive use of the numbers.

EPRI's Emissivity Test Instrument (ETI)

EPRI, in collaboration with Pike Electric, has developed the Emissivity Test Instrument to accurately measure the emissivity of conductor samples specifically for the purpose of line rating. A short conductor sample is prepared and placed in the ETI chamber. Then, the requested parameters are entered into the ETI operational software, and the system automatically performs the test.

[1] IEEE Standard 738, "IEEE Standard for Calculating the Current-Temperature Relationship of Bare Overhead Conductors."
[2] House, H. E., Taylor, C. S., "Emissivity and Its Effect on the Current Carrying Capacity of Stranded Aluminum Conductors," AIEE Transactions, pp. 970-976, Oct 1956.

EPRI Emissivity Test Instrument

How it works

An internal heater continuously heats the conductor sample, which is equivalent to heating the conductor by current. The radiated heat loss from a conductor depends on the conductor temperature, the ambient temperature, the conductor's diameter, and the emissivity according to the following equation.

$$q_r = 0.138 D \varepsilon \cdot \left[\left(\frac{T_c + 273}{100} \right)^4 - \left(\frac{T_a + 273}{100} \right)^4 \right]$$

And where:

q_r = radiated heat loss, in watts

D = diameter of the conductor, in inches

ε = emissivity of the conductor, unitless

T_c = temperature of the conductor, in degrees C

T_a = ambient temperature, in degrees C

Solution Examples

Emissivity is determined by measuring the temperatures and the radiated heat loss. In regular air, the radiated heat loss is difficult to figure out, because a hot conductor simultaneously undergoes quite a bit of complex convective heat loss at the same time (because hot air rises). The ETI eliminates convective heat loss by testing the conductor sample in a vacuum chamber. Once steady-state is achieved, the power supplied to the internal heater must simply equal the radiated heat loss out of the conductor. The heater power and temperatures are measured in this steady state condition, and the emissivity is then calculated by the previous equation.

Emissivity can be thought of as a surface "darkness," but that is a simplification. Emissivity is really the "darkness" at the specific wavelengths that are being radiated. However, human eyes respond to various visible wavelengths, so the visual appearance can be misleading.

That is, a surface that appears light can be actually dark for cooling purposes. For example, white paint has about the same emissivity as black paint because these look about the same in the infrared spectrum where heat is being radiated. Emissivity also varies with wavelength, and a hot conductor radiates a spectrum of wavelengths (about 3 to 30 um.)

The surface material and oxide influences the radiated spectrum shape. You can see the complexity increasing. Infrared techniques only "see" a portion of the emissive wavelengths, so they make an approximation for the whole radiated spectrum. Total *emissivity* is the value of interest for conductor thermal rating, because it is the effective emissivity over all emission wavelengths.

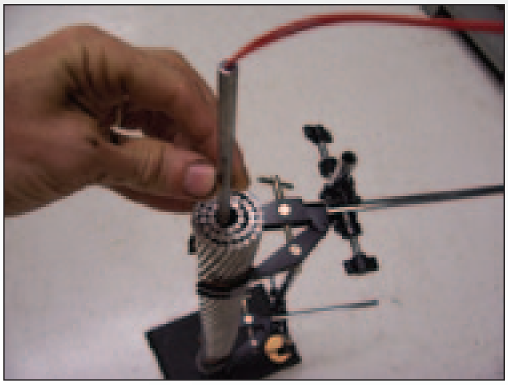
The emissivity of a surface also varies with the angle of radiation, because a surface does not radiate equally in all directions. Some emissivity measurement devices require a smooth perpendicular surface and are therefore unable to perform measurements on round conductor. The complex surface due to conductor stranding also complicates attempts to determine emissivity. Emissivity can also vary around the periphery of conductors, possibly due to the bottom being more darkened than the top. Infrared cameras measure over a narrow angular view, so the measured emissivity is only applicable for energy coming directly out of the surface (*perpendicular*) rather than for all angles (*hemispherical*).

For real surfaces, the perpendicular emissivity will typically be greater than the hemispherical emissivity. For conductor cooling and rating, *hemispherical emissivity*, or the effective emissivity over all emission angles, is the parameter of interest. Finally, it should be recognized that emissivity can also vary with surface temperature.

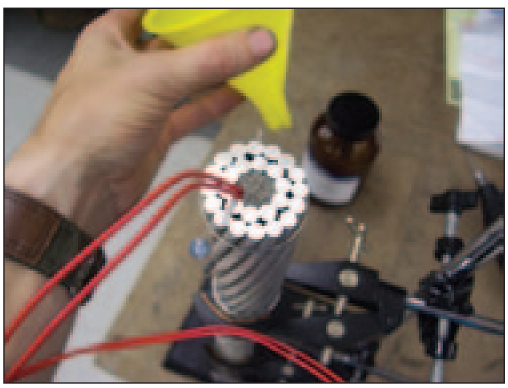
The ETI determines the emissivity applicable to line rating, i.e., the total hemispherical emissivity at the applicable conductor rating temperature. The ETI measures sample temperature and watts, which is a very direct approach to determining emissivity, making minimal assumptions. The complex effects of emissivity variation with temperature, wavelength, position around the conductor, and the effects of conductor stranding are automatically accounted for using this method.

Measuring Emissivity with the ETI

To measure a conductor sample's emissivity, the sample is first cut to 15 inches and the inner strands are removed and replaced with a cylindrical cartridge heater. Since the test is done in a vacuum, it would be difficult for heat to travel from the heater to the sample. Therefore, the void between the heater and sample is filled with metal powder to create good conduction.

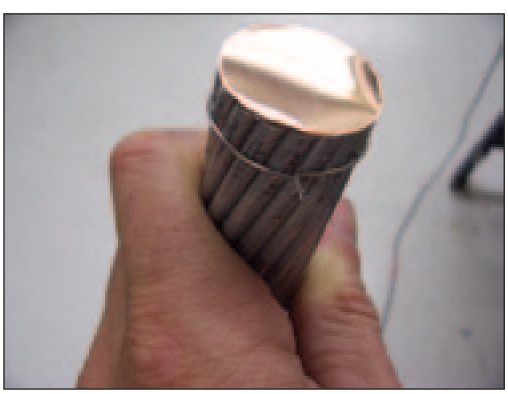


Inserting the cartridge heater into the conductor sample



Metal fill allows heat conduction from the heater to the sample in the vacuum

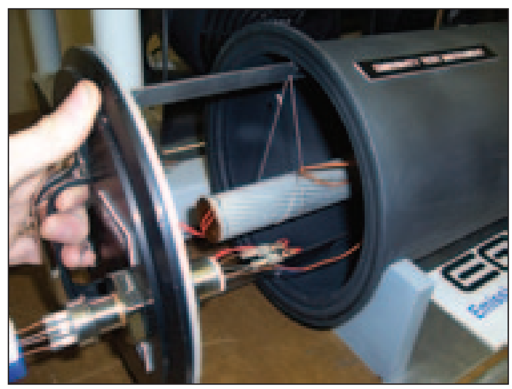
Stainless wire bands are applied to keep the sample from expanding. The sample ends are capped with a mirror finish material to reduce heat loss and to allow compensating for what little heat does exit the end. Also, a thermocouple is inserted under the outer layer.



Special End Cap reduces heat exiting the end

Attaching a thermocouple under the outer layer

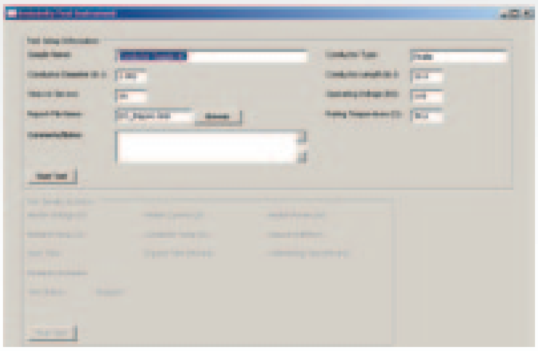
The conductor sample is placed inside of the cylindrical vacuum vessel, which has a high absorptivity interior. Insulating hangers hold the sample in the cylinder. A vacuum pump removes air from the vacuum vessel.



