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In complete control

How PowerStream updated and upgraded following their merger to become the fourth largest utility in Ontario.

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JUST WHERE DOES THE CARBON FOOTPRINT BEGIN

By Don Horne

Much was made of the pollution and smog during the Summer Games in Beijing.

The Chinese government took drastic steps leading up to August 8, restricting vehicular traffic in the capital and shutting down factories that produced emissions.

Despite these actions, there remained some smog surrounding Beijing for most of the Olympics, and the media underlined the explosion of industrial pollutants in China, naming coal-generation as one of the major culprits.

Yes, China burned a whopping 2.2 billion tonnes of coal in 2006, more than the United States, Japan and European Union combined. And that number grows by leaps and bounds with each passing week, as a new coal-fired plant comes on-line every week to 10 days.

Under the current Kyoto Protocol, China would be hammered heavily for its carbon footprint.

But we really need to take stock of our side of the Pacific Ocean, and our comparable contribution to the various dioxides, oxides and particulate matter that are being spewed into the atmosphere.

Despite the clamor for green generation among North Americans, the mining and burning of coal has doubled since U.S. domestic oil production began to fall off in the 1970s. In British Columbia, a province that prides itself on green generation, exports of coal have grown dramatically (B.C. is home to 12 of the nation's 25 coal mines, with six more awaiting approval to begin operations). The combined coal exports in 2006 from B.C., Alberta and Saskatchewan were 28 million tonnes.

However under Kyoto, British Columbia would be viewed as absolutely pristine.

But replace the word "coal" with "cocaine", and the laws of the land would take a very different view.

Those involved in the making and selling of cocaine receive far harsher penalties than those who merely use it. Could not the same logic be applied to coal?

North American coal-generation plants are taking steps to apply scrubbers, filters and underground sequestration to reduce harmful emissions. But those new coal plants coming on-line every 7-10 days in China have none of these. Should not the rewards for employing such scrubbers be counted?

From 1990-2005, carbon dioxide emissions have increased by 32 per cent. Coincidentally, coal production has increased the same amount.

Market forces are rewarding the construction of coal-generation plants. Coal is cheap – wind, solar and nuclear (initially) are not. In Ontario, the government has introduced the Integrated Power System Plan (IPSP), which requires an increase in renewable generating capacity by 47 per cent in two decades.

The Fraser Institute — a think-tank based out of British Columbia – states that this goal cannot be met without a hefty increase in taxes.

In fact, it takes direct aim at Ontario's central planning policies, recommending a repeal of two Electricity Restructuring Act of 2004 provisions (eliminating the IPSP and ministerial involvement in generating capacity), and a removal of all restrictions on coal and nuclear accompanied by an elimination of quotes for renewable energy.

The bottom line being – government is not equipped to micro-manage the energy sectors.

Yes – but no.

Really, instead of the government forcing what crops are to be grown (or in this case, what percentage of generation is to be "green" or renewable), they should provide the fertilizer (incentives, tax breaks) and prepare the soil (like harmonizing federal and provincial standards to lower transaction costs so as to encourage compliance) so the necessary generation grows as market forces dictate.

Instead of closing down coal plants, the marketplace will push harder to find better scrubbers and filters so as to meet carbon standards. There are more than 50,000 coal plants currently in operation around the globe. Although solar and wind should be developed, those plants are not going away any timesoon (if anything, they continue to grow in number). Should not the priority be to reward those technologies that reduce carbon dioxide emissions? And if a province, state or country wishes to wave the green banner and reap the benefits of a small carbon footprint, should they not take responsibility for the very fuel that they dig from the ground and export to those countries that choose to burn it?

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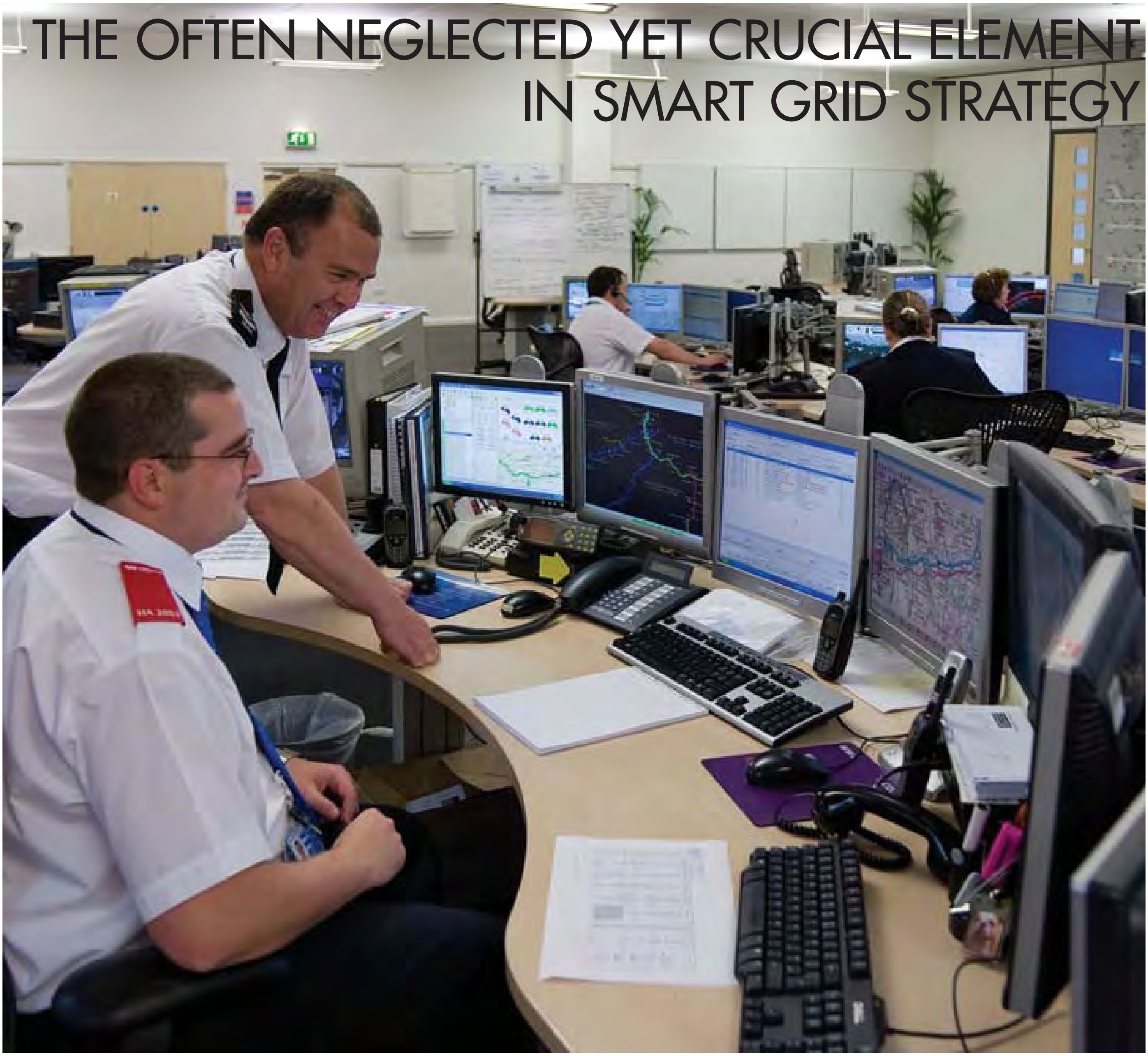
THE OFTEN NEGLECTED YET CRUCIAL ELEMENT IN SMART GRID STRATEGY



The operations control center can often be overlooked when creating a smart grid strategy.

By Tony DiMarco, Director, Utility Industry Global Marketing Security, Government & Infrastructure Division and Wayne Smith, Marketing Communications Manager, Intergraph Corporation

Electricity providers around the world are implementing new applications and technology to better serve their customers. These technical advancements form the basis of the so-called smart grid, an integrated network of applications enabling utilities to operate more efficiently than ever.

The smart grid has different meanings for various electricity providers, depending on the number of devices implemented into their own systems. It is a popular subject today and is mentioned in most any discussion involving electrical utility infrastructure and operations. A true smart grid brings more automation technology – and complexity – to utility providers. This includes developing self-healing networks, intelligent applications, and smart meters to improve load management.

Utilities are in the position to gain many benefits by making the transition from existing infrastructure to cutting-edge technology, including improved

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Smart Grid

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reliability and reduced maintenance costs. These benefits come at a crucial time. The global energy demand continues to grow even as oil and natural gas prices climb. Worldwide energy consumption is projected to increase by 57 percent by 2030. Meanwhile, utilities are facing more stringent regulations in reducing greenhouse gas emissions, conserving energy, and continuing to provide customers with services at reasonable costs. For example, the Canadian government's mandate to implement smart meters by 2010 is driving the increasing utility automation in that country. At the same time, many utilities are having to replace aging infrastructure as well as losing experienced employees to retirement.

The smart grid is viewed as the means of linking new technology and leveraging it to improve electrical transmission and distribution efficiency, whether it involves carbon policies, grid modernization, renewable and alternative energy sources, or smart end-use devices for the customer. Smart grids are expected to improve everything from scheduling efficiency and dispatch management to transmission line surveillance and cyber security. They are expected to reduce the time needed to access critical information, enabling faster and better decisions from the control room.

The transition to a smart grid will add automation and additional sophistication to utility operations. It will also be more complex. With all of the advantages offered by new technology, the operator is the component often overlooked in smart grid. The human factor is a potential weak link to smart grid unless a common operating picture is at the center of building a true command-and-control environment.

Supervising an electric utility network is a complex and critical task. An operator inside a control center is likely monitoring information from multiple sources. Some may have to use multiple systems and displays to get a complete view of operations. Some centers might still have only paper wall boards for tracking outages and the locations of field crews. An operations center that is already complex can have its effectiveness further hampered by storm conditions, with considerable effort and coordination required to keep data accurate and current.

Many visualization tools exist for the operations control center, but they fail to:

• Integrate distribution and transmission systems and various data sources;

• Accurately represent a wide area of current operations;

• Provide customized views for different users.

Operators will realize the greatest benefit of the smart grid when it is used to integrate multiple applications into one unified system.

"Prior to moving toward a smart grid, our operators were responsible for using five to six separate applications on multiple screens just to try to get an overall picture of what was going on with our grid," says Charles Jenkins, SVP Transmission and System Operations, Oncor. "Utilizing multiple systems made it more difficult for our employees to quickly and efficiently respond to storms and other outage situations. The true value of the smart grid for us is being able to see and control our various critical applications – outage management, distribution automation, geographic information systems, network analysis, workforce management, SCADA, the list goes on – all through one unified system."

WHAT IS SITUATIONAL AWARENESS?

Building a common operating picture is one way a utility can optimize its smart grid implementation. This is key to situational awareness, which is simply being aware of everything happening around you and understanding how information, events, and your own actions impact you now and in the future. Situational awareness is recognized as a critical, yet often elusive foundation for successful decision-making across a broad range of complex and dynamic industries susceptible to human error, such as aviation and air traffic control. For example, aviation experts view integrating weather, camera, sensor, radar, and other data into a common operating picture as a valuable decision-making tool for airlines, air traffic controllers, and pilots.

A smart grid control center is another example of an environment prone to human error. An operator must monitor mapping data, locate personnel and work crews, analyze power system reports, and survey real-time transmission line data. The main goal of the command-and-control center is to ensure reliable transmission services. To accomplish this, operators must choose optimal network configurations, whether it's to control voltage or to manage system restart following an outage.

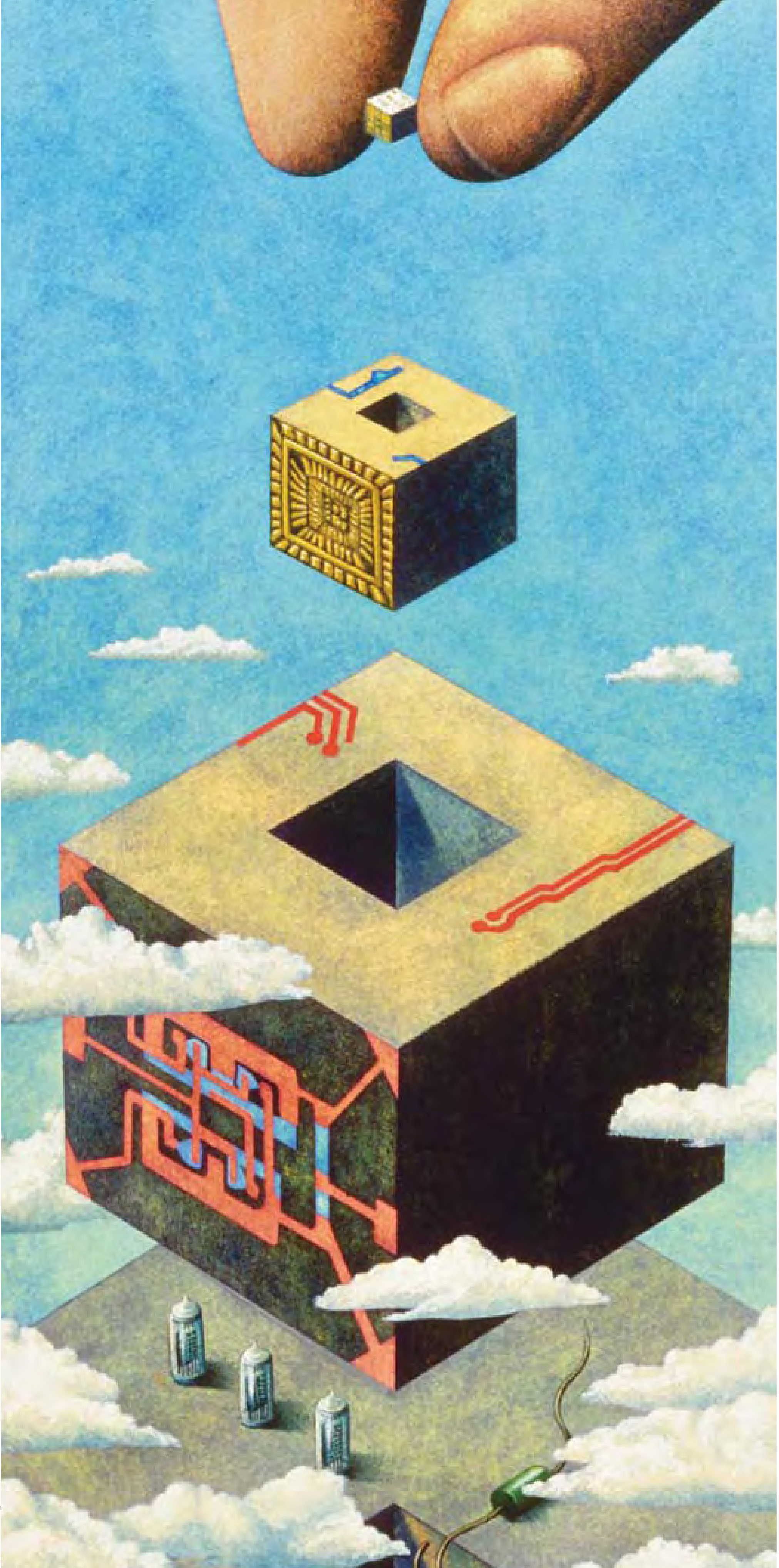
Recognizing a problem and knowing what actions to take are fundamental requirements in making quick, well-informed decisions. The lack of situational awareness is one of the primary obstacles, and a major factor in accidents attributed to human error. If a dispatcher or operator is distracted having to search for information or with other actions, this can interfere with the decision-making process and lead to mistakes at critical times. Human error has been blamed for several major power failures in recent years, including blackouts that left millions of customers in the dark in the United States and Europe.

Operators will require a system in the control room that will allow them to speed their analysis and take action. A common operating picture improves overall situational awareness, helps achieve significant cost savings, and increases efficiency in grid operations. In addition, linking the operations center and field personnel through a common operating picture provides numerous benefits, including safety, faster response times, and more accurate reporting on outages and repair work.

The control center of the future will have 2D and 3D graphical visualization of complex real-time data to improve situational awareness, with multiple layers of information available in one unified system. A graphical display of the entire network will help operators understand the relationship between events throughout the system. This will enable operators to monitor alarms and other network problems, as well as physical security.

With a true smart grid implementation and an operations control center that leverages the infrastructure to its full potential, utility companies can increase reliability, decrease outage response times, keep rates reasonable, and remain profitable.

However, a smart grid strategy alone does not address the impact it will have on the control center and operators. To develop a complete strategy, utilities should also consider improving situational awareness and understanding the greater complexity that will come with more automation. Taking steps to ensure the control center can easily adapt to new smart grid technology will provide a key step toward continued success for the utility and its customers.



SECURE SUPER GRID CONCEPT KEY TO MODERNIZING THE URBAN GRID

The world's first HTS power transmission cable system operating in Long Island Power Authority's Holbrook transmission right of way. This system, which consists of three cables running in parallel in a four-foot wide underground right of way, is capable of carrying 574 megawatts of power. The three cables shown entering the ground can carry as much power as all of the overhead lines on the far left.
Photo courtesy of American Superconductor Corp.

By Jack McCall, Director of Business Development, HTS T&D Systems, American Superconductor

Passage of the Energy Independence and Security Act by the United States Congress in 2007 set the stage for the "Smart and Secure Grid" initiative. To fulfill the goal of modernizing the grid, the U.S. Department of Energy's National Energy Technology Laboratory (NETL) set forth the Modern Grid Initiative, which specifies performance requirements of an optimized power delivery system.

High temperature superconductors (HTS) directly address three primary grid objectives of the Modern Grid Initiative, namely: the ability to self-heal, to resist attack, and to improve power quality. American Superconductor's Secure Super Grid (SSG) technology is a "system-level" superconductor cable solution that fulfills these criteria that are vital to enhancing over-taxed and aging power grids in the U.S. and around the world.

Introduced by AMSC in 2007, the SSG technology provides electric utilities with a powerful and secure means to simultaneously address the rising electricity demands and increasing fault current levels of today's growing, digitally-based economy.

High-capacity, very low-impedance superconductor cables that are able to transmit up to 10 times more power than traditional copper-based cables have

Alternating current, very low-impedance HTS power cables can draw power flow away from overtaxed conventional cables or overhead lines, relieving network congestion. The very high power capacity and small footprint of high-temperature superconductor cables makes them much easier to site, especially in dense, older urban areas.

Photo courtesy of American Superconductor Corp.

been well demonstrated at electric utilities and are now being deployed in the grid. Over the past two years, three of these cables have been energized in the United States. Fault-current limiters based on superconducting materials also offer a new vista in grid security and technical control of system operating parameters.

With over 250,000 miles of electric utility network assets in the U.S. requiring tens of billions of dollars in upgrades, a major strategy of the Modern Grid Initiative has been to focus efforts on large, densely populated urban areas. It is these settings where the unwanted power disruptions pose the greatest risks. Superconductor cable systems exhibit a number of unique operational characteristics providing a highly effective tool for such metropolitan grids. With their ability to conduct significantly more power in a smaller right of way at lower voltages, superconductor cables offer a desirable alternative to higher voltage cables or even overhead lines.

For example, replacing an existing copper-based cable with a superconductor cable can provide the ideal means to increasing power supply to dense urban environments without building new lines. This is not only an attractive option to meet traditional urban area load growth, but also to address future incremental power demands created by the adoption of plug-in electric vehicles, which are expected to dramatically increase electricity demand in the coming years.

SSG DELIVERS MORE POWER WHILE MANAGING FAULTS

Since late April, a 138 kV HTS transmission line has been operating successfully in the United States just outside of New York City on Long Island Power Authority's (LIPA) primary transmission corridor. LIPA's installation is the longest and most powerful superconductor cable system in the world. The cable cores utilize hair-thin HTS wires produced by AMSC that conduct 150 times the electricity of similar sized copper wires.

This exceptional power density enables transmission-voltage superconductor cables to utilize far less wire, yet conduct up to five times more power than traditional copper-based cables. At full capacity, LIPA's HTS cable system is capable of transmitting up to 574 megawatts (MW) of electricity, enough to power 300,000 homes, in a right of way approximately one meter in width. A new phase of the project calls for the replacement of one of the existing HTS cable system's phases with a 600-meter-long cable employing SSG technology.

A project showcasing the fault current capability of the Secure Super Grid concept is also underway in New York City at Consolidated Edison, Inc. where the first distribution-voltage (13kV) level SSG solution is being installed in the utility's Manhattan power grid. The full-scale, 300-meter-long HTS power cable system will connect two of Con Edison's Manhattan substations and is scheduled for operation in 2010. The system will require approximately 93 miles (150,000 meters) of AMSC's 344 superconductors.

The U.S. Department of Homeland Security (DHS) is contributing up to $25 million for the Con Edison project. DHS's interest stems from the fact that SSG technology permits the construction of multiple paths for electricity flow in dense metropolitan power grids; the resulting grid concept boosts system reliability when individual circuits are disrupted due to faults, whether caused by equipment failure, severe weather, accidents or willful destruction. The cables take advantage of the special properties of superconductors to not only relieve grid congestion, but also instantly suppress power surges that often damage utility equipment and disrupt service. This latter capability is critical because even without additional interties, utilities are witnessing a marked increase in fault currents.

Illustration shows telescopic view of high temperature superconductor cable.
Photo courtesy of American Superconductor Corp.

New transmission and distribution equipment installed to meet load growth, as well as the requirement to add new generation sources, all contribute to increasing fault current levels. Fault currents now exceed 60,000 A in some transmission substations; they also can reach 40,000 A in certain distribution substations. These values approach the limit of today's conventional circuit breaker ratings and, given the unrelenting expansion of grids, they will continue rising.

While higher-rated circuit breakers may become available, a large number would have to be deployed to adequately protect the grid, which would be prohibitively expensive.

HTS-BASED FAULT CURRENT LIMITERS

Secure Super Grids cables employing HTS-based fault current limiters (FCLs) provide an effective means of addressing this conundrum.

One such design, termed a "resistive" FCL, serves as an automatic switch, creating a state of high resistance in the HTS cable when fault currents exceed a predetermined value. The resistive FCL's ability to operate in this manner hinges on a fundamental property of HTS materials: above a critical current, their superconductivity is quenched and their electron transport characteristics become resistive. Indeed, the inherent conductive properties of HTS materials establishes the most important characteristic of HTS-based fault current limiters - they are fail-safe.

Depicts the first cable phase being pulled through a conduit in Long Island Power Authority's Holbrook transmission right of way.
Photo courtesy of American Superconductor Corp.

Ultimately, HTS-based cable designs can significantly enhance operational control of the grid and, most significantly, minimize costs in this era of rapidly escalating energy prices.

MULTITASKING METERING ENHANCES GENERATION, TRANSMISSION OPERATIONS

By Ed Sullivan

Figure 1: DPC produces in excess of 1,000 MW of electric power from hydro and coal-fired plants and from waste-to-energy plants using renewable resources, such as animal waste-to-energy conversion and landfill methane recovery. The customer area covers 62 counties in four states (Wisconsin, Minnesota, Iowa and Illinois).

Advancements in products that leverage converging technologies have created significant opportunities throughout the power systems industry. With communications-related advancements, the right choice of solutions can extend return on investment (ROI) via expanded power system benefits. Such has been the case at Dairyland Power Cooperative (DPC), head-quartered in La Crosse, Wisconsin.

In 2004 DPC, a 1,000 MW generation and transmission cooperative, was experiencing diminished service within its analog cellular-based data communications system, with the possibility of no further service beyond February 2008.

DPC provides power for 25 member cooperatives and 20 municipalities who serve over 500,000 customers. A Touchstone Energy affiliate, DPC's service area encompasses 62 counties in four states (Wisconsin, Minnesota, Iowa, and Illinois). The cooperative owns and operates over 3,100 miles of transmission lines and 348 substations. The cooperative produces electric power from a variety of sources, including hydro and coal-fired plants plus renewable resources, such as landfill methane recovery and animal waste-to-energy.

"With the imminent need to replace the old cell phone system, there was an opportunity to install a new automated telecommunications system that would provide secure collection of meter readings from all of our substations," explains Ed West, Director of Telecommunications and Control at DPC. "At the same time, we wanted the same system to provide real-time meter data, local alarms, and a secure communications path for our AMR (automatic meter reading) members."

The DPC staff identified a list of required capabilities for a secure communications path including:

• Substation automation information from the substation to the DPC office;

• Real-time meter data for display on a Security System Operations (SSO) website;

• Substation kWh meter readings every 15 minutes for billing purposes;

• Automatic Meter Reading (AMR) data from the substation to the distribution cooperative office;

• One system that could support the needs of both the member utilities and DPC for secure, robust, wide-area communications.

In order to simplify new equipment installation in each distribution substation and minimize the amount of training required, DPC staff made decisions early in the design process including:

• Each distribution substation would have a "standard" set of equipment;

• The communications cabinet would have a custom-designed enclosure;

• The communications cabinet components would be assembled in the DPC facility;

• The spread-spectrum radio, router, communications, protocol interface device, and high-end multifunction meter would be tested and verified by the DPC meter lab;

• Remote facility monitoring would be provided with physical and cyber-security;

• A 48 Vdc battery-backed power supply must be included for all equip-

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The Dynamic Duo of Substation Automation

OrionLX

The intuitive configuration and
cyber security of the NovaTech OrionLX...

Bitronics M571
Multifunction IED
and M570D
Remote Displays

...together with the legendary reliability and speed of
Bitronics Measurement IEDs.

from NovaTech®
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Bitronics
The Engineer's Choice

Multitasking Metering

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ment;

• The cabinet design must allow for modular expansion to meet the requirements of each substation;

• Each completed cabinet would be taken to the substation to be installed and field verified.

In December 2004, a comprehensive plan was approved for the installation of an upgraded distribution automation/telecommunications system to accomplish these goals. The project included:

(1) expansion of the existing digital microwave network;

(2) installation of point-to-point, IP-capable spread-spectrum radios; and

(3) installation of a custom-designed metering and communications cabinet to provide secure serial and IP connections for real-time billing metering data, historical data, distribution SCADA, load management, and AMR traffic.

Because metering was a primary goal of the project, Dairyland Power decided to evaluate a multifunctional digital meter from Schweitzer Engineering Laboratories, Inc. (SEL). "We had used a number of SEL relays and other protection products over the years and felt very confident about their quality," West says. "Plus, we wanted to integrate the metering equipment into a highly customized communications system, so the product features and level of SEL technical support were also important to us."

The SEL-734 Revenue Metering System, which DPC considered for the project, offers complete instantaneous metering functionalities, including voltages, currents, power, energy, and power factor. Other capabilities, such as predictive demand, time-of-use metering, automatic voltage sag/swell monitoring, harmonics metering, and synchrophasor measurement, make this meter an exceptionally versatile system component.

"From a metering perspective, Dairyland Power wanted to do daily load profile and interval-by-interval metering of their delivery points for billing purposes," explains Dick Martin, Product Manager of SEL's Meter Systems Division. "They also wanted to provide real-time monitoring of energy — the amount of power being delivered — for both generation and transmission purposes and to make that information available on a distribution SCADA system to their members. As a multifunction device, the SEL-734 Revenue Meter is very well suited to all of those needs."

Billing data are collected from the meters by a master station system running Itron's latest MV-90xi meter-reading software, which has the ability to query devices over a wide area network (WAN). At the same time, via the meter's DNP3 protocol capability, Dairyland is using its distribution SCADA sys-

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Figure 2: DPC owns over 3,100 miles of transmission lines and 348 substations like the one shown in this photograph. DPC provides electric power for 25 member cooperatives and 20 municipalities who serve more than 500,000 customers. The cooperative experienced diminished service within it s analog cellular-based data communications system and upgraded to an IP communications system.

Figure 3: Shown above is a metering and communications cabinet providing secure serial and IP connections for real-time billing metering data, distribution SCADA, load management, and AMR traffic.

Multitasking Metering

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tem to poll the meters for real-time operational data.

Otherwise, this remote function would typically be done by installing RTUs costing $3,000–$5,000 (for models suitable for this application). "Historically, the sensors on RTUs required DC input," says Martin. "That usually meant incorporating AC-to-DC transducers that require annual calibration, which can be a maintenance nightmare. However, because the SEL-734 Revenue Meter communicates via DNP3 protocol, it is compatible with SCADA just as if it were an RTU — without the maintenance costs and headaches."

"Another factor that drove the scheme was that the meters Dairyland Power was using before had room for improvement," says Ken Graves, the utility's Manager of Telecommunications Services. "Based on Schweitzer's reputation, we felt confident that the SEL-734 Revenue Meter would provide us with a good, workable solution. Also, because we were fabricating our own panels, we wanted a panel-mounted meter.

"For our transmission environment, the SEL-734 met our requirements nicely, rather than the standard round, socket-based meter. So, there was interest in the SEL-734 from the transmission side of our business. Plus, using a high-end, panel-mounted meter allowed us to use the same meter to meet our distribution metering needs."

The SEL-734 Revenue Meter's power quality monitoring capability is another feature that is significant to DPC. The utility wants to make certain that the power it delivers to customers is within its high-quality parameters, and if there are any issues, they have the information they need to quickly solve the problem.

"This metering device is very feature-rich for an affordable price," Martin says, "when you consider that capabilities like power quality monitoring and instantaneous synchrophasor measurements are usually collected with expensive single-purpose devices that can cost from $25,000 to $50,000."

Figure 4: The back of the SEL-734 Revenue Metering System is shown with current, voltage, serial communications, Ethernet communications, output contact, and optoisolated input connections. A total of five communications ports are available on the SEL-734 with simultaneous operation on four communications ports (not included in the model shown here).

The SEL-734 provides programmable logic to combine meter quantities, contact inputs, remote command inputs, and timers to control meter calculations, internal logic, and contact outputs. The meter is compliant with the following standards: ISO 9001:2000, CAN/CSA Certification C22.2, IEC Safety Standard 61010-04-1:2001-1:2004 2nd edition, and CE:Mark-EMC Directive, Low-Voltage Directive.

"Dairyland Power selected the SEL-734 because it provides very high-accuracy energy metering, load profile data collection, instantaneous power measurements, power quality monitoring, and communicates simultaneously over a modem, serial ports, and wide area networks (WAN)," Martin explains. "The meter is backed with a ten-year, no-questions-asked warranty and SEL's network of factory and field support engineers."