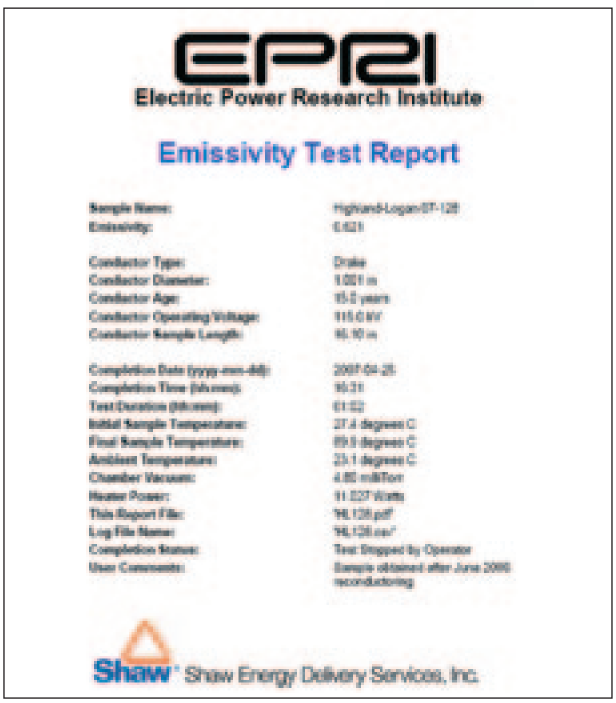
Inserting the sample into the vacuum chamber

The ETI software prompts the user for parameters such as the test name, diameter, and desired rating temperature. The conductor emissivity may vary with temperature, so it is desirable to measure the emissivity of the conductor at the temperature at which the conductor will be rated. Using this user-specified target temperature, the ETI software automatically adjusts the heater voltage until the desired conductor temperature is reached.

Once the conductor reaches steady-state, the measurements are recorded, small adjustments are made for heat losses through the wiring, banding, and end caps, and the sample emissivity is calculated very directly by equation 1. Because of the long thermal time constant of a conductor in a vacuum, this process may take 3-6 hours to complete. However, the process is automated. The ETI produces a pdf report listing the emissivity applicable for thermally rating the conductor.



ETI Software automatically heats the sample and determines the emissivity



EPRI
Electric Power Research Institute

Emissivity Test Report

Sample Name:	Highland-Logan-07-128
Emissivity:	0.621
Conductor Type:	Drake
Conductor Diameter:	1.081 in
Conductor Age:	15.0 years
Conductor Operating Voltage:	115.0 kV
Conductor Sample Length:	46.10 in
Completion Date (yyyy-mm-dd):	2007-04-25
Completion Time (hh:mm):	16:31
Test Duration (hh:mm):	01:02
Initial Sample Temperature:	27.4 degrees C
Final Sample Temperature:	89.5 degrees C
Ambient Temperature:	23.1 degrees C
Chamber Vacuum:	4.80 milliTorr
Heater Power:	11.027 Watts
This Report File:	'HL128.pdf'
Log File Name:	'HL128.csv'
Completion Status:	Test Stopped by Operator
User Comments:	Sample obtained after June 2006 reconductoring

Shaw Energy Delivery Services, Inc.

Emissivity Test Report produced by the ETI

It is anticipated that whenever a line is retensioned or reconductored, samples could be retained and sent to EPRI for testing. Testing these samples will give the line owner emissivity information about other similar lines. EPRI is accumulating an emissivity knowledge base that will improve emissivity assumptions and possibly enable the future development of a live-line emissivity measurement technique.

In a time when it is difficult to build or rebuild overhead lines, line owners are looking for ways to increase the capacity of the existing lines. Some options include real-time rating using actual rather than worst-case weather conditions, surveying the line and removing any sag buffer built-in at installation, and retensioning the conductor. Measuring conductor emissivity is an option that can be combined with these other methods.

Emissivity Tests of PSE&G Conductor

For the past five years PSE&G has been re-vitalizing its 138 kV overhead electric transmission system by re-conductoring, re-insulating and replacing hardware components. These lines were predominantly designed and constructed between 1925 and 1947.

One facet of this re-vitalization project involves the random selection and evaluation of hardware components being replaced, such as conductor, insulators, line splices, connectors, and removed structural members. The components are sent to independent laboratories for inspection, dissection and testing using applicable industry standards in order to determine their present condition and, where possible, their approximate remaining life. These evaluations provide a number of benefits, including a better understanding of line aging that can be applied to other lines of similar vintage and revealing possible design weaknesses. The results may also drive changes in line inspection practices and work priorities. Just as important is information that can help to validate past engineering judgment or assumptions, such as emissivity in this particular case.

This was the motivation for sending both new and in-service Condor ACSR conductors to EPRI for emissivity testing using the new ETI. PSE&G wanted to test in-service aged conductor and compare the measured emissivity values against established criteria used in rating bare overhead conductors. With little effort there may be opportunity to fine-tune line ratings if it is found that actual conductor emissivity values are different than established utility rating criteria.

PSE&G is a Pennsylvania-Jersey-Maryland (PJM) Interconnection member company and adheres to the PJM rating methodology for rating overhead transmission lines. The PJM rating methodology goes back to the early 1970's at which time a Task Force was developed to formulate a rating system for adoption by member companies.

At that time, the Task Force made arrangements for emissivity tests to be made on four 230 kV ACSR conductor samples; one sample from new stock and three samples with different periods of in-service time (10 months, 8 years and 36 years). These samples were taken from a non-industrial area in the vicinity of Washington, D.C. The values obtained from careful NASA testing compared favorably with other emissivity studies available at the time. As a result, the Task Force selected an emissivity of 0.7 for the PJM area. PJM currently follows IEEE Standard 738 for its rating methodology.

EPRI's ETI measured the emissivity for the Condor conductor sample to be 0.63 [+/- 0.02] as compared to the prescribed value of 0.7. The conductor sample was estimated to be in-service approximately 15 years in an industrial area in New Jersey. This emissivity would result in a slightly lower rating if based on this test sample alone. Additional in-service samples need to be tested before any consideration is given to changing the present emissivity value. In support of EPRI's development efforts with the ETI, PSE&G expects to send additional samples of different conductor sizes, types, and various years of operation to EPRI for testing.

With the availability of the ETI and present EPRI research, opportunity exists to address a number of open questions relative to emissivity such as, how long does it take for a conductor to reach its final emissivity value? How does emissivity change with conductor type (T2, for example), size, and service environment? Having an instrument that can readily evaluate emissivity provides utilities with a means to determine and fine-tune one of their own rating parameters, and perhaps increase their line ratings with minimal cost. ■

About the Authors

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Automated Distribution Feeder Fault Management: Possibilities and Challenges

By Roy Hoffman, DMS Product Manager, SNC-Lavalin Energy Control Systems

With increasing pressures from regulators and customers to provide more reliable power supply to customers, Automated Distribution Feeder Fault Management is one of the most interesting and beneficial Distribution Automation functions. This article reviews various approaches for implementing Fault Detection, Isolation and Restoration (FDIR) schemes and discusses the benefits and limitations of each implementation. In addition a number of practical issues and challenges that need to be addressed are discussed.

Faults on distribution feeders are a fact of life. Compared to transmission networks, distribution networks are very large and must extend to every customer. The result is that some distribution feeders may be very long in sparsely populated rural areas and frequently must be constructed in adverse environments, especially through wooded areas where tree branches and wildlife may frequently come in contact with the distribution wires, causing both temporary and permanent outages.