COMPLETE COMMUNICATION WITH COMPLETE CONTROL AT POWERSTREAM

By Caroline Lofthouse

In an era that has seen over 300 Ontario utilities narrowed down to 90, mergers and acquisitions have presented both opportunities and challenges to the operation of the newly formed entity.

The merger of Hydro Vaughan and Markham Hydro and acquisition of Richmond Hill Hydro in 2003 created the fourth largest utility in Ontario.

Operating initially out of two former head offices in Vaughan and Markham, PowerStream Inc. looked to increase both economic and operational efficiencies with the construction of a 92,000 sq. ft. LEED Gold certified head office in Vaughan. This presented a unique opportunity for John McClean (Senior Manager, System Control) and the system operations group to put their years of experience into designing a new control room.

Integrating three SCADA systems, 100 feet of static display boards and different communications systems presented a challenge.

Starting from scratch, the systems group put together a business case for the design of the control room with a focus on efficiency and reliability. Updated technological features were vital. The 100 feet of static display board was replaced with a dynamic electronic display allowing for scalability and other applications such as internet and cable. The display is made up of 12 cubes, yet maintains a seamless view with two lights per cube and a display system that

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Complete Control
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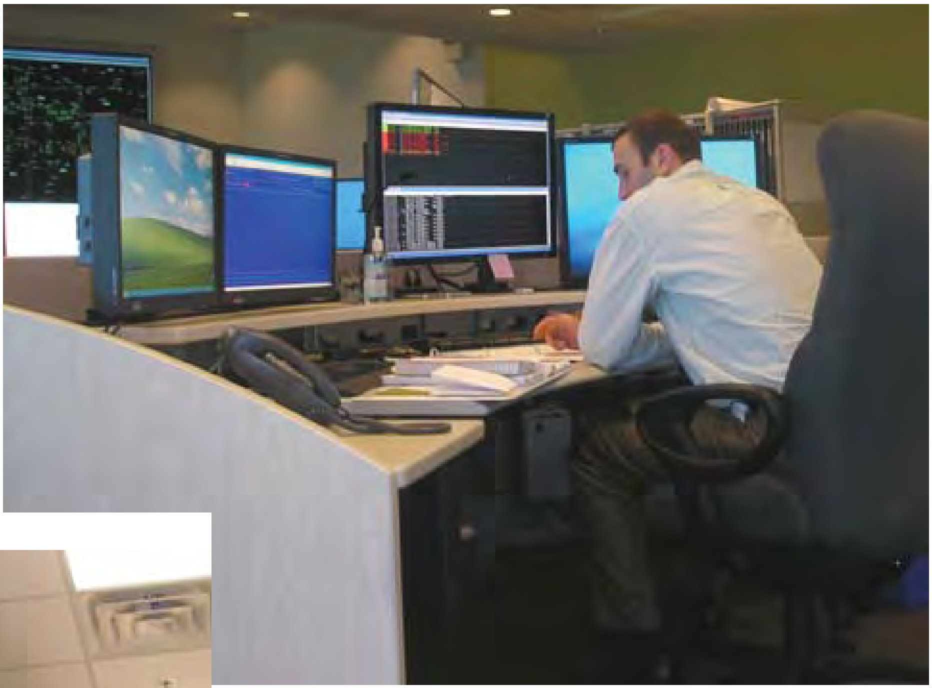
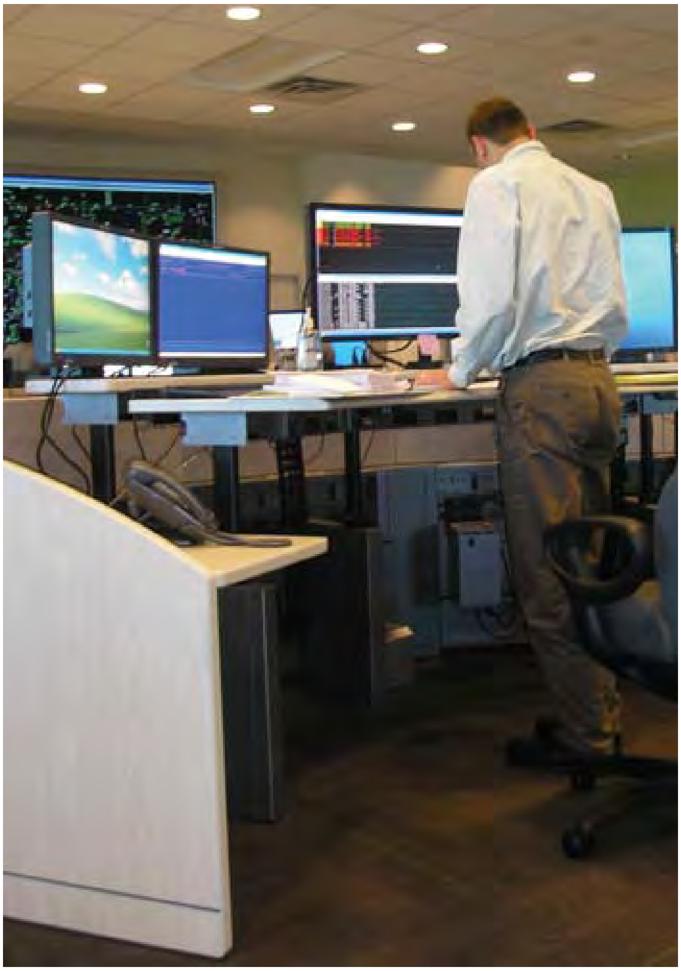
constantly monitors and adjusts colour and lighting to ensure a uniform display. Optimal features such as size, font, colour and scale were assessed to maximize efficiency.

Given the importance of the control operations centre, a secure power supply is a necessity. To ensure reliability, a number of features were integrated into its design, like a back-up generator. The room's entire power supply comes from the back-up generator panel. Power is further secured with an uninterruptible



The workstation can be used at a lowered (above) or raised (shown below) position.



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Complete Control

Continued from Page 24

power supply (UPS) system that has a reserve battery that can supply minimum critical devices for two and a half days if necessary.

The new location was problematic for two-way communication with field staff. Markham was beyond the range of the analog system. To solve this, the existing system was leveraged by converting to digital signal through a SONET ring, which is relayed out to the repeater where the signal is then converted back to an analog signal. Rather than upgrading the system, a cost-effective solution was implemented with the purchase of applicable hardware.

Equipment is protected with a dry-sprinkler system. This prevents potential leaks and damage to the equipment. If air-pressure drops, as it would if a sprinkler head melted, a valve would open and water is released.

In addition to technology, the human factor was a key consideration in the ergonomic design of the new control room. Control Room complex is self-contained with kitchen, shower, washroom, offices for key personnel and meeting room. The key conservation feature of the new building, natural lighting, was easily integrated into the design. A focal point of any control room is the display board. To ensure a clear line of sight from most points, the interior walls are composed of glass.

Room location also plays a key role.

Located in the northwest corner, systems operators have a direct exposure to weather conditions. Given the prevalent weather patterns in the area, severe weather can be anticipated more readily. Also, a lightning detector on the roof of the building can identify lightning frequency and pinpoint the location of the strike within a 50-kilometre radius.

Distractions have been minimized with the new layout and design. The ceiling tiles have a high acoustic value that dampens sound, in addition to increased reflectivity that maximizes available lighting. Each work zone can control individual lighting. Work Stations have sit/stand function that allow for flexibility. Operators tend to stand during emergency situations. Adjusting heights allow system operators better viewing of the screens. Also, the entrance is at the exterior of the complex, and glass partitions remove distractions to operators from the traffic. The meeting room is also located at the exterior and provides workspace for senior management during emergency situations without hindering control room operations.

Pandemic planning was a key consideration in design, as required by the province's system operator, the Independent Electricity System Operator (IESO). The heating & ventilation are separate from the main building and powered from a backup generator panel. This system has no common return with the main building HVAC. This is the only room in the building with a humidifier and three zones of ventilation.

The merging of two control rooms goes beyond updating technologies and layout and design. As PowerStream discovered, bringing two operator groups together takes reorganization of work structure and procedures.

The differing corporate cultures presented a challenge for the effective operation of one control room. Neither culture is incorrect, but communication is hindered without a unified "language". Modified operational procedures and protocols are being implemented to ensure effective communication.

At present, operators are required to wear many hats. To minimize distraction and increase efficiency, two new roles will be created:

- a Trouble Call Dispatcher, to handle the 7,000 trouble calls a year; and
- a Planner Coordinator to receive and process outage applications.

This fall, the city councils of Markham, Vaughan and Barrie approved the merger of PowerStream and Barrie Hydro. This pending merger will position PowerStream as the second largest distributor Ontario. The design features of the new control room have been implemented with an eye towards growth, and integration of this new service territory should occur with relative ease.

Where as, with the acquisition of Richmond Hill Hydro, the static board was relocated to the Vaughan control room, this new merger requires only the transfer of information, people and ideas. In a business where reliability is the primary measure of success, PowerStream demonstrates the value of corporate growth for the consumer.

TRANSFORMER OIL COOLERS: ESSENTIAL FOR ENSURING OPTIMAL OPERATIONS

By Laurie Brescacin, Senior Consultant, Unifin International, LP

Transformer oil coolers play a critical role in keeping electrical generation systems reliable. Transformer oil coolers are a small investment that protect the power industry's huge capital investment in the massive transformers that make up the backbone of a nation's energy supply.

Power plant generators produce electricity that has to be converted to high voltage for more efficient transportation across wires to substations near businesses, factories and homes. The transformers that convert the electricity to high voltage do so extremely efficiently with only something in the order of 0.5% of the electrical load being lost in the form of heat. Even though the loss percentage is small, the actual quantity of heat can be quite large. The heat that is produced must be carried away from the transformer and dissipated. If not, the transformer will overheat and be damaged or even destroyed.

The windings of the transformer are immersed in an enhanced mineral oil that is circulated to cool the transformer. This oil also remains stable at high temperatures and has excellent insulating properties that protect against stray current path. The oil circulates through both the transformer windings and the cooler and the heat lost is transferred either to the ambient air around the transformer or to water. The oil-filled tank often has radiators through which the oil circulates by natural convection. Large transformers use forced oil circulation by electric pumps, aided by external fans or water-cooled heat exchangers.

The transformer oil cooler has to be sized to transfer the amount of heat that needs to be dissipated from the transformer, depending on its size, design, and configuration. Some transformer oil coolers are designed to take into effect the kinds of adverse conditions around the transformer that could potentially cause a shortfall in performance.

DESIGN CONSIDERATIONS TO ENSURE PERFORMANCE

Air-cooled systems most prevalent

Most fossil fuel plants use air-cooled systems because air is always readily available and its use in transformer oil cooling systems usual-

Performing maintenance on the transformer cooler.

ly involves fewer environmental concerns.

There are several design considerations that must be taken into account with air-cooled systems. The temperature difference between the oil and the air determines the amount of surface needed for cooling. The greater the temperature difference between the oil and air, the less surface is needed. So if the air temperature has been elevated but the oil temperature is fixed because the application cannot allow it to increase, the size of the cooler's surface area must be increased as a result.

Air-cooled transformer coolers are typically mounted on the side of the transformer, usually vertically about 3 feet or 1 meter away from the transformer wall. The coolers take air from around the transformer, and fans then draw or push the air through the transformer coolers. The air is then discharged to the environment around it. To get the level of cooling required, designers must be able to accurately predict the amount of air that will actually flow across the heat exchanger as well as the temperature of that air.

Depending upon how many coolers are required and how much heat has to be dissipated, one to six coolers might be placed along each side of the transformer. The more coolers mounted along the side of the transformer, the more likely there will be adverse air recirculation from the discharge of that air. This is because the discharged air is warmer than before, and if blended with the air that is being drawn in to cool the transformer, the discharged air will raise the temperature of the air that's coming through.

Several other site-specific factors must be taken into account to avoid detrimental affects on cooler performance:

• Wind speed and direction can be a factor - for example if fans are blowing air away from the transformer but the prevailing wind is blowing towards the transformer, warm air will be pushed back.

• Buildings around the transformer, firewalls or other fire protection components can trap air and impede air exhaust.

• Existing transformer cooler applications elsewhere on the site could blow heated air toward the new installation.

For example, a designer may be asked to design a system based on a 30 Celsius (°C) ambient situation. However, due to one or more of the factors described above, the air immediately adjacent to the transformer might not be 30°C, but could possibly be as high as 35°C to 50°C. Experienced designers know to design a system that reflects these actual ambient conditions.

Water-cooled systems

Water-cooled transformer oil coolers are considered more efficient, and are used where water is plentiful, for example in hydropower applications. After the heat from the transformer is dissipated to the water, it is necessary to either discharge the water back to its source (which has potential environmental issues), or lower the water temperature before recirculating it through the transformer cooler (which requires an auxiliary system). Also, water-cooled systems require a leak detector system to make sure water doesn't get into transformer oil and then into the transformer, which could have disastrous consequences.

Unifin International, LP manufactures transformer oil coolers that are fitting for numerous different applications in the power generation and power transformer industry from nuclear to hydroelectric to gas-turbine power. They are made for the most efficient heat transfer in the most demanding settings with long-lasting durability and low cost in mind.

Fans and Motors are Key

Another factor that makes a big difference in the operation of the transformer oil cooler is the selection of the fans and motors for the unit. Designers must size the motor correctly to drive the air without overheating the motor. Motor cost, cost for required circuitry and/or need to use existing circuitry, and noise levels are factors that must be considered.

Experience shows that if fans and motors are selected based solely on the manufacturer's specifications, they may not perform as required. Fan and motor performance specifications are usually based on optimum conditions, inconsistent with the extreme environment of most power applications. In these conditions, fans frequently require more energy than specified, requiring larger motors that in turn use more power.

To deal with this issue, Unifin International, LP developed a set of specifications for transformer oil cooler fans and motors that meet the power industry's need for reliability, efficient power consumption, and the ability to withstand the various ranges of temperature and other weather conditions encountered. Unifin selected a series of efficient, low-noise fans, conducted specialized tests at the revolutions per minute (RPM) that might be used with various cooling applications, and measured airflow versus pressure loss and power consumption of the motor and noise of the fan. Based on the results, Unifin developed its own set of fan curves of airflow versus pressure loss for each of the fans at each RPM they would be using, and selected motors that would meet the specifications.

Maintaining cleanliness of the internal surfaces of the cooler during manufacturing is extremely important, especially surfaces that would come in contact with the circulating oil.

Manufacturing Process Must be Strictly Controlled

Manufacturing processes must be strictly controlled to ensure that the oil cooler meets the specifications. For example, Unifin's transformer oil coolers use integral finned tubing formed using an extrusion process that hardens the aluminum so the fins are very strong, resulting in optimal heat transfer efficiency and exceptional durability. Unifin also offers a high quality plate-fin technology as a premier heat transfer surface in a more compact design. The plate-fin surface can be augmented to enhance performance. As a result the specified heat to be dissipated can be done with less material.

Maintaining cleanliness of the internal surfaces of the cooler during manufacturing is extremely important, especially surfaces that would come in contact with the circulating oil. It is essential that no metal particles are introduced that could contaminate the oil. Particles that could get into the transformer windings with the oil would be extremely detrimental to the life of the transformer.

In addition to a clean manufacturing process, cleaning processes like a flushing system and electronic monitoring or particle counting systems can be insurance that the system will perform as required and protect the transformer.

Oil Coolers Protect Transformer Investment

Power facilities must perform continuously, often in extreme environments. Properly sized and configured, high quality transformer oil coolers play a vital role in maintaining safe, efficient, and reliable electricity production. Overheating can shorten the transformer's life and, in severe cases, could lead to serious and costly damage or even destruction of a transformer. Cooling the transformer is affected by the varied conditions that can occur, and special care is needed to design cooling systems that actually reflect the existing ambient conditions on the site.

DRIVING CHANGE IN CONSUMER BEHAVIOR TO CREATE A CULTURE OF CONSERVATION

By Ven Seshadri, The SPi Group Inc. and Helen Platis, Elenchus Research Associates

The Province of Ontario has identified a significant gap in its generation capacity and, accordingly, has drafted an Integrated Power System Plan to address this situation. Although new generation capabilities such as nuclear power stations and investments in renewable sources are required, the goal is to address at least 6,300 megawatts (25%) of the supply gap through conservation measures.

This plan is not without its challenges. Ontario has a strong consumer and consumption culture, with a large amount of disposable personal income. Geography, climate and a subsidized, regulated price for electricity contribute to high electricity consumption.

Ontarians are among the largest per capita consumers of electricity in the world, ranking higher than American consumers.

In order to meet the conservation challenge, Ontario must shift to a culture of conservation from a culture of consumption, and smart meters are a key tool in enabling this shift.

SMART METERING IN ONTARIO

During 2004 and 2005, the Government of Ontario mandated that all residential meters in the province should be replaced with smart meters that could measure consumption in hourly intervals. It also mandated that hourly interval data would be gathered and stored centrally in a Meter Data Management and Repository (MDM/R) operated by the Independent Electricity System Operator (IESO).

The intent of this plan was that the regulated price paid by consumers not enrolled with an electricity retailer would be based on the aggregated consumption in three standard time slots (called time-of-use, or TOU, “buckets”), with different rates for each of the three time slots. The ability to measure electricity consumption at hourly (or finer) levels of granularity allowed for more accurate determination of individual consumption and the ability to create incentives and disincentives based on consumption patterns.

As of mid-2008, 1.4 million of the 4.5 million electricity meters in Ontario have been replaced with smart meters, three mid-sized utilities have begun using the centralized MDM/R to collect data, and a small number of consumers are billed on time-of-use rates. In addition, a number of smart metering and smart suite metering pilot projects were conducted by several local distribution companies (LDCs) including Hydro Ottawa, Newmarket Hydro, Oakville Hydro, Veridian Connections and Hydro One Networks.

These pilot projects offered some interesting results:

• Different pricing structures yielded varied consumer behaviour and preferences. While the standard TOU pricing scheme was preferred by the largest consumer segment, it yielded the smallest reduction in overall load and the lowest load shift.

• Other pricing schemes such as critical peak pricing (CPP) and critical peak rebates (CPR) yielded considerably greater conservation and load shifting results, but were preferred by a minority of consumers.

• Consumer awareness of their own consumption resulting from the introduction of smart suite metering in multi-residential dwellings, such as condominiums, caused a considerable reduction in electricity consumption.

• Real-time monitoring tools had a significant impact in driving consumption behaviour towards reducing overall demand.

These results suggest that, in order to achieve the greatest benefits from smart metering for conservation and load shifting, multiple billing plans/options for different consumer segments are needed.

In addition, consumer awareness of their consumption patterns and the availability of in-home technology to adjust consumption behaviour are critical to leveraging the smart metering infrastructure to achieve demand reduction.

As of mid-2008, 1.4 million of the 4.5 million electricity meters in Ontario have been replaced with smart meters, three mid-sized utilities have begun using the centralized MDM/R to collect data, and a small number of consumers are billed on time-of-use rates. In addition, a number of smart metering and smart suite metering pilot projects were conducted by several local distribution companies (LDCs) including Hydro Ottawa, Newmarket Hydro, Oakville Hydro, Veridian Connections and Hydro One Networks.

INSIGHTS FROM THE TELECOMMUNICATIONS INDUSTRY

When considering the impact of smart meters on the evolution of the electricity industry, parallels can be drawn with the telecommunications industry. Like electricity, the telecommunications industry was opened up to choice, and consumers view both call minutes and kilowatt-hours (kWh) as commodity products.

Innovation in the telecommunications sector came through packaging of the product (minutes) to meet consumer needs (customized price plans) and add-on technology options, such as call-waiting or caller-identification.

Availability of data was important in order to deliver maximum value from the telecommunications infrastructure. An example is the congestion introduced with free evening and weekend minutes. These products were initially introduced to move congestion in the downtown core from peak to non-peak periods. What was overlooked was that most users left for the suburbs in the evenings, increasing after-hours congestion in areas where the infrastructure was less developed. A similar situation in the electricity industry may be created in the downtown core as plug-in electric vehicles become more prevalent. Since telecommunications providers were able to measure the consumption of their product at a very fine level of granularity, the companies had the data available to diagnose the problem and create consumer-specific billing packages to further modify behaviour.

Consumer awareness was critical in developing and understanding the issue and driving product differentiation. Segmentation was a key strategy in this industry. Packaging of minutes, creating price points and billing options provided strategic differences among the major players and gave consumers the best price and service for their individual circumstances. Providers learned that there were products to be created through bundling – that is, plans – and consumers learned that they could tailor their packages. Key to the success of this approach was consumer understanding of the options available to them.

Infrastructure and technology also evolved to meet new demand, and many new companies, such as Research In Motion, were created as a result. Government intervention in the early stages of telecommunications deregulation also established a platform and a clear set of guidelines that enabled the industry to attract private sector capital.

The overall lessons learned from the telecommunications industry are that mass customization, customer choice designed to drive desired behavioural change, and the need for private investment will ultimately lead to better and more effective utilization of capacity and infrastructure.

SMART METERING DRIVING CONSUMER AND TECHNOLOGICAL CHANGE

We believe that the smart metering and smart grid infrastructure being created today can be leveraged to drive a dramatic change to the electricity industry, similar to that which we have witnessed in the telecommunications industry over the past 20 years. These changes will result in a more effective and efficient use of energy infrastructure and create a culture of conservation. We have identified three key steps that must be taken to enable the desired change.

• Understanding consumer behaviour

In order for providers, such as energy consultants and retailers, to competitively offer a variety of TOU billing options, they need access to the hourly meter data stored in the MDM/R. Currently, retailers obtain meter data from LDCs through Electronic Business Transaction (EBT) hubs, which are transaction clearinghouses that manage the exchange of standardized transactions underlying the Ontario retail electricity market.

Access to this consumer information is protected by the LDCs, governed by standard agreements between LDCs and energy retailers and consultants, and regulated by the Ontario Energy Board (OEB). LDCs, however, do not store hourly smart meter data. Therefore, integration of EBT hubs to the MDM/R is required so that vendors can provide innovative time-of-use billing plans to targeted consumer segments, while still ensuring the same protection of consumer data that exists in the market today.

• Providing consumers with enhanced information

Smart metering is expected to increase the availability of information and the complexity and variety of billing plans offered. Consequently, consumers need to be more informed of their plans as part of the billing process. This can be accomplished by including additional lines to the standard electricity bill with detailed consumption and billing information. However, it is also important to develop tools, such as online access, that explain how the bill was calculated, different rate plans, options available to reduce bills, detailed consumption information and any other information that may be necessary.

• Developing the infrastructure

Change in consumer behaviour must be supplemented with development of the technology infrastructure for the potential of smart metering to be more fully realized. As consumers begin to understand the implications of TOU rates, and customized rate plans, there will be a desire for more long-term solutions. Standards will need to be established to provide a gateway between the in-home devices (load control units) and the smart meter or smart grid interfaces. It is important to note that security concerns regarding the amount and type of information released will need to be addressed.

By leveraging existing electricity market and distribution network infrastructure, all of these changes can be enabled incrementally. Such changes are, overall, cheaper and more reliably executed than wholesale, “big-bang” implementations. Only then will Ontario be able to reach its conservation goals.

CONCLUSION

The smart meter infrastructure is the foundation that will transform the industry and consumer awareness and interest in electricity. This approach outlines what we can do today, to achieve our conservation goals in the future.

Ven Seshadri is the President and Chief Executive Officer of The SPi Group Inc., a leading provider of information technology solutions to the energy industry.

Helen Platis is Vice President, Operational Solutions at Elenchus Research Associates, a consulting firm providing strategic energy industry advice to manage current risks and technical support to navigate the complexities of the business and regulatory environments.

HOW INNOVATIONS IN DEMAND RESPONSE ARE SHAPING A NEW ENERGY FUTURE

By Peter Kelly-Detwiler, Constellation NewEnergy

According to estimates from the United States Energy Information Administration, in just two decades U.S. energy consumption will increase by about one third. The majority of this new generation will go toward meeting the needs of our built infrastructure. Whether this increase in demand is accompanied by a corollary increase in greenhouse gas emissions has a great deal to do with the energy decisions we make today. Against this backdrop, Constellation New Energy, an experienced energy advisor to several hundred megawatts of load response customers across North America, is driving innovations in demand response that have the potential to significantly alter the energy landscape.

5 easy steps to enrolling in the NewResponse program

1 Contact your business development manager at Constellation NewEnergy (CNE). If you aren't a CNE customer yet, please call 866.237.POWER or email loadresponse@constellation.com.

2 A CNE energy expert may evaluate your organization's curtailment capabilities to determine opportunities and optimal strategies. This may include analysis of usage and an onsite evaluation.

3 CNE will then calculate the appropriate curtailment commitment to be performed during an event that maximizes program benefits while minimizing any risks to your organization.

4 CNE will enroll your committed load reduction in the Regional Load Response Program sponsored by your Independent System Operator (ISO) or utility.

5 Where appropriate, CNE will work with you to install meters, enhance your energy management capabilities and complement your building automation system through installation of software and/or hardware to allow your organization to analyze usage, curtailment potential, and energy prices in real time via the Internet.

Figure 1: There is an annual deadline for enrolling load into the demand response program and the minimum commitment is for one year. Getting started takes five easy steps.

TRADITIONAL DEMAND RESPONSE PROGRAMS

Traditionally, demand response has been a program designed by independent system operators (ISO) to help prevent blackouts and brownouts on the hottest or coldest days of the year when energy is at peak demand. Commercial and industrial customers, who demonstrate an ability and commitment to curtailing at least 100 kilowatts of electricity, can sign up to participate in an ISO-directed demand response program through a competitive energy supplier such as Constellation NewEnergy.

For smaller businesses or facilities that cannot solely meet the 100 kilowatt minimum requirement, it is possible to aggregate load reductions across multiple locations. There is an annual deadline for enrolling load into the program and the minimum commitment is for one year. Getting started requires that a facility be equipped with an interval meter capable of reading consumption in hourly increments and communicating with the ISO or responsible utility.

In this way, the ISO harnesses the energy conservation efforts of its customer base rather than bringing older gas, oil or coal plants on-line to meet demand. At the individual facility level, these conservation efforts often reflect dimming lights and raising the set point on thermostats, or changing production schedules in some cases.

Participating customers commit to curtailing their energy usage for a designated amount of time during these peak events. This is a win-win for business and the environment as 1) participants avoid purchasing energy when it is at its highest costs, and 2) it avoids the need to have older, greenhouse gas emitting peaking plants come online. In addition, participants earn year-round financial benefits for committing to reduce energy consumption from the grid when called upon.

For businesses seeking a real-time return on investment, enrolling in a demand response program is a smart business decision. The payback for participating can be measured in immediate savings. In exchange for enrolling load into the program, a participating company or facility can begin earning compensation in the form of recurring monthly capacity payments simply for committing capacity to the program. In addition, participants receive an energy payment for their participation during an actual ISO-initiated event. This payment reflects either the going market price or a minimum price per megawatt-hour of the electricity curtailed during the event.

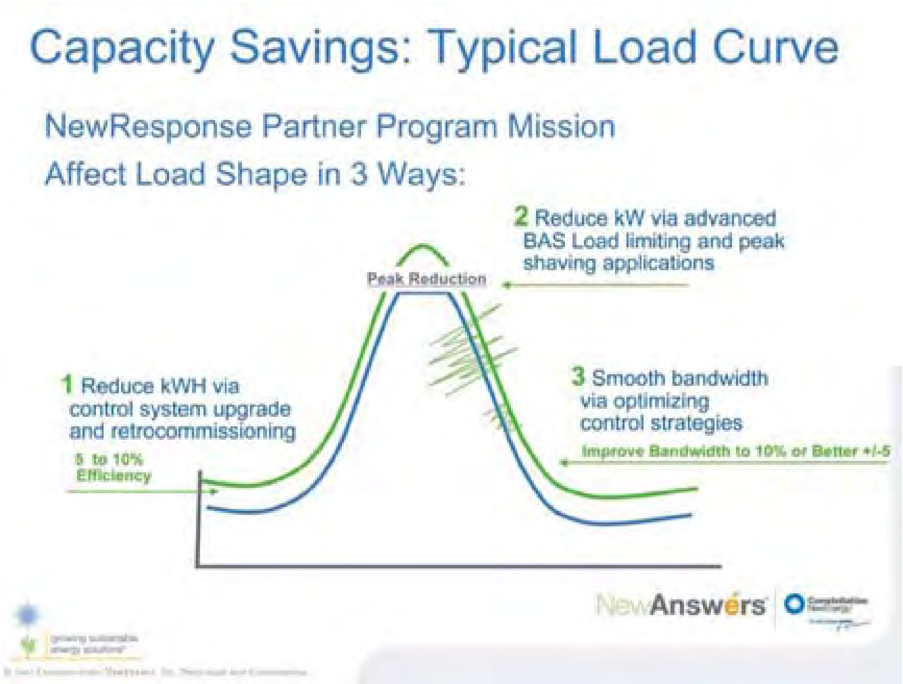


Figure 2: Potential capacity savings as seen in a typical load curve.

A NEW APPROACH TO DEMAND RESPONSE

What is important to recognize is that until recently, demand response has been primarily a reactive program and the typical response to an ISO-initiated directive to curtail energy load has been to fire up the back-up generators – a fairly blunt instrument with its own air emissions issues. Today, thanks in large part to innovations introduced in the deregulated energy market, the fundamentals of demand response are changing rapidly, bringing increasingly more sophisticated and environmentally sound ways of limiting energy consumption to the table. These opportunities, which go well beyond dimming lights and adjusting temperature, can be leveraged during peak times and all year.

When deploying a load response solution, it is imperative to actively engage facility managers from companies of all sizes to keep a wide range of systems operating efficiently and effectively under a myriad of conditions, including a volatile energy market and a steady increase in capacity costs. To advance this approach further, Constellation NewEnergy is partnering with multiple systems integrators to develop a holistic load response solution that incorporates energy supply and demand information and knowledge onto one comprehensive and open IT management platform.

Systems integrators already utilize building automation systems to manage the lighting, HVAC, and air conditioning infrastructure within a facility. In fact, open platforms are proving to be the most successful foundation for integrating once disparate control processes and infrastructure. This ability to bridge and consolidate information on one platform has focused on introducing efficiency and conservation efforts such as automated lighting, internet access, phone systems and heating and ventilation control. These integration efforts have required significant capital investments but improved efficiency and enhanced decision-making at the building management and operations level of an enterprise. Even so, today's buildings are still not realizing their full potential. Constellation NewEnergy is leveraging the opportunities that have come about as a result of a more competitive energy market to change this paradigm.