In today's environment, there is increased pressure from regulators and customers to reduce the number and duration of outages. The use of performance-based rates with financial penalties for poor performance is a commercial incentive for utilities to better manage outages attributable to system faults.

The essential characteristics of improved fault management are:

- Quicker detection that an outage has occurred
- Accurately determining the location of the fault
- Isolation of the faulted section of a feeder
- Re-energizing the un-faulted sections of the feeder outside the isolation zone, upstream and/or downstream of the faulted section.

Fault Detection

On traditional distribution networks without Supervisory Control And Data Acquisition (SCADA) at the substation utilities had to wait for customer calls reporting outages to be aware that an outage has occurred. With SCADA Remote Terminal Units (RTUs) at the substation the SCADA system is immediately aware of faults that cause both temporary and permanent breaker trips. However, faults that are cleared by fuses can still go undetected until customers call to report outages.

An interesting possibility – one not too widely used – is for the SCADA system to detect sudden drops in feeder amps larger than normal load variations and predict the presence of partial feeder outages due to faults when the SCADA system is monitoring feeder currents at the substation. Moreover, when the DMS (Distribution Management System) has a real-time model of the distribution feeder with some form of state estimation, the DMS can use the magnitude and phase of the drop in amps to trace down the feeder and thus, determine possible locations where a fuse may have blown and or an open-conductor fault has occurred. This information can also be combined with customer call data to get more specificity about the suspected location of a blown fuse or other open circuit fault.

Fault Location Methods

Fault passage indicators being tripped by the passage of a high phase current with a threshold above the maximum expected normal feeder load have traditionally determined fault locations. In the past, such fault detectors were purely local, and field crews had to travel to each fault indicator site to see if it was set or not. However, with telemetered fault indicators, the status of each fault detector can be determined almost immediately by a SCADA/DMS system and can be used by the DMS – again in conjunction with the DMS network topology model – to determine the section of the feeder in which the fault has occurred.

However, very long feeders with only a few widely-spaced, telemetered fault passage detectors, may require that field crews drive considerable distances, continuously patrolling the line, to locate the actual fault location.

Modern digital relays have the ability to calculate the fault impedance based on measured phase voltage and current waveforms captured during the fault before the breaker opens.

This additional impedance information, as well as the phase of the fault, can be mapped against the feeder impedance model to estimate the actual location of the fault. Unfortunately, when a feeder has a tree-like structure with multiple branches, several theoretically possible fault locations – all having the same network impedance – may exist.

Another source of error when estimating the fault location from fault impedance measurements is that the impedance of the fault itself is not known. If the fault has significant impedance, the estimated fault location (assuming zero fault impedance), may be further away from the substation than the true location. Nonetheless, this information is still very useful since the estimated fault location distance from the substation is an upper boundary, and dispatchers can know that the true fault location is closer to the substation. Since the fault impedance tends to be purely resistive, another alternative is to do the calculations considering only the reactive component of the impedance values.

Switching actions to isolate the fault and restore power to un-faulted sections

One of the most important drivers for feeder automation is to permit fairly rapid switching actions to isolate the fault and restore power to un-faulted sections occurring upstream and/or downstream of the faulted section.

Most regulatory bodies consider momentary outages lasting less than a defined maximum period of time (typically of the order of one minute) to be less serious than sustained outages. Therefore, it is highly desirable that the fault isolation and restoration switching be completed in less than the threshold for momentary outages.

Various types of systems are available to provide automated detection and location of feeder faults, followed by automated switching actions to isolate the faulted section and to restore power to un-faulted sections of the feeder, as follows:

- Distributed fault management using multiple intelligent local controllers
- Centralized intelligent fault management system

Using a distributed system with multiple intelligent local controllers

In this type of system, multiple feeder switches are equipped with intelligent local controllers that are able to monitor electrical variables at that switch as well as open and close the switch autonomously. From a fault management perspective, the main variables monitored by the intelligent switch controller are the detection of fault currents larger than normal load currents and loss of voltage due to an upstream breaker or re-closer trip.

It is also desirable that the local controllers collect and store historical load data for each switch that can be used later to estimate the total load of an un-faulted downstream feeder section for determining the feasibility of the load transfer to a neighboring feeder. Another key requirement is that the intelligent controller needs to have a basic topological model of the feeder, including the relative location of other switches having intelligent controllers.

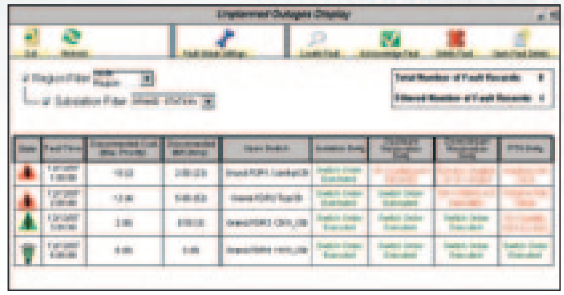
Finally, in order to perform the fault location analysis and reasoning about feasible switching actions, the local controllers need communications facilities to communicate with one another and determine which switches saw (or did not see) the fault current.

The advantage of using local intelligent switch controllers is that small systems for fault management can be deployed relatively quickly and inexpensively. For example, it is possible to deploy a scheme for a single feeder using only two intelligent controllers; one at a normally-closed switch at the midpoint of a feeder and one at a normally open tie switch downstream of the first controller. This allows a utility to deploy a small pilot project on a few high priority feeders with a relatively small investment. Then, after gaining experience with a small deployment, the utility can gradually expand the system to automate additional feeders.

The main disadvantage of using local intelligent controllers is that the system usually functions properly only under normal network operations. That is, whenever the feeders are in an abnormal condition, the local controllers must be turned off or reprogrammed, which is not usually a trivial task. Also, as the number of deployed intelligent controllers increases, the data maintenance and management of the decentralized scheme becomes increasingly burdensome.

Using a single centralized fault management system

Centralized fault management schemes are usually implemented as a subsystem within a general purpose SCADA and Distribution Management System. In such a system feeder switches can be made remotely controllable by the addition of relatively simple motorized switch controllers and a low cost small RTU equipped with communications facilities to communicate with the centralized DMS. As a minimum, the RTU must be able to detect the passage of fault currents, report this to the DMS and subsequently process and apply switch open/close commands received from the DMS.



The figure shown here is a display from a centralized FDIR showing the status of the isolation, upstream and downstream restoration switching orders for multiple faults.

There are a number of advantages of using a centralized scheme, as follows:

- Among the most important advantages is that the DMS typically has a comprehensive real-time view of all network conditions – including all of the planned and unplanned outages – as well as all abnormal network topologies. Thus, when a fault occurs, the centralized fault management application can automatically take into account any currently abnormal network conditions when analyzing fault locations. This is especially key when determining and evaluating possible load transfers to restore power to un-faulted sections downstream of the identified feeder fault location. For this reason, the centralized fault management scheme is generally deemed more robust and reliable than a de-centralized scheme.

- A centralized system is able to analyze and recommend more complex switching scenarios, including second-order load transfers, to increase the capacity of neighboring feeders to pick up load from the faulted feeder.

- In a centralized scheme implemented on a DMS, the switching actions determined by the fault management software – in some cases including multiple possible alternatives – can optionally be first presented to a network operator for approval before the switching is performed. (This is generally not possible on a distributed system.)

- The centralized system can also be used on non-telemetered feeders, once field crews have provided indications of a feeder fault, to determine possible isolation and restoration switching scenarios, using manually operated switches, in cases where the time to repair the fault will be significant.