Load management and energy efficiency strategies are most effective when all elements of the energy chain are linked together for the customer. Integrating load response programs onto existing open platforms brings the supply side of the picture into perspective, putting facility managers, business owners and building management in a position to leverage both the demand and supply side of the equation. This holistic approach allows an energy team to take full advantage of opportunities in an ever-evolving energy marketplace. As illustrated in Figure 2, these opportunities include:

1) Reducing load via control system upgrades and retro-commissioning.

2) Reducing load via advanced BAS load limiting and peak shaving applications.

3) Smoothing bandwidth via optimizing control strategies.

Enhancing the flexibility of a company's facilities is fundamental to reducing future energy demand. Just as importantly, it reduces stress on the power grid today. By incorporating load response metering and real-time market pricing into existing energy management techniques and multiple building systems, a business is able to elevate its energy management and conservation efforts well beyond dimming the lights or adjusting the thermostat.

Access to real-time metering and price information systems, which allow up-to-the-minute views of energy usage and costs and the ability to employ this information to better shape and control usage patterns, puts a business in the driver's seat of a smarter and more energy responsive building. Fully integrated and intelligent buildings do more than respond to mandatory curtailment demands. These buildings are capable of reacting to changes in the energy marketplace at anytime by shedding load and adjusting consumption to maximize economic efficiency. As a result, intelligent buildings are able to shift electricity consumption from periods of high prices to periods of low prices and reduce overall energy costs in the process. In this respect, the initial commitment to enroll load in a region's ISO-directed demand response program represents only the first step on a path to participating more fully in the restructured energy market.

Overlaying the new demand response onto existing open platforms makes it possible to more successfully harness and shape load whether the load is distributed across a single facility, college campus, or retail chain with multiple locations throughout a large geographic area. At Constellation NewEnergy, we think this ability to shift and shape load across multiple buildings is going to reveal itself to be the smartest and most efficient way to create the virtual peaking plants and intelligent buildings of the greener energy grid of the future.

FUTURE INNOVATIONS AND OPPORTUNITIES

Looking to the future, buildings of all sizes will be flexing and pulsing in response to energy prices and elasticity in the marketplace. Imagine a big box retailer shifting load among 30 of its stores based on inputs such as day-ahead pricing, customer patterns and weather. From there, it is a short distance to a future in which the ebb and flow of electricity will not solely be from the grid but rather among the individual and collective enterprises which comprise the built landscape. Innovations of this magnitude in our built environment, by virtue of its role in consumption, have the potential to shift our understanding of energy generation, demand and load allocation in an entirely new direction.

This shift in understanding is already underway, as recently evidenced by the success of DR-Expo which took place in Chicago, Illinois. DR-Expo brought together over 200 building owners, energy and facility managers, systems integrators and building automation contractors to discuss the benefits of demand response and other efficiency programs as both a short-term business proposition and as a route to the significant future market in sustainable energy. A renewed commitment to deliver the perspective and tools required by the industry to incorporate innovations in demand response into existing building automation efforts is perhaps best demonstrated by the creation of the NewEnergy Alliance, of which Constellation NewEnergy is a founding member.

Formally announced at DR-Expo, the NewEnergy Alliance is bringing together leaders from the retail energy and building automation industry. Alliance members are intent on developing and advancing innovative and sustainable business solutions for successfully integrating advanced demand response opportunities into existing efforts to reduce the carbon footprint of the established building environment.

The NewEnergy Alliance brings together the technologies, manufacturers, engineers, and service providers from across the energy, IT, and building systems industries that can collectively help drive pioneering approaches in demand and load response technology for decreasing the energy use in our built environment. The Alliance will work to fast-track innovations in demand response technology that are demonstrated to provide greater building efficiency. This collaborative effort will help empower and create immediate revenue opportunities for all who wish to directly participate in demand response with their products, services and technologies.

Participants in the building automation sector already know that reducing costs by automating functions across a facility is good business. Those that can bring an enhanced intelligent market-based load management product to the table will be well received by customers seeking to leverage existing investments in technology and infrastructure in a way that unites their energy purchasing strategies with corporate responsibility.

In today's competitive business environment, managers and owners are thinking about energy as a strategic asset integral to every aspect of the bottom line. The capacity to actively monitor and manage usage and adjust operations accordingly reflects the increasingly sophisticated energy strategies now available. Load response solutions are particularly attractive to businesses that have already invested in intelligent building designs, and wish to leverage the full spectrum of the energy chain to maximize these energy investment decisions. Constellation NewEnergy is helping customers adapt successfully to this new energy paradigm and positioning them to make the most of the opportunity to participate in the emerging energy marketplace of the 21st Century.

Peter Kelly-Detwiler is Senior Director of Energy Technology Services for Constellation Energy's Sustainable Energy Solutions Group.

BENEFITS OF THE 700 MHZ SPECTRUM FOR ELECTRIC POWER COMPANIES

By Brent E. McAdams, Director of Sales, FreeWave Technologies, Inc.

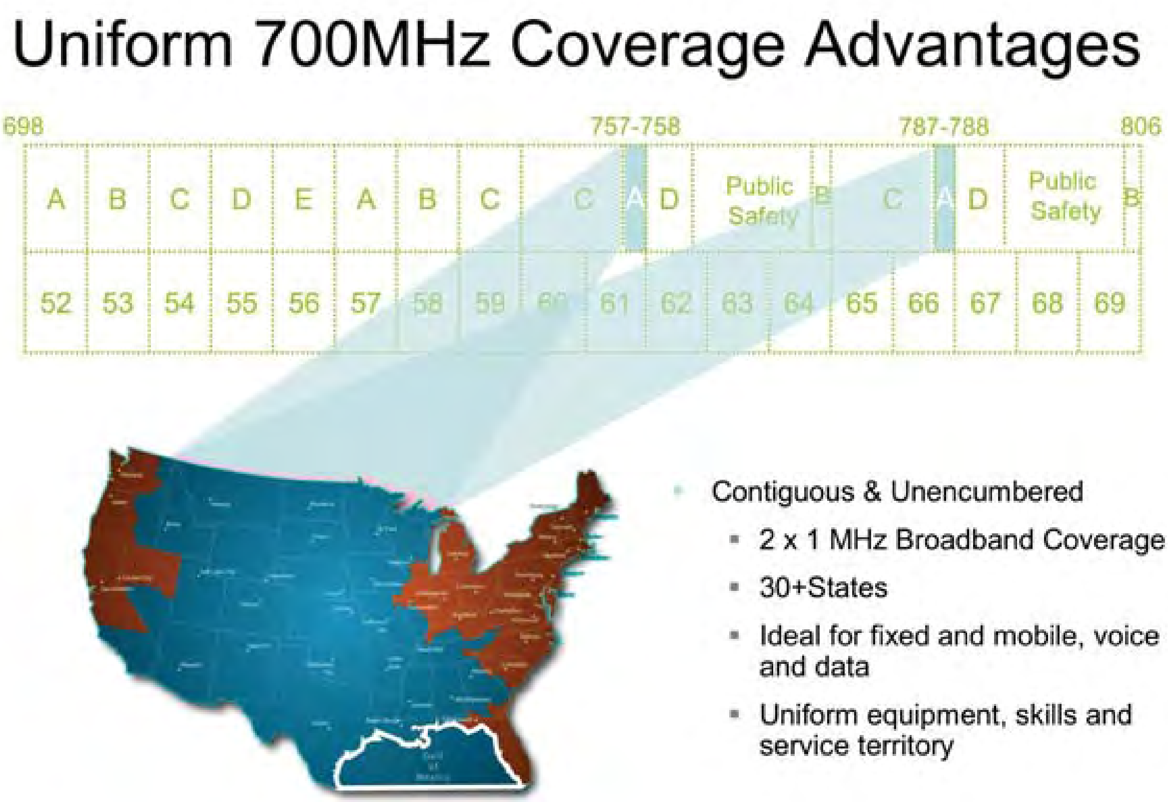
Until recently, electric power companies faced the challenge of incorporating applications and technologies in a complex field infrastructure that was constructed over decades. Utilities today deploy a variety of siloed networks that originally were selected based on a variety of needs.

For example, some utilities urgently needed applications, others had budget constraints and many were looking for carriers that could function in remote regions. The field communication networks then became clustered together rather than engineered or architected. The end result is a tangled infrastructure of terrestrial and wireless systems.

Mission-critical processes are measured by their ability to meet uptime and performance requirements, especially with wireless. Carrier-grade wireless equipment and 700MHz licensed high-speed spectrum is now available, for the first time, to deploy for electric power communications. The 700 MHz licensed spectrum (versus unlicensed) provides a predictable RF environment protected from external interference, thus improving control over band management, security and speed. In addition, it provides privacy and extraordinary propagation. The broad propagation characteristics reduce the number and height of towers needed, resulting in a more cost-effective deployment.

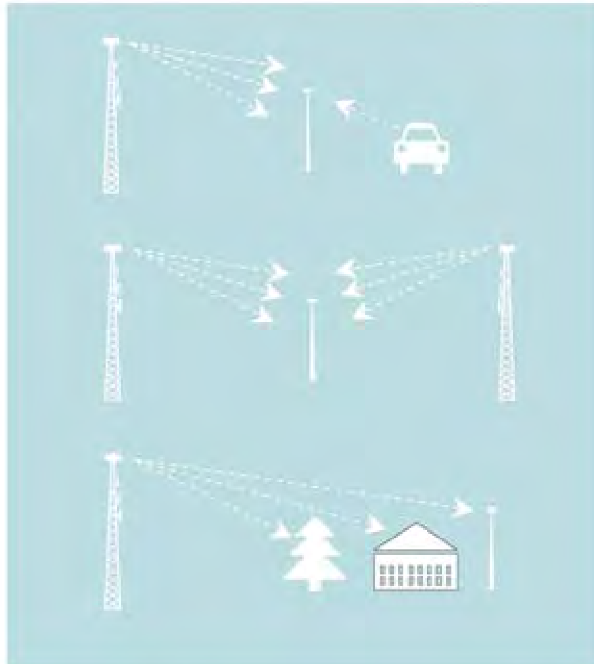
Many companies and municipalities have realized the benefits of using the 700MHz band. It is the choice of the federal government for first responders and is now available for use in SCADA operations for electric utilities to incorporate the industry's most advanced ISM band radio technology and wireless data solutions on a 700 MHz private, licensed and secure communication platform as a single, seamless and integrated "Smart Grid" or "Smart Field" solution. This capability provides electric utilities companies with greater equipment diversity and flexible bandwidth and deployment options. Essentially, it helps untangle the wireless infrastructure outlined above by providing a single communications solution.

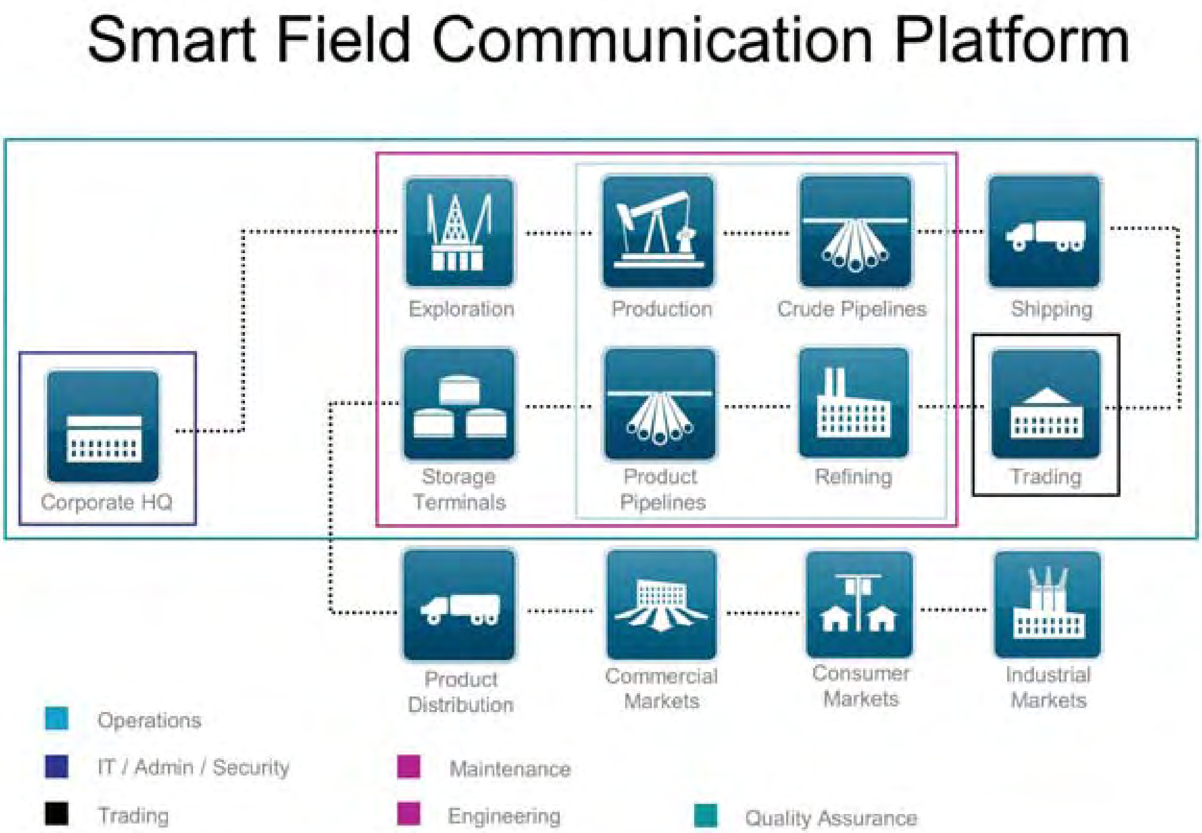
Additional physical attributes contribute to the superior value of the 700 MHz spectrum, making it an important consideration for wireless radio networks in the electricity industry. Signals at this spectrum travel farther than higher-frequency signals and also require less power for the same range. A former television frequency, the 700 MHz can pene-



Interference Protection Advantages

- Third-party Interference
  - Licensed Spectrum Protected from third-party interference by FCC
- Self-Interference
  - Eliminated via Arcadian Networks RF design and NOC monitoring
- Environmental Interference
  - Network architected with proper signal & reliability margins





trate obstacles with a higher level of success even in the worst environmental conditions. This spectrum also is ideal for rural and dispersed applications due to the fact that it's less dependent on line-of-sight. The FCC also allows higher power limits for 700 MHz than other wireless spectrums.

Engineers have seen an increased performance in accuracy, cost and timeliness of designs for new customer facilities. All of these factors lead to an improvement of design in technologies made for the 700 MHz spectrum. Board level radios used in the 700 MHz licensed spectrum provide exceptional performance and versatility in a small footprint that is ideal for internally mounted applications. These radios also offer a cost-effective solution which allows users to incorporate wireless communications into electric power applications. Additional benefits of using a wireless radio in the 700 MHz spectrum include having a private, secure network with advanced, reliable and robust radio communication technology.

Many expect the 700 MHz portion of radio spectrum to favorably impact the wireless world. The FCC has called it, "the last beach front property in the wireless world."

The 700 MHz radio spectrum is a unique value for wireless broadband. Possibly the most significant benefit of having a licensed spectrum is that it is exclusive to the spectrum holder. In a way, spectrum is similar to land. If you have and own, you can keep others from trespassing. The licensed 700 MHz spectrum on is exclusive. The result is that the 700 MHz frequency is not prone to interference. Licenses for the spectrum are widely available from Arcadian Networks. Spectrum in the 400 MHz band is not nearly as available largely because the spectrum has been available for decades and most of the licenses are already owned or controlled. Many expect the 700 MHz portion of radio spectrum to favorably impact the wireless world. The FCC has called it, "the last beach front property in the wireless world."

Brent E. McAdams is the Director of Sales at FreeWave Technologies, Inc., a premier RF design and manufacturing organization. Prior to joining FreeWave Technologies, Mr. McAdams served as the Vice President of Technology and Business Development for the U.S. Telemetry Corporation where he led product development strategy and business development initiatives.

ANAHEIM UTILITY MAKES IT EASIER TO BUILD GREEN

The historic "Colony District" of downtown Anaheim is the location for Southern California's first "GreenPoint Rated" single-family detached home. The home, which was built by Colony Developers LLC, recently received the prestigious GreenPoint Rating by Build It Green, a non-profit membership organization whose mission is to promote healthy, energy- and resource-efficient building practices in California.

This unique home, located at 1122 W. Santa Ana Street, was constructed with the cooperation and guidance of Anaheim Public Utilities and the Anaheim Redevelopment Agency. It is the first of 10 such "GreenPoint Rated" single-family detached homes being planned in Anaheim by Colony Developers.

"The City of Anaheim is making it easy for developers to build green by promoting and offering incentives for this type of environmentally conscious development," said Roy Ward, a principal for Colony Developers. "We are pleased to be working with Anaheim and some of the area's top green architects and consultants on this project. They represent the leading edge for incorporating sustainable technology and green practices into single-family residential construction."

"Because we have a city that works together, builders with projects of all sizes find it easier to go green in Anaheim," said Marcie Edwards, Anaheim Public Utilities general manager, "from bigger projects like Brookfield Homes' Colony Park townhomes to this single-family detached residence by Colony Developers. We currently have 11 green projects in our pipeline, making Anaheim one of the 'centers' for new green building in Southern California."

The Santa Ana Street's home performance was rated above California code in all five of the measurement categories, with the highest marks coming in the energy and water categories, where Anaheim Public Utilities assisted the builder through rebates and incentives worth thousands of dollars.

"Through our Plan Check Fee Waiver Program alone, the builder saved nearly $4,000," Edwards said. "And, there were additional savings with rebates on high-efficiency toilets, a SmarTimer irrigation system, ENERGY STAR appliances, high-performance windows, plus GreenPoint Rater and design consulting services."

Landscaping improvements included free shade trees from the City's TreePower Program, as well as an abundance of California friendly drought-tolerant plants.

While landscaping the 18,000-square-foot lot, special care was taken by the developers to preserve a 150-year-old oak tree in the back yard. The tree is believed to be one of the oldest oak trees in Anaheim.

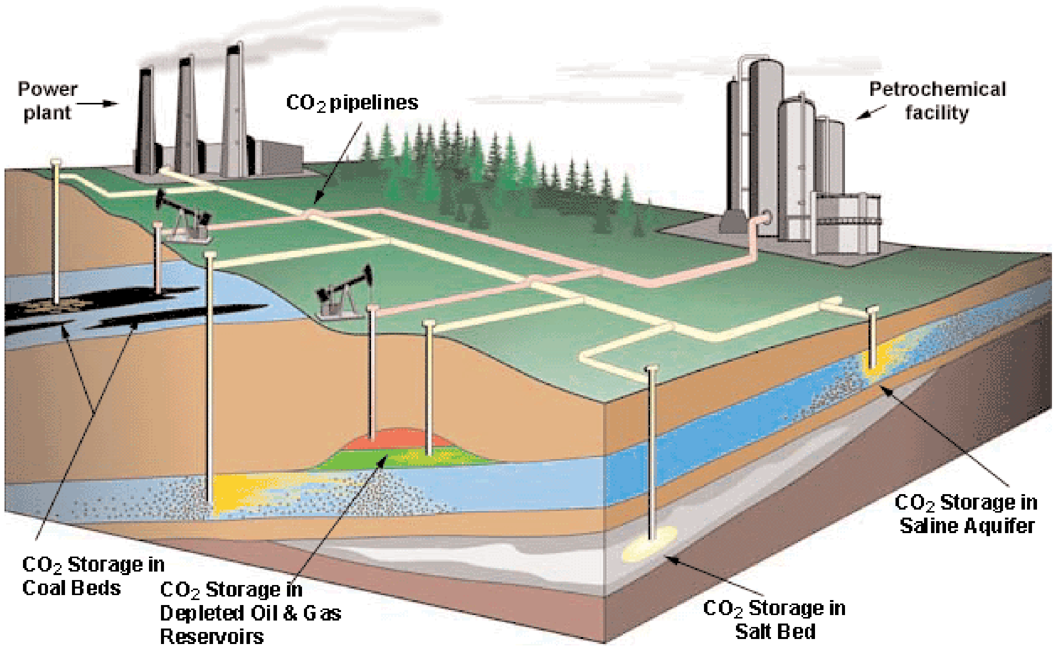
"Our added costs to get this home's performance ratings above California code did not exceed 5 percent above normal construction costs," Ward said. "And, the estimated carbon footprint reduction is 30 percent or nearly 12,000 pounds of carbon emissions being saved annually. That's equivalent of the amount of carbon dioxide released into the air annually by a standard car driven 12,000 miles."

Other principals of Colony Developers are James Tran and Jeff Leeper. In addition to Anaheim Public Utilities and the Anaheim Redevelopment Agency, other project partners included: architects Corcoran, Botich, and Associates, Newport Beach; green consultants Andrea Taber and Elaine Hsieh from Kema Services, Oakland; and licensed Build It Green rater Nathan Krantz from CTG Energetics, Irvine.

Earlier this year, Brookfield Homes' Colony Park became the first residential community in Southern California to receive a GreenPoint Rating from Build It Green. Both Colony Developers and Brookfield Homes were recently honored with Green Connection Leadership Awards at Anaheim City Council meetings.

SASKATCHEWAN LEADS THE CHARGE ON CARBON STORAGE

By Ucilia Wang



Canada is set to undertake a task that the United States has failed to accomplish so far: capture and store carbon dioxide from a working coal-fired power plant.

Saskatchewan Power Corp., the primary utility serving the Canadian province of Saskatchewan, said it is soliciting project proposals to demonstrate carbon-capture technology as part of a plan to retrofit one of the six power-generation units at a coal-fired plant.

The Boundary Dam Integrated Carbon Capture and Sequestration Demonstration Project seeks to harvest carbon-dioxide emissions and ship them to nearby oil fields for use in extracting oil from hard-to-reach reservoirs deep inside the Earth.

The project, if carried out as planned, would mark the first time carbon-capture technology is used at a working coal-fired power plant in North America. About half of the electricity generated in the United States comes from coal-fired power plants, according to the U.S. Energy Information Administration. Coal makes up much less of Canada's energy generation – 16.5 percent, according to the country's National Energy Board.

The news comes after a U.S. project to build a new 275-megawatt power plant equipped with carbon-capture and storage technology stumbled last December. After years of development on the project, the U.S. Department of Energy had said it had serious concerns about the project's growing cost, which was pegged at $1.5 billion. The DOE had been expected to cover over 74 percent of the cost.

The DOE has since restructured the FutureGen project and now plans to invest $1.3 billion to equip new coal-fired power plants with carbon capture-and-storage technology.

The project by Saskatchewan Power, also known as SaskPower, includes retrofitting the 100-megawatt power-generation unit, adding carbon-capture technology and building oil-field infrastructure. It is expected to cost a total of $1.4 billion, SaskPower said. The utility plans to shoulder $760 million of the cost while receiving $240 million from the Canadian government.

The utility plans to raise the remaining $400 million from oil businesses that would benefit from the project. SaskPower intends to generate revenues by selling the carbon dioxide to oil-field operators, but has yet to sign any carbon-dioxide sales contracts.

Max Ball, the project manager, said that the carbon-capture technology selected by the utility will reduce carbon-dioxide emissions at the power plant by 1 million tons per year.

SaskPower, which has already received regulatory approval to begin engineering the project, plans to select a winning carbon technology next year. Construction is scheduled to begin in 2011. The renovated power-generation unit is expected to begin operating in 2013 and become fully operational by 2015. SaskPower previously proposed building a $1.5 billion, 300-megawatt coal-fired plant equipped with carbon-capture technology. In 2006, the utility said it was planning to work with Babcock & Wilcox Canada and Air Liquide to develop the carbon-capture technology.

But the high cost and the fast-growing demand for electricity led the utility to settle on building a natural gas-fired plant instead, according to the National Energy Board.

The National Energy Board also said that environmental concerns, in particular greenhouse-gas emissions, are likely to limit the growth of coal-fired power plants in the country, leading to an estimated 10 gigawatts of power-generation capacity by 2030. The capacity in Saskatchewan is expected to decline to about 1.49 gigawatts, or 30.7 percent, of the total capacity.

USING NERC CIP AND IEC 61850 TO IMPLEMENT SUBSTATION NETWORKS

By Frank Madren

FERC and NERC timetables for cyber security compliance are forcing significant changes in utility networking and computing infrastructure in North America. Throughout the world, security planning and implementation are under increased scrutiny. In addition, IEC 61850 is gaining traction as an international standard for network communications in substations. In this environment, utilities can look at compliance as merely an intrusive requirement, forcing investment – or, alternatively, utilities can view the necessary enhancements to their infrastructure as an opportunity for much broader improvements and benefits.

Both the IEC 61850 standard and NERC CIP compliance requirements provide opportunities for significant changes in SCADA and data management infrastructure. Now is the time to reinvent substation networks and implement future-proof, easily extensible communications architectures.

The overhead of compliance can become an opportunity for modernization of network infrastructure.

The road is not totally smooth. Both the IEC 61850 and NERC CIP are evolving entities. In the heat of the moment, it is possible to move down a road that still leads to a dead end. Without planning, each step taken in deployment of a substation network infrastructure can become a technological or economic barrier to the next project.

Common mistakes when implementing new technologies and standards include having too narrow a technology focus, missing still-emergent product requirement, introducing too many vendors with no clear strategy for management and interoperability, and making tactical compromises on requirements such as product hardening.

The reinvention effort is best served by taking the time to develop a comprehensive architectural vision that builds upon an Ethernet technology core with multiple complementary technologies; a strategic requirements forecast that looks into the future to anticipate emerging feature requirements, and finally, an analysis of Total Cost of Ownership that drives decisions towards long asset life and low operational cost.

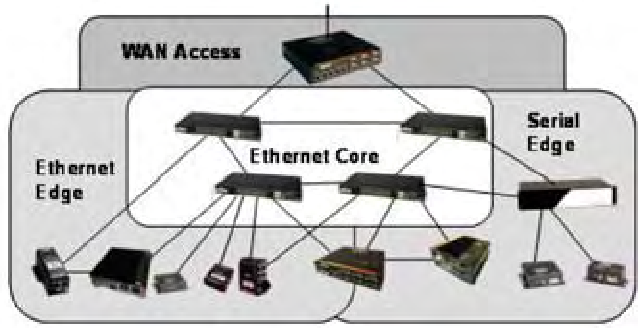


Fig. 1. Illustration of core/edge/access layers of an integrated network.

STRATEGIC ARCHITECTURE

The most fundamental requirement is to define a clear and comprehensive long-term architectural vision for the substation network. That vision should include an integrated network. Historically, substations have often implemented multiple different networks running separately within the same substation: SCADA networks were separate from metering, and different control systems used differing data protocols, forcing additional network separation.

Protection signaling was isolated from other communications largely because the extremely low latency and guaranteed performance requirements of protection events could not be assured in a shared network. Video surveillance, if implemented at all, was usually on a separate CCTV analog network.

A successful integrated network allows one core set of network devices, with fiber facilities and network support people to serve many different applications. When multiple projects share the network, an immediate benefit will be reduced cost for network equipment and facilities. The larger economic benefits come from reduced cost and delay in adding additional systems to the substation in the future, and also in reduced cost of ongoing operations including training and maintenance. Also, with a larger scaled network serving more applications, it is easier to justify added features in the network to increase reliability and security as additional benefits.

The key success factors for an integrated network design are: (1) Flexibility to adjust and grow the topology as requirements change, (2) Performance, especially Quality-of-Service techniques to enable effective prioritization among competing applications and to meet critical requirements of the most important protection and control systems, and (3) Reliability, for critical protection systems, and also because so many different systems are relying on the same infrastructure.

ETHERNET CORE

IEC 61850 and other initiatives identify Ethernet as the basic networking technology for substation network architectures. There are many factors encouraging rapid deployment of Ethernet as the core technology for substation networks. IP/Ethernet provides a broadly supported technology for system interconnection across many system suppliers. It leverages mass-market component volumes to create a cost-effective, high-performance network. Ethernet lends itself to fiber-based connectivity that is vital in electrically noisy industrial environments.

Ethernet also supports ring, star and mesh topologies that are highly resilient against network faults, thus improving operational reliability.

A complete view of the integrated substation network (as depicted in Fig. 1) uses high capacity Ethernet switches at the core of the network, and then surrounds this core with edge and access layers for Ethernet devices, serial devices and wide area network (WAN) connections.

ETHERNET EDGE

The Ethernet edge network extends fiber media effectively throughout a substation and connects Ethernet-based IEDs back to the core network. Many substations now have hierarchical edge networks using multi-port Ethernet collector switches. While the collector switches may be unmanaged devices today, increasingly the Ethernet edge will use compact managed switches that provide additional resiliency, access security and network event monitoring capabilities throughout a distributed substation network.

SERIAL EDGE

A similar transition is underway for connecting IEDs that have serial protocol interfaces. For full-time or occasional-use access to serial-based IED administrative ports and for many serial SCADA protocols (e.g., serial DNP-3), serial-to-TCP/IP protocol converters (device servers/terminal servers) are often combined with Ethernet ports to provide integration with the IP/Ethernet core infrastructure. As with the Ethernet edge, this device/terminal server function will increasingly be distributed using compact devices deployed throughout a large substation.

This more dynamic serial edge network will provide dual fiber connectivity and resilient networking features and extend security (e.g., SSH/SSL) to the connection point of remote serial IEDs. In some cases, multi-purpose industrial routers will provide both serial and Ethernet edge connectivity.

WANS

Finally, the substation must be connected to the outside world, usually to redundant control centers via Wide Area Networks (WANs). Many substations are still making the transition from per-application dedicated leased lines or dial-up connections to integrated WANs across all substation systems. New industrial routers are adding to the system choices. The demands placed on WAN access are rapidly changing. For example, to integrate SCADA with other applications, WAN access must be able to effectively prioritize application traffic differently, giving SCADA preferred treatment. As discussed below, WAN service options from carriers are continually evolving and access devices should be flexible enough to support multiple options.

REDUCED COMPLEXITY

Integrated networks typically using Internet Protocol (IP) can converge serial and Ethernet devices and operational and engineering applications into a single infrastructure. Figure 2 contrasts a single IP-centric substation wide area network with more historical, non-integrated networks.