- To a considerable extent, the algorithmic logic used to determine the switching actions to isolate and restore faults in a centralized system is quite similar to the logic required to determine pre-planned switching actions to realize planned outages on a distribution network. As such, the fault management software can also be used to generate planned switching sheets.

- Because all of the fault management parameter data and algorithms are stored locally on one centralized system, the general management of this data is much easier than with a distributed system.

A centralized fault management system can, when desired, be enhanced to perform more precise fault location using fault impedance data available from modern digital relays. Compared to a distributed system, perhaps the biggest disadvantage of a centralized fault management system is that it is generally less practical to deploy for managing faults on a small number of feeders.

Finally, since centralized systems are usually part of a comprehensive SCADA/DMS system, these systems are generally deployed with a view to managing a complete distribution network, and the capital cost is typically significantly larger than that required to deploy a small, distributed system.

Conclusion

This article has focused on the basics of fault management on distribution feeders. However, a relatively wide range of fault management schemes are available from multiple suppliers that can provide assistance with decreasing the duration of outages experienced by utility customers. Both distributed systems (using local intelligent switch controllers) and centralized systems are available, each of which has advantages and disadvantages that must be weighed by the user to determine which approach is best for a given application. ■

About the Author

Roy Hoffman is currently DMS Product Manager for SNC-Lavalin Energy Control Systems. He has over 25 years experience in SCADA, EMS and DMS systems. Dr. Hoffman is interested in the application software of SCADA, Energy Management and especially Distribution Management Systems as applied to the real-time operation and control of electric power networks. He is a member of several committees of the IEEE Power Engineering Society related to his area of expertise as well as the Canadian Standards Committee for IEC TC 57 – Power System Control and Associated Communications and is a member of the IEC TC57 Working Group 14.

The Survival of and Potential for Decentralized Power Generation

By Harry Valentine

Every day we hear reports and read articles about distributed energy resources (DER). Much of what we hear and read about, however, is extensively focused on wind and solar. Other DER technologies are also addressed, but to a much lesser degree. This article by guest author, Harry Valentine, shows that there are several other technologies at various stages of development poised to contribute to the evolving DER solution set. These alternative technologies – though perhaps not as high-profile as others – are nonetheless emerging and promise to help solve the energy challenges we are facing, even as formidable issues such as load growth, environmental complexities and cost concerns loom large. And, while some seem driven toward finding a singular solution, it is increasingly evident that the final solution set will likely be every bit as diverse as the challenges.

The origins of using energy other than human or animal power to perform work can be traced back over 4000 years when the first known waterwheels appeared. At that time sailors learned to harness the power of the prevailing winds by installing crude sails on trading boats. Hero of Alexandria used the power of steam to rotate a large drum. The power of river water and wind power formed the basis of decentralized mechanical power generation that drove the grinding wheels to convert grain into flour. Steam power eventually joined river power and wind power to drive the production machinery of the industrial revolution.

Mega-power installations evolved from small-scale power generation and realized benefits from the economy of scale. Fewer men could produce more kilowatts at a large power installation than at a smaller installation. Many small-scale or decentralized power plants closed during the latter 19th century and early 20th century as mega-power plants flourished. However, decentralized or distributed generation did not quite disappear and included small, privately-owned hydroelectric power plants that served local communities in many parts of the world.

Development of Distributed Generation Technology

Despite the proliferation of large-scale centralized power generation, entrepreneurs and inventors continually sought ways to improve small-scale power generation. The same hydraulic turbines are used in small-site hydroelectric power dams served equally well in the hydraulic torque converters of automotive automatic transmissions, including in units used in some diesel-hydraulic railway locomotives. Steam turbines were developed from hydraulic turbines and formed the basis of ocean ship propulsion during the early decades of the 20th century and continue to be used in nuclear powered military ships and submarines.

Manufacturers connected to the commercial transportation industry developed a range of reciprocating compression-ignition engines to power trucks, buses, locomotives and ships. Diesel engines developed for commercial road and railway application were used in certain marine vessels. Some marine and railway diesel-electric propulsion systems were eventually to burn fuels such as natural gas and propane. During the late 1980's and early 1990's technical breakthroughs increased both the thermal efficiency and service life of diesel engines of 250kW to 500kW output.

The early turbine jet engines were developed from steam turbines and in turn formed the basis of gas turbine engines. Following World War II several companies sought to develop gas turbine engines for applications in locomotive propulsion, ship propulsion and even motor vehicle propulsion. The Allison division of General Motors began testing a gas turbine engine in a bus in 1947 and continued doing so right into the 1970's. Gas turbine powered locomotives pulled trains the USA, the UK and several other nations. Several of the world's navies tested and operated various designs of boats powered by gas turbine engines.

Beginning during the early 1960's, NASA literally commandeered the research into improving externally heated piston engines or Stirling-cycle engines to provide needed onboard power in manned spacecraft using intense solar thermal heat as its source of energy.

During the period between the mid-1960's and the early 1980's there were several attempts to develop large-scale externally heated piston engines; however, the research and testing indicted that the Stirling engine was in fact a small-scale power technology.

Potential for Improved Distributed Generation Technology

The ongoing research and development that has been undertaken into power conversion technology for mainly transportation purposes can be refined at relatively little or no cost to provide service in distributed generation applications. Ongoing design and refinement of hydraulic turbines has resulted in the development of ultra-low-head turbines that can operate at high efficiency on rivers and streams. Diesel-electric systems, steam turbine electric systems and gas turbine electric systems that were originally designed for railway or marine propulsion can be readily adapted to decentralized power generation.

During the latter 20th century there was ongoing development of new materials with improved mechanical and thermal properties that could be used in various power generation applications. Ceramics such as silicon nitride and silicon carbide provide excellent thermal properties at elevated temperatures and were applied to large-scale commercial piston and turbine engines. While turbine blades made of silicon nitride could improve the efficiency of large-scale turbine engines, entire turbine wheels of small turbine engines could be made from the same material to improve thermal efficiency and extend service life.

Modern Water Power

A low head turbine built by Zotloeterer or Austria can deliver some 150kW at 70% conversion efficiency while operating over a head difference of 0.7m or 2 feet, 4 inches. Another design from Canada can offer 1MW at a nominal efficiency of 84% over a head of 3.5m or 11feet, 6 inches and can produce power over a head of 1.2m or 4 feet. Examples of such technology can be applied on rivers and streams around the world to serve small communities at remote locations. In some cases local power generation would ease strain on strained power grids.

Several companies have developed technology that based on the classical waterwheel that can extract power from the kinetic energy of rivers and tidal currents without constructing a dam. Free-flow kinetic turbines are currently been tested and demonstrated on numerous streams, rivers and tidal straits.

The larges turbine is that is currently being developed will yield a peak output of 2MW while many smaller turbines deliver 250kW. Several companies offer a range of technologies that can convert the power of ocean waves to electric power with ocean wave power conversion technologies currently being demonstrated around the British Isles and the Iberian Peninsula.

Modern Small Steam Power

Development of steam power technology has given rise to newer large-scale power stations that operate using ultra-critical steam at over 4000-psia at temperatures well in excess of 1200°F. Companies such as Enginion in Germany (now Amovis) and Cyclone Power in the USA have developed diminutive steam piston engines that also operate using ultra-critical steam and can deliver the thermal efficiency of a diesel engine. These engines receive superheated steam at a pressure of 4000-psia at 1200°F and can exhaust saturated steam at much lower temperature and pressure.

The exhaust steam may be suitable for numerous industrial applications as well as to heat buildings, drive bottom-cycle engines that operate on low-grade heat or energize absorption cooling technology. Small-scale steam power would appeal to companies that process organic agricultural material or wood products and that have much waste organic material that may serve as fuel for the steam engines. Such engines could find application at ethanol plants and paper plants.

Steam engines may also operate on concentrated solar thermal energy as well as on small-scale nuclear power. Toshiba has developed a micro nuclear reactor of 200kW that uses lithium-6 as its fuel source while Hyperion Power Systems has developed a reactor of 25MW output that uses uranium-nitride as fuel. Modern high-efficiency steam engines may operate in combined-cycle operation in rural communities where suitable waste organic material is readily available.

Efficient Gas Micro Turbines

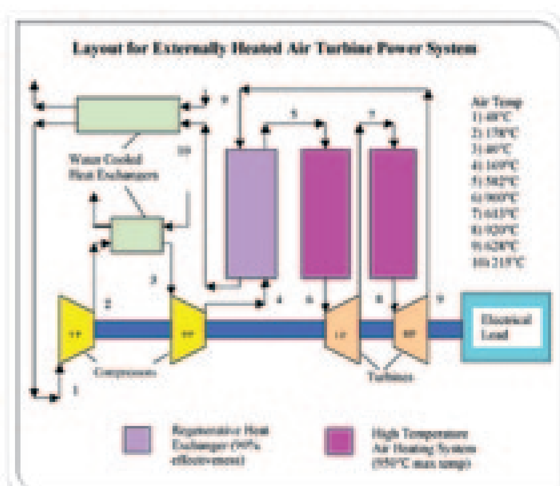
There has been improvement in the efficiency, fuel flexibility and durability small-scale gas turbine engines of up to 300kW output. Combustion chambers and entire turbine wheels are now made from silicon-nitride that can maintain constant mechanical properties up to 1400°C or 2550°F. Improvements in the recuperative heat exchanger that recaptures exhaust heat and puts it to productive use has raised thermal efficiency to the levels of large-scale gas turbine engines. Wilson Turbines of Massachusetts offers a small-scale gas turbine engine of 300kW that offers the thermal efficiency of large units of some 30,000kW.

Gas micro-turbines fueled by natural gas have been installed in the basements of many large office towers to provide back-up power or co-generative power. The exhaust heat can provide interior heating to the building or energize absorption cooling technology. Over the long term the cost savings from reduced electrical and/or natural gas consumption allows for full cost recovery of the micro-turbine engine. The fuel flexibility of the micro-turbine engines makes them especially attractive where a variety of fuels with high solvent properties are available and that could otherwise destroy the lubrication used in piston engines.

Externally Heated Air-based Engines

There is much development in air-based engines that convert heat into electric power and include Stirling-cycle engines, thermo-acoustic engine and air turbine engines. Stirling Energy Systems has plans to develop a farm of solar-heated Stirling-cycle engines that will provide electric power to California's Pacific Gas and Electric Company. There is scope for private companies and individual owners to generate electric power using Stirling-cycle engines using concentrated solar thermal energy or the exhaust heat of various internal-combustion engines.

Thermo-acoustic engines convert heat to low-frequency standing sound waves that resonate inside a pressure chamber and drive a linear alternator of 50kW to 200kW maximum output. The conversion efficiency can exceed 40% and the desired source of fuel would be concentrated solar power. Thermo-acoustic engines can operate as bottom-cycle engines and convert the exhaust heat of many types of internal-combustion and external-combustion engines into useable power.



Modern open-cycle and closed-cycle air turbine engines can deliver much higher efficiency than their predecessors of an earlier generation due to improvements in the design of heat exchangers and air heaters, as well as in improvements in the material from which such components are made. Air turbine engines need a heater temperature of some 1000°C or 1800°F in order to operate efficiently from a variety of heat sources that include concentrated solar thermal energy or high-temperature nuclear energy. The range of power output can vary from some 10kW to over 50MW.

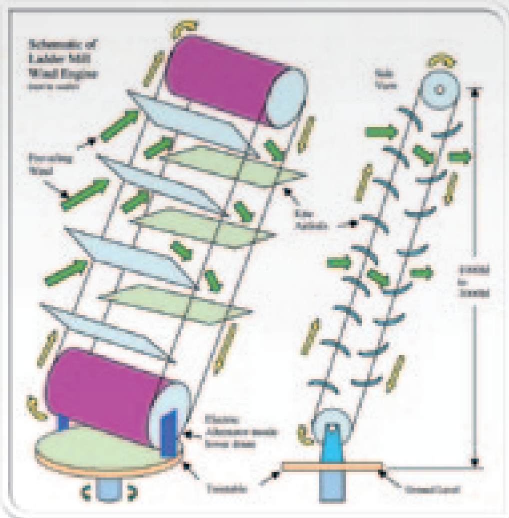
Solid-State Engines

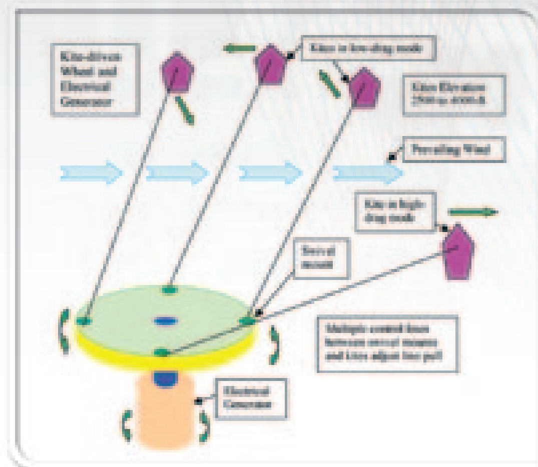
The attractiveness of solid-state engines is the absence of moving parts. Solar photovoltaic cells and thermo-electric panels are the most common form of solid-state engines. There is ongoing research intended to raise the efficiency and lower the cost for both the photovoltaic and thermo-electric versions of the engine. Johnson Electro-Mechanical Systems of Texas is one of several groups seeking to raise the efficiency of thermo-electric engines from 5% or 6% to over 30%.

Some experimental photovoltaic cells have converted energy at well over 30% efficiency. The cost per kilowatt is gradually declining for solar PV cells as the efficiency slowly improves. Recent breakthroughs include thin film technology, silicon-free solar photovoltaic cells, photovoltaic roofing tiles, photovoltaic siding for buildings and photovoltaic windows. Breakthroughs that lower the cost and improve the conversion efficiency of solid-state power technology would attract customers after the economy improves.

Wind Power

Ongoing developments in the aeronautical field and in the development of innovative designs of kites along with advances in mass-production technology form the basis upon which to develop cost competitive wind power technology. Several companies offer vertical-axis wind turbines that can be fitted on to the roofs of buildings. Other developments revolve around the ongoing development of airborne wind turbines by groups such as Magenn, Skywindpower and Makani Power whose technology carries airborne electrical generation equipment. The greater energy in winds at higher elevation can provide more power at more competitive costs.





Competing designs combine ground-based electrical generation equipment with various forms or airborne technologies that include wings and kites. A research group based at Delft University in the Netherlands has developed a LadderMill (Insert: Laddermill) that involves a series of kites that form the rungs of a giant ladder. A design from Italy and New Zealand proposes to coordinate the drag of kites via multiple control lines to drive a vertical drive shaft connected to generation equipment (Insert: Kite-Driven-Wheel). Various wind power technologies are well suited to serving localized markets through distributed generation.

Conclusions

Distributed or decentralized generation is a power generation option awaiting application on a mass scale. Most of the expense of developing the technology was focused on other applications, except that the technology could easily and be adapted to distributed generation at low cost. An increased demand for electric power could see and increased number of smaller power plants supplying that electric power.

Advances in the efficiency, reliability and durability along with low cost make distributed generation a competitive option. Multiple small power stations can be monitored and managed remotely using computer control and modern telecommunications technology. The technology has perhaps unexpectedly advanced to the point where it challenges the economy of scale of mega-scale power stations.