The requirements for developing an integrated architecture will differ from one utility to another.

In some cases, all applications may run on a single IP-based infrastructure. In other cases, technologies such as Frame Relay permit IP services and legacy services to efficiently merge and share a common digital Wide Area Network (WAN). Integrated networks consolidate the electronic perimeter entry points of the substation while minimizing telecomm costs and facilitating additional application deployment.

STRATEGIC FEATURES FORECASTING

Planners can never see all possibilities nor can they afford to cover all contingencies, but it is important to investigate alternatives, and access technical organizations and suppliers about their awareness of industry trends and their current and planned accommodation of foreseeable future requirements. One clear area of concern globally is cyber security. In North American substation data network infrastructures, the emphasis is on CIP-005 Electronic Perimeter Security and CIP-007 Systems Security. Most strategic planners are already projecting additional requirements that will emerge. Both NERC CIP and IEC 61850 can be expected to continue evolving for the foreseeable future.

CIP-005 mandates that an Electronic Security Perimeter (ESP) must be established at control centers, critical substations and any other locations having Critical Cyber Assets (CCAs). The utility must identify all CCAs within a physical location and then define an electronic perimeter such that all connections to this collection of devices and software systems are secured. All network connections across this defined perimeter must have, at a minimum, a 'firewall' that permits only authorized connections and traffic to enter the secured zone. In addition, all physical and software-defined ports to all devices and applications within the electronic perimeter must also be identified and secured, and all unused ports must be disabled (see Figure 3).

Systems Security (CIP-007) requires network elements themselves (as "systems") to have user access controls with strong passwords and differentiated user profiles, as well as extensive logging of security, management and network events and activities linked to centralized archival, auditing and compliance management systems.

There are also changes in carrier WAN service offerings. As an example, Frame Relay remains an effective service technology for connecting distributed substations to control centers, supporting resilient connectivity and providing rigorous traffic prioritization. However, virtual private networks using Multi-Protocol Label Switching (MPLS), are being positioned by major carriers as strategic replacements for Frame Relay, as well as for dedicated leased analog or digital circuits.

PHYSICAL SECURITY

As a component of a strategic features forecast, planners need to look at the ease with which a physical security component can be added to a network with Ethernet at the core. Video surveillance, with the inclusion of motion-sensing software intelligence, acts as a complement to other sophisticated measures to provide access control and intrusion detection. It also provides another operational view of the status of equipment and of weather conditions. IP-enabled video cameras can now share the Ethernet infrastructure with other applications so long as bandwidth is sufficient and Quality of Service is effectively implemented. IEEE 802.1af standard Power over Ethernet (PoE) provides a standard for implementing the distribution of electrical power directly over a 10/100TX electrical Ethernet connection from an Ethernet switch to an end device. PoE simplifies the deployment of video cameras by eliminating the need for a separate electrical power feed to the camera, and may also be used for applications such as powering VOIP telephone handsets or access control readers. In addition, new IP-based security products are coming on the market each day.

TOTAL COST OF OWNERSHIP

The keys to optimizing Total Cost of Ownership (TCO) are to build for a long-lived installation, and to factor in both immediate equipment costs and longer-term costs of maintenance, replacement and ongoing systems integration.

A basic consideration for substation project longevity is network product hardening. IEC 61850-3 and IEEE 1613 standards define equipment requirements that increase product reliability in harsh substation environments. Meeting these standards involves higher product immunity on both power input and I/O interfaces to surges, fast transients and other electromagnetic events common in substations, as well as supporting extended high and low temperature ranges (-40 to +85° C). Substation standards are considerably more stringent than common industrial-rated products. Also, while some products can tolerate short-term exposure to harsh environmental factors such as high temperatures, sustained high temperatures above product ratings significantly diminish long-term product failure rates (MTBF). Planners should look at both third party "type test' results and more extensive product long-term components ratings before depending upon products in substation settings.

The number of different vendors introduced into a substation network environment significantly impacts maintenance costs, training costs, and vendor administration costs. Having too many vendors sacrifices "economies of scale" in all aspects of vendor interaction. Perhaps most importantly, with multiple vendors, there is no focused responsibility for interoperability and systems level integration. Suppliers who can provide all or most of the design elements needed both now and to complete the long term network vision add value far above the sum of their product parts.

SUMMARY

Deployment of new standards, such as IEC 61850 and new U.S. federal requirements such as NERC CIP, offers a unique opportunity to review substation communications architecture and define and implement a more streamlined, easier to use, more cost-effective networking strategy.

Ethernet switching is at the core of any strategic architecture designed to meet today's requirements and positioned for future growth. The technologies contributing to the creation of a dynamic edge of services around this core will accommodate a multitude devices and applications with specialized needs.

With the technology now available to integrate the various communications requirements within a substation into a single high-reliability extensible secure infrastructure, substation designers can take advantage of the many economic benefits, as well as the practical advantage of making it easier to add automation projects over time.

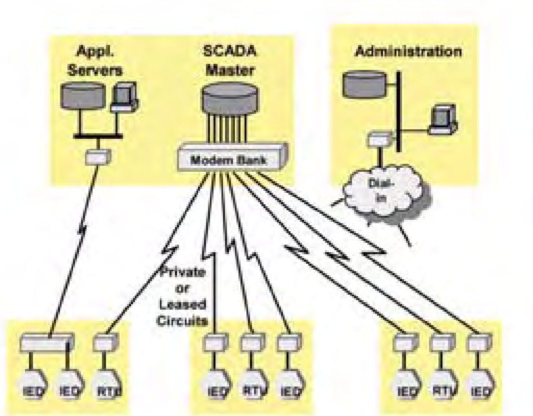


Figure 2: Multiple circuits vs. Integrated Substation Wide Area Network

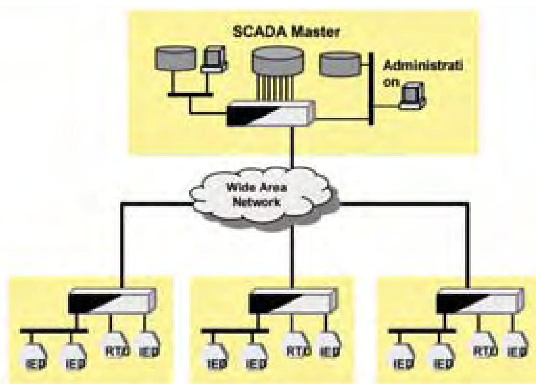


Figure 3: Electronic Security Perimeter vs. Physical Security

IGT REPAIR SOLUTIONS TO ENHANCE POWER PLANT PROFITABILITY

By Kevin Davis, President of Frarendi, Inc.

THE CHALLENGE

Between 1995 and 2001, more than 200 gigawatts, of mostly F-class gas turbine combined cycle power production, was initiated in the United States alone. This phenomena was driven primarily by independent power producers (IPPs) and their merchant market strategy for selling power.

This historic "bubble" of capacity was followed by a "bust" period between 2001 and 2005, where little or no new power was created and the surplus was absorbed into the marketplace. In many parts of the U.S., excess capacity drove down market prices for electricity, financially impacting many IPPs. At the same time, the price of natural gas tripled, resulting in significantly higher electricity prices. Power companies passed-through these higher fuel costs to retail consumers, leading to a public and governmental outcry for a return to strict price regulation.

Due to this new norm in natural gas prices, electrical power producers are heavily scrutinizing every aspect of their plant operation expenses. Some of the greatest potential for cost efficiencies is being found in the operational lifecycle of F-class gas turbines. This renewed and reinvigorated look at controlling operations and maintenance costs has prompted innovative market solutions. In fact, several new F-class hot gas path turbine parts suppliers and improved repair technologies for these components have been introduced to the industry in recent years.

The first stage nozzle is proving to be an integral factor in controlling the costs associated with refurbishing and repairing F-class hot gas path parts during routine maintenance. Qualified repair companies and power plant owners regularly must assess the cost-benefit scenario of scrapping or repairing these critical parts. The repair method used for first stage nozzle trailing edges is particularly important because of material erosion caused by thermal fatigue, oxidation and foreign object damage.

Figures 1 and 2. Foreign Object Damage to a First Stage Nozzle Segment - A perfect candidate for a trailing edge replacement coupon.

Procuring entire new replacement nozzle segments is not usually a viable option due to the high cost of these cobalt, nickel-based investment castings and because of demanding, quick cycle maintenance schedules. To address these challenges, some non-OEM suppliers have developed proprietary processes to design and manufacture first stage nozzle trailing edge "coupons" for use by qualified repair shops. The coupons exactly match the geometric dimensions and metallurgical properties of the existing part and include pre-machined cooling air holes so they can be simply assembled into the existing nozzle segment. This innovative technology introduces a new viable solution to service facilities and plant operators who are weighing the pros and cons of repair or replacement. These coupons are currently being used by the repair industry and have been field-validated on practically the entire B&E class of General Electric gas turbines.

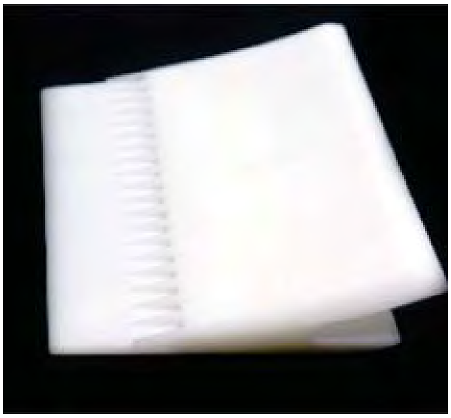
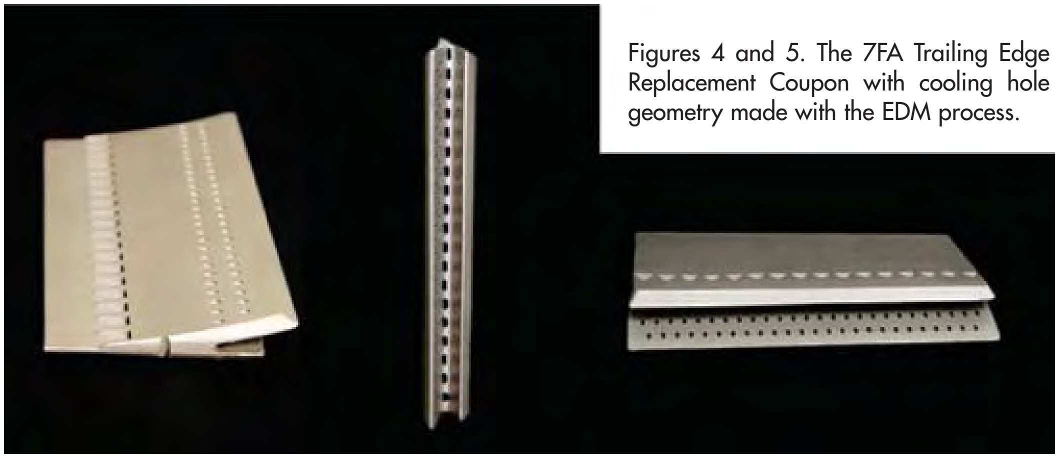


Figure 3. SLS of 7FA First Stage Nozzle Trailing Edge Replacement Coupon

This "set it and forget it" coupon provides a fast, robust and cost-effective repair option. It also significantly increases the lifespan of the original component compared to a typical hand weld repair (if a simple weld repair can even be performed). Today, first stage nozzle trailing edge coupons for GE's 7FA+e gas turbine are in demand and are ready to be implemented in service shops.

This article outlines the market need for this new type of repair technology, its inherent advantages over the typical refurbishment methods, and an overview of the basic design and development process of manufacturing a trailing edge replacement coupon.



Figures 4 and 5. The 7FA Trailing Edge Replacement Coupon with cooling hole geometry made with the EDM process.

THE OPPORTUNITY

Hot gas path components of large, industrial gas turbines used for power generation are typically designed to operate between 24,000 to 36,000 hours (3 to 5 years) before they require refurbishment. During the initial repair cycle, it is not uncommon to observe some cracking in the trailing edges of the first stage nozzle. In cases like this, a low-tech weld repair process would be acceptable. However, welding is a manual process and the fillers used are not as metallurgically sound as the base metal. Therefore, welding these cracks is not a long-term repair solution; it is more of a band-aid or stop-gap approach.

During the second repair cycle, extensive cracking and burning-away of the trailing edge base metal is common. This is called oxidation. At this point, the part requires a more holistic repair approach. Foreign object damage (FOD), such as failing combustion system components that are liberated downstream, can cause even more extensive distress or oxidation. A typical example of a first stage nozzle trailing edge with FOD is shown in figures 1 and 2. A decade ago, this part would have landed on a scrap heap. However, in today's economy and with the exorbitant cost of replacement parts, this is a perfect candidate for a trailing edge coupon repair.

THE PROCESS

First stage nozzle trailing edge replacement coupons are strategically designed and manufactured to be an exact dimensional and metallurgical match to OEM first stage nozzles. Using a new or refurbished OEM part, the surfaces of the nozzle rails, platforms and airfoils are laser or optically scanned and the data is imported into an industry standard CAD/CAM software package. Because nozzle airfoils are hollow to allow air to cool the part during operation, Computer Tomography (CT) scans, X-rays or cut-ups of the original part are used to determine the wall thickness and internal geometry features. Surface features, such as cooling air exit holes, are also measured. With this information, Stereolithography (SLA) or Selective Laser Sintering (SLS) is used to generate the prototype (Figure 3) to serve as a visual tool and as a way to initiate casting.

The casting process is as important as the coupon's design. Therefore, factors that could affect the coupon's dimensional and quality requirements are addressed before casting begins. These issues include tooling design, gating methods, shrink factor, microporosity and grain size limits and surface imperfections.

The coupon is then cast in metal, using an industry standard nickel, cobalt-based superalloy called FR FSX-414. Coupons are cast with similar-sized material grain structure, the same as the base nozzle material.

THE VALUE

At this point, the coupon is ready to be machined. It is this stage of the manufacturing process that sets coupon suppliers apart and provides the service shop and power plant operator with the prospect of a high value, predictable repair method. As shown in Figure 3, the first stage nozzle is hollow and allows internally delivered cooling air through a series of holes or slots that cover the outside of the airfoil during operation. This air provides a boundary layer on the nozzle surface which prevents the nozzle material from melting under the extreme heat of the combustor-supplied gas, which can reach temperatures up to 3,000 degrees Fahrenheit.

Additionally, some first stage nozzle designs also use thermal barrier coating (TBC), a yttria stabilized zirconia material, to further insulate the nozzle material from hot gas. Surface cooling is achieved through a system of intricate trailing edge slots and rows of shaped cooling holes on both the pressure and suction sides of the nozzle airfoil as shown in Figures 4 and 5.

The coupon becomes a valuable and robust process to service shops when the intricate cooling hole geometry is already machined into the coupon itself. The holes are made using an Electro-Discharge Machining (EDM) process that creates a highly accurate shaped hole geometry. EDM, in its simplest form, is machining using an electrical spark. A controlled electrical spark is used to erode away material that can conduct electricity. A series of controlled electrical discharges takes place between the two conductors separated from each other by a film of non-conducting liquid, called a dielectric or deionized water. When the electrode is plunged into the base metal, a hole is created. It is a highly specialized process which requires competencies in EDM tooling and equipment design, as well as electrode plunging methodologies.