About the Author

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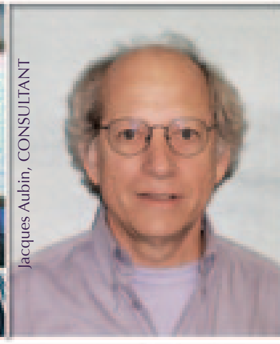

Jacques Aubin, CONSULTANT

Optimum transformer cooling control with fiber optic temperature sensors

By J. N. Bérubé, B. L. Broweleit and J. Aubin

Cooling control of power transformers is traditionally provided by a winding temperature indicator (WTI) that is based on a measurement of the top-oil temperature and a simulation of the winding hottest spot temperature. This method has some drawbacks and utilities are now considering the application of fiber optic temperature sensors for this critical function.

Assessing winding temperature from directly measured top oil temperature can lead to significant errors depending on the cooling mode and shape of load profile. This situation is reflected in the current revision of the IEEE Loading Guide. The industry consensus leans toward a method based on bottom oil temperature and a proper representation of temperature evolution in the cooling duct.

The various hot spot temperature calculation methods are reviewed for a real 240MVA transformer where fiber optic sensors have been selected for controlling the cooling banks. It can be shown that during rapid load change, methods used by classic WTI's can indicate a lower temperature by more than 10°C even if they are properly adjusted for steady state conditions. Our conclusion is that given the dependability of modern fiber optic sensors, long-term performance of transformer cooling can be better achieved with these more accurate monitoring devices.

Winding temperature determination

Winding temperature is a prime concern for transformer operators. This variable needs to be known under all loading conditions, and especially during rapid dynamic load changes. Accurate knowledge of the winding hottest spot temperature is a critical input for calculation of insulation aging, assessment of the risk of bubble evolution, and short term forecasting of overload capability. It is also critical for efficient control of the cooling banks to ensure that the transformer is cooled effectively. Today, several methods are available for on-line determination of the winding hottest spot temperature.

WTI approach

Cooling control of power transformers is traditionally provided by a winding temperature indicator (WTI). These devices typically rely on a measurement of the top-oil temperature and a simulation of the winding hottest spot temperature rise. This method has drawbacks and many utilities are now considering the application of fiber optic temperature sensors for cooling control, because they provide for faster and more appropriate response to sudden load increases.

WTI's come in several variations. The classical instrument involves a bulb inserted in a thermowell surrounded by insulating oil. To simulate the winding temperature, the thermowell is additionally fitted with a heater element which is fed by a current proportional to transformer loading. The bulb is filled with a gas or liquid with a large coefficient of thermal expansion, and is also connected through a capillary tube to a spiral-wound Bourdon tube in the measurement device. The Bourdon tube will unwind slightly when the gas expands in response to increasing temperature and the torque generated is transmitted to a pointer moving in front of a calibrated scale.

In some variations, the heating element is located directly in the measuring instrument. In more recent devices, the top oil temperature and load current signals are fed to a numerical microprocessor where the winding hot spot temperature is calculated using a standard algorithm based on inputs from the top oil temperature plus an increment for winding hot spot rise.

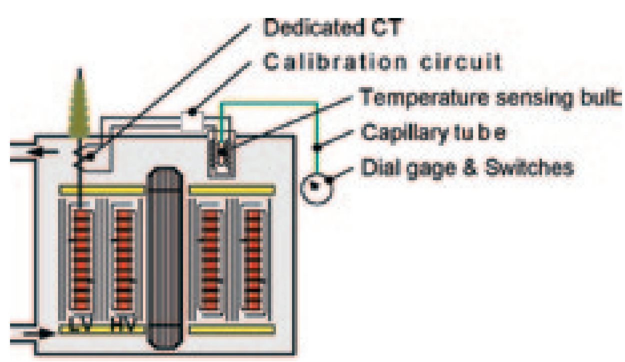

Fig.1 Schematic arrangement of WTI.

This simulation method is consistent with the traditional equation used in loading guides since 1945. It implies that the winding hot spot temperature can be continuously simulated (or calculated) by measurement of the top oil temperature plus a factor proportional to the load, as follows:

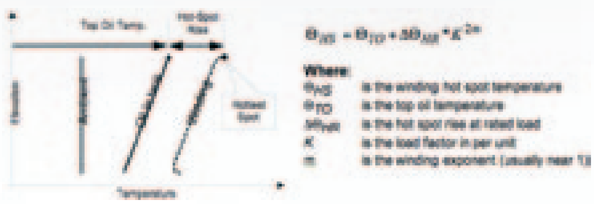

Fig.2 Hot spot temperature computation using top oil temperature.

This calculation method is based on the thermal diagram shown in Figure 2. This model assumes that the oil temperature at the top of cooling duct is the same as the top oil temperature.

The rated winding hot spot rise above top oil is usually derived from the temperature difference between average winding and average oil temperatures; this difference is then multiplied by a hot spot factor to take into account additional losses toward the winding ends. This hot spot factor is normally estimated using factory heat run test results and must be provided by the manufacturer. For a given load current, the difference between average winding and average oil temperature is assumed to remain the same, operating under any cooling stage. This method was the basis of IEEE and IEC loading guides since 1945 and has been well accepted by the industry.

Now that transformers are operated closer to their rated values and overloading is more frequent, the hot spot calculation method needs improvement to cover occurrence of a step load increase. It was observed that the model was not adequate to simulate the winding temperature during severe dynamic loading conditions, because:

- Oil temperature in the winding cooling duct can be much higher than top oil temperature
- The time constant of oil in the cooling duct is much shorter than the top oil time constant
- Under sudden load variations, oil circulation does not respond immediately.

Due to the above factors, the winding temperature *transient* value can thus be significantly underestimated.

Direct measurement of winding temperature

In order to rectify these short comings, IEEE is developing a more sophisticated calculation method based on additional parameters extracted from transformer characteristics. Fiber optic (FO) temperature sensing can be seen as an alternative approach for the determination of winding hot spot temperature under dynamic loading conditions. The use of fiber optic sensors removes several uncertainties in the process, including:

- Calculation of eddy and stray losses in the hot spot area
- Estimation of oil flow and temperature in the hot spot area
- Estimation of winding temperature rise above local oil in hot spot area
- Adjustment of these values for various tap positions and cooling stages
- Modeling of winding(s) time constant(s)
- Modeling of top oil (or top of cooling duct) time constant as a function of oil viscosity

The main constraints with fiber optic sensors are that they must be installed at the winding manufacturing stage and the locations of the hottest spots must be known to the manufacturer. This last requirement also applies to the other methods since determination of winding hot spot rise above oil implies that the location of this hottest spot is known.

Assessment of winding insulation temperature under any loading condition is a critical step for efficient management of a power transformer. The traditional model used for hot spot temperature determination has shown serious limitations, especially under transient conditions. New models based on bottom oil temperature could provide more accurate results but they require that 12 to 15 parameters be determined accurately for each cooling stage.

Direct measurement with fiber optic temperature sensors bypasses these difficulties and uncertainties. These sensors provide dependable information for each winding, under any loading condition, and are sufficiently rugged now to provide cooling control during the entire transformer life.

Field experience with direct temperature measurement

The Priest Rapids Project is located on the Columbia River in Washington State and is operated by the Grant County Public Utility District (GCPUD). The generating station has recently been refurbished with new GSU transformers, 3-Phase, 240 MVA, 13.2/13.2/230kV, with ONAN/ONAF cooling (Figure 3).

Fig.3 Application of FO sensor for cooling control on 240 MVA transformer at GCPUD.

The transformers are located on a concrete powerhouse deck that exposes the transformers to solar heat during most of the day. The ambient temperature is high in summer when the power delivery is most critical, and the concrete structure retains heat long after direct exposure to the sun. Since each increase of 7°C in the winding temperature doubles the solid insulation aging rate, Fiber Optic Temperature Sensors were selected for cooling control. They provide the most dependable tool to optimize cooling control and also allow accurate, long term estimation of insulation aging.

The new GSUs have dual-primaries. In the coil assembly, the two LV 13.2 kV windings are erected one above the other as shown in Figure 4a, as “X” and “Y”. Each unit was fitted with 18 fiber optic sensors in the winding plus three more on the core legs (1/ph, not shown here).

The winding sensors are located as shown below:

- 6 near top of HV winding in spacers between disks or in oil duct (2/ph)

- 6 near top of upper primary oil duct (X-winding, 2/ph)
- 6 near bottom of lower primary oil duct (Y-winding, 2/ph)

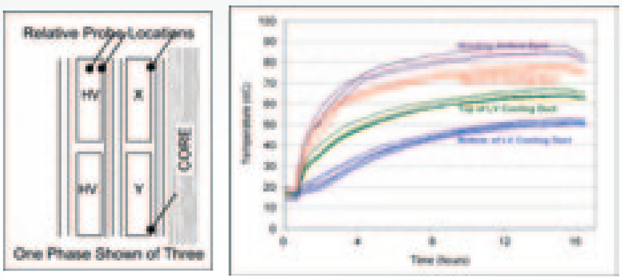

Fig.4 Detailed locations of FO sensors on the HV and LV windings (4a) and temperature recorded during heat run test under ONAN condition (4b).

The data collected during one ONAN heat run test with constant losses is shown in Figure 4b. All 18 sensors operated normally and measurements are very consistent. Fiber optic sensors on similar locations on phase A, B and C give almost identical results indicating a uniform oil circulation in each phase. The differences between phases may be attributable to oil-flow patterns influenced by asymmetrical tank geometry – the no-load tap-changer compartment shares the oil space on one end of the transformer – and the influence from many leads routed to the NLTC.

Design requirements for long life fiber optic probes

Controlling the cooling banks with fiber optic sensors implies that these sensors must be designed to outlast the transformer itself, which normally means periods as long as 50 years. When users started to install fiber optic sensors 20 or 25 years ago, they were happy to see them survive the heatrun test, as their main goal was to confirm the thermal model of their transformers. Today, however, transformer users are demanding more.

Ideally, long-life probes should have the following characteristics:

- The sensing technology must be absolutely stable with time, immersed in harsh chemical environments, and at elevated temperatures
- The probes must be designed so they can mechanically survive steady vibrations and frequent thermal cycles
- The technology that converts the light signal into temperature information must be insensitive to light intensity variations. This is required to avoid problematic compensation for any aging effects in the optical fiber link and any interconnections
- Fiber connectors must be leak-proof, reliable and maintenance-free. Oil in optical path should not interfere with signal.

These essential points are discussed below:
Neoptix equipment relies upon the well proven GaAs sensing technology. This technology has been used for temperature sensing inside power transformers for almost 15 years, and is based on a phenomenon that any semiconductor material exhibits: the band gap wavelength or absorption shift. As it is a fundamental characteristic of the crystalline structure of GaAs material, it is always the same and thus never requires re-calibration. Furthermore, this absorption shift is absolutely stable as a function of time.

The band gap wavelength technology has a big advantage of being completely insensitive to signal or light intensity. Any aging effects that might happen through the optical link between the electronic module and the GaAs chip will have no effect on temperature reading accuracy. Because temperature reading rates for transformers are relatively slow (e.g. seconds, not milliseconds), the Neoptix electronic module can be set to operate with de-rated light level, which gives extraordinary light source lifespan, calculated at more than 300 years for a typical system.

Neoptix probes are constructed with the GaAs chip being freely mounted at the end of the fiber optic cable. Thus, the sensor "floats" in a very small volume of transformer oil. This insures that the constant mechanical vibration and numerous temperature cycles inside the transformer will not "fatigue" the bond between the GaAs chip and fiber, while also exhibiting virtually no partial discharge.

Recommendations for efficient installation of fiber optic temperature sensors

The 240 MVA transformer studied in this paper has been fitted with a large number of fiber optic probes, i.e., a total of 21 probes. Normally, 8 to 12 probes are considered sufficient, providing some spares in case some probes are broken during installation.

A good discussion of sensor placement is provided in section 4 of the IEEE P1538 Guide for the Determination of Maximum Winding Temperature rise in Liquid Filled Transformers [1].

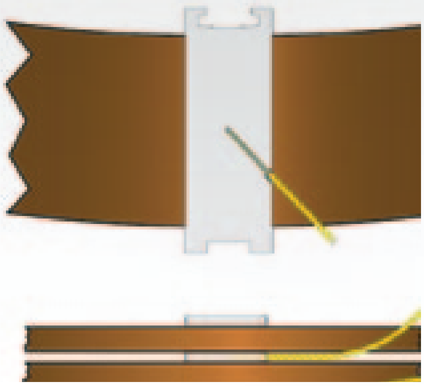

Fig.5 Probe installation in spacers.

Typically, 2 probes will be mounted at the hot spot location in each phase. Usually, conductors near the top of a winding are exposed to the maximum leakage field and the highest surrounding oil temperature; however, experience has shown the hottest spots are down a few conductor layers from the top. Furthermore, at least one additional probe should be used for top oil temperature. ALL probes should be monitored during the heatrun test, and the hottest ones should be selected for long term monitoring. Depending on the winding design parameters, it is often the case that the highest temperatures are found in the low voltage windings.

For long-term reliability, ensure that probes are solidly attached in their intended position. Teflon® material tends to soften as temperature increases, so it is important that the probe cable be well supported at the installation point and along its entire length.

Mountings probes on conductors or in radial spacers?

Although it may seem more accurate to mount fiber optic probes directly on the conductors, experience has shown that it is much simpler to mount them in radial spacers, as shown in Figure 5. Also, it appears that the temperature [3] under the spacer is higher by 1 or 2°C than the surrounding conductor.

Furthermore, when the probes are installed in spacers, they can be installed much later during the transformer manufacturing cycle, reducing the chances of probe breakage. Due to these considerations, most fiber optic sensors today are installed in radial spacers.

Conclusion

Numerous papers have shown that older transformer loading equations were quite imprecise. The new equations presented in recent versions of loading guides are quite complex, and assume knowledge about parameters that are not readily available. A large number of assumptions must be made in order to use them. As demonstrated in this paper, an easier and more accurate solution is to use fiber optic sensors embedded into the transformer windings, both for heatrun tests and long-term transformer cooling control. Conventional control technology (WTI, etc.) is progressing too, so we expect to see more and more transformers in the future where fiber optic sensors and conventional measuring means will coexist. FO probes have been installed in transformers for more than a quarter of a century. The technology has advanced rapidly so we can now envision using them to replace WTI devices to control cooling of newly built transformers. Installation procedures for probes have also matured, resulting in an installation success rate approaching 100%.

Neoptix' FO sensors have been designed to outlast the life of the transformers in which they are installed. By utilizing FO cooling control and the new loading guide methodology, it is possible to minimize the solid insulation aging during operation, thereby reducing chances of premature equipment failure by this mechanism and making a 50+ year transformer lifetime a realistic expectation. Conversely, FO technology can allow utilities to manage overload conditions more effectively, making better-informed economic decisions about trading Megawatts-hours for transformer life.

The installation of 5 new HHI (Hyundai Heavy Industries, Ulsan, Korea) GSU transformers at Priest Rapids Dam, GCPUD (Grant County Public Utility District) in Washington State has shown that the GaAs sensors can be reliably used to control the cooling fans. Some of these transformers have now been controlled by Neoptix T/Guard+ systems for more than 3 years, with no problems reported.

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Jean-Noël Bérubé is VP Technology at Neoptix Inc. A founding member and partner at Neoptix, since its inception in 2004, he is heavily involved in design and application of fiber optic temperature probes used for hot spot temperature monitoring in power transformers. Bérubé travels worldwide to train transformer manufacturers on how best to install and use fiber optic temperature probes. An electrical engineer and IEEE member with more than 35 years of experience, his field of expertise has been instrument design and applications where optic, electronics and software are applied together.

Bruce Lee Broweleit was educated in Electrical Engineering at Washington State University, has been employed with Grant County PUD for almost 27 years, and is currently pursuing professional licensure in the State of Washington. He is the designated "Subject Matter Expert" for transformer maintenance at the PUD's Hydro Division. His transformer-related responsibilities include: factory witness and field testing, electrical and oil test analysis, engineering design, procurement and installation technical specification preparation, on-line DGA monitoring, internal inspections, and making recommendations about maintenance and continued operation. Bruce recently completed replacement of 5 GSUs at Priest Rapids Dam, and presently is Project Manager of a contract to supply six replacement GSUs for Wanapum Dam from 2011 through 2016.

Jacques Aubin is a consultant to the electrical industry on power transformers. He is mainly involved in development and testing of advanced monitoring systems for power transformers. Aubin has spent 30 years with Hydro-Quebec where he was initially involved with transformer design, specifications and acceptance tests. He later directed research activities related to overload, short circuit and other acceptance tests on power transformers. Aubin is a former member of the IEEE transformer committee and he has lead several Working Groups at CIGRE and IEC.

Washington Watch

Cost Recovery of Energy Efficiency and the Impact on Utility Credit Ratings

By Gregory K. Lawrence, Partner; McDermott Will & Emery LLP

The Obama Administration's 2010 budget, the American Recovery and Reinvestment Act (ARRA) economic stimulus plan and certain state policies envision a transformation of how Americans will use electricity. Key elements include energy efficiency measures and related rebates, demand response programs that will reduce power usage in response to price signals, and "smart meters" that facilitate more granular and dynamic pricing information to inform usage behavior. Energy efficiency (EE) mandates to reduce electricity use pose potential credit quality and profitability risks for investor-owned utilities (IOU), particularly in today's economic environment. Such risks could slow the deployment of EE measures despite intense pressure to scale up such programs.

IOUs have already seen notable sales volume erosion as the recession has reduced energy demand. The continued push for greater consumer access to EE measures, and dynamic retail pricing and enhanced metering technology to facilitate those measures, create an investment dilemma. In the eyes of many investors, without a change in cost recovery, a utility helping its customers reduce their usage would be like an auto manufacturer encouraging people to carpool so they could buy fewer cars – a strong argument against purchasing the auto company's shares.

The other side of the equation is the utilities' continuing investment needs to upgrade aging infrastructure and address decreasing generation reserves. Government mandates for meeting renewable portfolio standards and greenhouse gas reduction targets also will require additional IOU capital investment and the assumption of new technology and regulatory risk. The result combines an irresistible force and an immovable object: upward pressure on revenue requirements and retail rates in a tough economic climate. Utilities have less usage volume by which to earn a return (a situation EE will exacerbate), at the same time costs and risks are increasing.

How do investors gauge what's happening in this climate? If utilities invest in significant EE, will they recover those costs sufficient to maintain the utility's financial quality? To answer such questions, investors must assess certain key factors for any IOU that pursues an EE program:

- Materiality: the impact of an EE mandate must be material compared to the utility's overall rate base, revenues and sales volumes
- Regulatory risk: the certainty and timing of any cost recovery mechanism
- Regulatory balance: the likelihood that utility regulators (and the investment community) will do a peer comparison of return on equity performance for utilities that do and do not pursue EE, along with assessment of EE incentives and cost recovery mechanisms
- Innovation: the technology risks that a utility's EE implementation may or may not meet expectations or targets
- Market conditions: whether EE is considered by the IOU and regulators as a long-term commitment or a temporary fix for wholesale supply scarcity

Ultimately, the investment judgment on a utility's EE programs comes down to the IOUs' ability to effectively use the various cost recovery tools available.

There are a number of options that IOUs often consider to provide a reasonable opportunity to earn an allowed return on equity or an incentive balanced against concerns regarding retail rate increases, credit quality and aggressive EE deployment. Each has its advantages and drawbacks, but IOUs have begun to propose them singly or in combination to address the cost recovery issue, their investment quality and thus willingness to engage in aggressive EE measures:

- Pre-approval of carrying/construction work in progress costs prior to new EE deployment (i.e., before the measure is deemed used and useful)
- Shared benefits that allow recovery of some of the net societal benefits
- Cost capitalization of program costs by allowing a "bonus" rate of return on the un-depreciated amount over part of the useful life of the EE measures
- EE performance target recovery of allowed program costs
- Recovery of lost revenue for a portion of the useful EE life
- Return on, and return of, avoided energy and capacity costs resulting from the EE measure
- Recovery of third-party EE provider service contract costs
- Shared revenues from EE bid into wholesale capacity markets
- Decoupling retail rates from volumes sales

Decoupling deserves special mention because of its impact on utility risk. One view is that decoupling does not decrease business risk, but instead simply offsets growing risk already posed by EE and conservation measures. Another view is that decoupling insulates utilities from revenue volatility caused by traditional risks like weather and economic downturns. This view could lead to calls for reduced rates of return because of reduced business risk. Decoupled utilities have not experienced much positive reaction from the stock and bond markets, while rating agencies typically do not improve ratings for decoupling, but may take a negative view for its absence. However, given the vastly increased political EE pressures, rating agencies may begin to view decoupling as a requirement for a utility to maintain its rating.

IOUs and their investors need to weigh the various cost recovery, incentive, and decoupling options together. It's an analytical question: What single tool, or combination, will ensure appropriate IOU earnings levels to meet investor expectations and demands for a significant scale up of EE; balanced against short and long-term rate impacts on consumers? All considered, of course, under the clouds of an uncertain economy. ■

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Washington Watch is a regular feature of *Electric Energy T&D Magazine* appearing three times annually and focused on regulatory and legislative energy- and utility-centric initiatives. **Gregory K. Lawrence** is a partner in the Energy and Derivatives Markets Group of global law firm McDermott Will & Emery, and leads the firm's Global Renewable Energy, Emissions and New (GREEN) Products Group. Mr. Lawrence focuses his practice on renewable power, emissions and energy efficiency project development, regulatory proceedings, compliance and investigations, transactions, and governmental affairs relating to the wholesale and retail electricity and natural gas industries.

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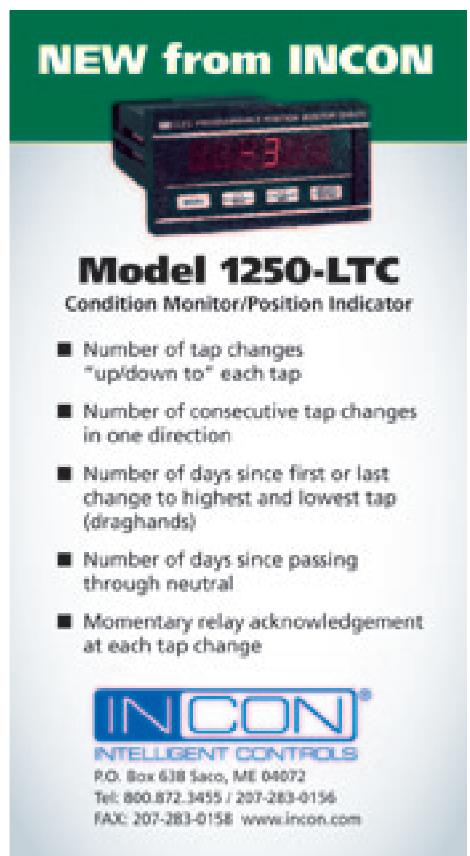

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