With the coupon ready to be installed, the damaged nozzle segment is prepped for repair. Figure 6 shows a trailing edge replacement coupon being readied for welding on a GE Frame 6 nozzle.

When coupons are manufactured with precision EDM cooling hole geometry, the repair process is significantly simplified and much more effective. Previous techniques have been tried where the coupon is welded in place first, and the cooling features are added later. This approach can often result in scrapping the entire coupon due to the mis-matching of the cooling holes. With the stringent quality requirements demanded by GE F-class gas turbine operators, especially cooling flow specifications, a “best effort” repair process is unacceptable.

Figure 6. Trailing Edge Coupon shown ready to be welded into place. Note the small trailing edge cooling holes and the extent of damage to a nozzle segment that can be repaired.

THE SOLUTION

Some coupon manufacturers sell first stage trailing edge coupons in both partial and complete sets, depending on the requirements of the service shop and the level of repair needed for GE Frame 3, 5, 6B, 7E and 9E gas turbines. The GE Frame 7FA+e coupon is currently available to qualified service shops and can be delivered in as little as four weeks. As firing temperatures of gas turbines continue to increase, coupon manufacturers will likely introduce coupons for second stage nozzles as well.

As demand for power increases, so will the number of gas turbines. Thus, power plant owners will rely more heavily on replacement coupon technology to control operational costs associated with repairing their growing legion of turbines. Not only will repaired parts last longer with coupons than the typical weld repair due to more consistent metallurgical properties, the investment casting coupons offer more precise dimensional control and the value-add of pre-machined EDM cooling holes.

Like any product, not all are equal. Manufacturing reliable first stage nozzle trailing edge replacement coupons requires extensive knowledge of the power generation industry, experience casting high-quality superalloys and expertise in EDM drilling for the demanding specifications of the aerospace and industrial gas turbine markets. Only coupon manufacturers that can honestly make these claims will offer the industry a viable alternative to traditional welds in first stage nozzle refurbishments.

Kevin Davis is the president of Frarendi, Inc. and plays a key role in establishing and overseeing the business and financial strategy for the company. He is a business innovator with more than 32 years of experience managing and growing successful manufacturing and technology companies across the United States.

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THE SMART ALTERNATIVE: SECURING AND STRENGTHENING OUR NATION'S VULNERABLE ELECTRIC GRID

By Kenneth R. Nahigian

With an increasing focus on developing and utilizing alternative energy sources to ensure a secure and reliable energy supply, the need is becoming abundantly clear for a modernized energy infrastructure capable of facilitating such innovation and enhancing America's resilience. The essence of resilience is the ability to identify, prepare for, respond rapidly to, and recover from any possible catastrophic event. The practical adoption and implementation of a next-generation electrical- power grid – Smart Grid – will reduce the consequences of the electrical grid being targeted by terrorists or adversely affected by a natural disaster while improving energy efficiency and reliability.

EXECUTIVE SUMMARY

The U.S. electrical power grid – installed more than a half century ago – has successfully provided energy to our homes and businesses for many decades and is a critical component of our national defense and infrastructure. It affects nearly every aspect of our daily lives. But the grid quickly is reaching the end of its design cycl, and in its current state, soon will no longer serve the rising energy demand of consumers or national resilience. Simply put, the evidence is clear that modernization of the existing grid – currently comprised of a patchwork of energy-inefficient fixes mending an overburdened system – not only is inevitable, but vital to national security and the ability to recover quickly in the event of a catastrophe.

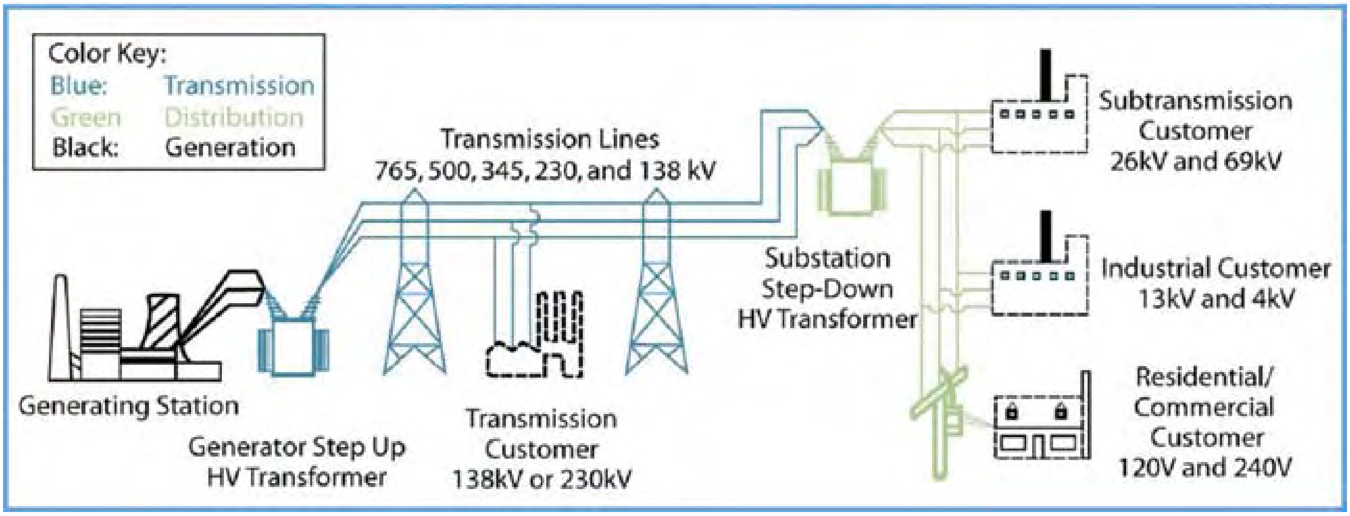
Hampered by rising demand, a lack of investment in transmission facilities, and federal policies that deter increasing domestic energy supply, the existing grid has been taxed to the limit and lacks the capacity to meet the Nation's growing energy demand.

The existing grid does not possess the capability to mitigate the occurrences of blackouts and their adverse consequences, provide incentives to consumers to reduce consumption, or improve environmental impacts through the utilization of more renewable resources.

These inadequacies place in peril national, economic, and environmental security and are unsuited to meet the long-term demands of the digital age. The task of hardening our critical infrastructures – including our military installations – against a catastrophic event must begin with efforts to bring resilience and security to the electrical grid which connects them all.

The next generation of electrical grid – widely known as "Smart Grid" – is an integration of advanced, two-way communications systems and sensors into the electrical transmission and distribution network enabling utilities to optimize grid performance in real-time, provide incentives to consumers for reducing energy consumption through demand response, and integrate renewable energy resources into grid operations. This smart system allows utilities to understand demand and regulate supply, and most importantly for the purposes of resilience, either reallocate electricity during times of crisis or peak demand or prevent outages through proactive diagnosis of the grid and its individual elements.

The Smart Grid offers the next generation of power delivery and furthers the ability of the grid to continue to provide power in the immediate wake of a catastrophic event. But the Smart Grid's benefits span far beyond resilience, as a modernized grid would have a dramatic positive impact on the environment by lowering consumption and increasing the utilization of renewable energy sources, and provide incentives and control for consumers and businesses to make decisions regarding their individual energy consumption.



Electricity Generation and Delivery Process

We must move quickly to secure a critical infrastructure and ensure that it can support vital emergency response, military, economic, and social activities during a crisis. Congress has recognized that the vulnerabilities of the current electrical grid threaten our national resilience and, therefore, necessitate change. Congress has only begun to explore, in the last two major energy bills, the potential of the next generation of power delivery through the modernization of the U.S. electric grid. But complex jurisdictional hurdles and a litany of regulatory and private-stakeholder interests still create challenges for realizing the full deployment of the Smart Grid.

Increasing the resilience of the electrical grid will require the data, technological intelligence and capacity to manage electrical congestion, avoid overburdening the system, and avert electrical outages even as the population requires greater quantities of quality electricity.

Keeping the power on is the first step to hardening the Nation's energy-dependent critical infrastructure. The electrical grid must be able to successfully manage a disaster and rapidly return to a state of near normalcy in order to maintain the integrity of all dependent infrastructures.

BACKGROUND

The U.S. electrical transmission and distribution system – installed many decades ago – provides electricity to every aspect of American society. This system is the largest machine in the world responsible for delivering energy from massive generation sources that derive power from coal, nuclear fission, oil, natural gas, hydro, geothermal, solar, and wind sources. Electric power originates at these generation stations, travels along massive high-voltage power lines to sub-generation transmission stations, and is ultimately distributed to the energy consumer – or end-user. The electrical grid has served its purpose well, but it quickly is reaching the end of its design cycle as it is an inefficient push system that offers little incentive to either the utility provider or consumer to monitor and conserve energy consumption.

The electrical power system in the United States entails over 16,924 electric generating units with more than 1,075 Gigawatts of generating capacity involving more than 300,000 miles of transmission lines and 500,000 miles of distribution lines. But the deficiencies of this current electrical grid are inherent in its design. Electrical energy is ordinarily consumed immediately subsequent to its generation as it historically has been difficult and inefficient to store for prolonged periods. Having an unequal supply and demand of generated energy creates the potential of overburdening and causing extensive damage to the system. To counter-act this deficiency, the electrical grid is designed to disconnect at first sign of an electrical imbalance. When the generator disconnects, it results in an electrical outage – or blackout.

Despite being designed to mitigate damage caused to the system and its users, electric delivery interruptions and the ensuing periods before power restoration threaten our national security as our defense capabilities are disabled, our economy is weakened, and the lives of those who depend on energy for basic needs – including heating and cooling, as well as emergency services – are placed in peril.

The electrical grid as we know it was installed at a time when the current massive consumer demand could not have been foreseen. The dramatic increase in the number of new and larger homes, rising urbanization, and the widespread adoption of digital technology and other energy-thirsty devices has overloaded our electrical delivery system and driven up costs as utilities search for new sources of energy to meet demand.

The electric grid is further burdened by public policies inhibiting the increase in domestic energy production.

The most significant corollary to our increased dependence on the electrical grid is the increased consequences of power fluctuations. Power fluctuations, which were once merely an inconvenience, now are a major grid vulnerability that threatens nationals security and costs tens of billions of dollars in lost commerce each year. Should the electrical grid become a deliberate target of a terrorist attack, a casualty of a natural disaster, or simply malfunction, an overloading of the system would create a ripple effect that could bring the economy to a standstill, jeopardize national security and possibly cost lives.

Blackouts and power quality issues are not the only reason for concern. The inefficiencies of the energy sector also burden the economy. Of all energy consumed to produce electricity, only 30 percent reaches consumers in the form of electricity, transmission and distribution losses are valued at more than $25 billion a year.

Adding more generators only increases these inefficiencies. Further exacerbating the problem is the physical limitations of the current grid. The aged grid has become so problematic in its limitations that it is incapable of employing new and renewable energy generation sources (e.g., solar, wind, hydro) at a capacity that justifies building new generation plants powered by such clean domestic energy. In some areas, the energy produced outweighs the transmission capacity by 65 percent. There is a vast need to increase not only the efficiency, consistency, and capacity of the electric infrastructure, but also its security.

Unfortunately, there exists little economic incentive for utility companies to address inefficiencies of the current grid.

Intuitively, making the electrical grid more efficient would mean delivering the same amount of usable electricity to the consumer but requiring less costly initial energy input to do so; that equates to selling the same output at a lower price. Left without incentive, utilities to date have preferred to retain the same inefficient generation, transmission, and distribution system to maintain profit margins.

The increase in demand for electricity and other sources of power is vastly outpacing the increase in power supply. The challenges and opportunities of the new century dictate that we not rely on an outmoded electrical grid system that is nearing the end of its design cycle. Growing the grid in the usual incremental manner through a patchwork of improvements provides only temporary relief to the burdens facing the grid and merely aggravates its vulnerabilities. For these reasons and more, the current electrical grid cannot continue to serve our national strategic objectives, the demands of consumers, or the need to improve our environment and mitigate global climate change. It is static in its design, inefficient, and limiting to a nation that seeks to expand its use of renewable energy resources. The existing grid is a liability to national security and resilience.

MODERNIZATION - THE SMART GRID

As the modernization of the domestic electrical grid is paramount to the resilience of the Nation, the centerpiece of this effort should be the deployment and utilization of a “futureproof” electrical system upgraded with advanced communications, sensors and diagnostic software commonly referred to as the “Smart Grid”.

What is the Smart Grid?

The Smart Grid, in essence, is an amalgam of communications and electrical capabilities that allow utilities to understand, optimize, and regulate demand, supply, costs, and reliability. This advanced technology allows electricity providers to interact with the power delivery system and determine where electricity is being used and from where it can be drawn during times of crisis or peak demand. The monitoring capability of the Smart Grid serves to improve grid resilience by empowering the utilities to re-route electricity to areas that have lost or are on the precipice of losing power. More importantly, the real-time diagnostic capability of a Smart Grid enables utilities to predict and prevent outages and power disturbances before they occur.

The communications overlay of the electrical system that comprises the Smart Grid can be described more technically as a “standard web services interface for new and existing utility applications, the ability to use any IP wide-area network for the data communications backhaul, and an open meter interface for connecting to in-home devices such as thermostats, water and gas meters, or any energy aware home area network”.

The Electric Power Research Institute (EPRI) envisions the Smart Grid as a power system that can incorporate millions of sensors all connected through an advanced communication and data acquisition system.

A system that will provide real-time analysis by a distributed computing system that enables predictive rather than reactive responses to blink-of-the-eye disruptions and is designed to support a changing generation mix in a carbon constrained world. It would allow for a more effective and efficient participation by consumers in managing their use of electricity.

Current Grid Deficiencies

In order to fully understand the benefits of this advanced Smart-Grid capability, it is constructive to comparatively analyze the existing electrical grid. Unlike the Smart Grid, the functional deficiencies of the current electrical grid include, but are not limited to, the following:

- It is an inefficient push system that requires utilities to flood the system with electricity – much more than is needed – to ensure reliability and meet demand.
- It is based on a consumption- and revenue-based business model that offers no incentive for utilities to conserve energy.
- It is woefully inadequate as its “static” design does not allow utilities to adequately monitor data pertaining to electricity consumption or outages, and thus respond and recover in the wake of a catastrophic event.
- It places in peril the ability of military and homeland security forces to fulfill their missions to defend.
- It veils the true costs of electricity until month’s end and, in turn, has a limited ability to provide end-users with the control to understand and regulate their individual electricity consumption.
- It requires maintenance costs from remote and automated disconnects/ reconnects and trips to the field.
- It causes a lapse of a significantly higher number of minutes without power incurred by end-users during outages during the restoration process.
- It lacks the communications overlay that would enable the expansion of existing cyber-security capabilities.

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Smart Alternative

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• It has a more significant carbon footprint due to higher peak demands, higher supply and consumption, a lack of incentive to conserve, and inability to utilize fully the potential of renewable and alternative sources of energy.

Each of these deficiencies cut adversely against the Nation's resilience in that the current grid lacks the ability to sufficiently protect itself and related critical infrastructure, reduce dependence on foreign sources of energy, conserve energy, capitalize on alternative sources of energy, improve the environment, and lower enduser costs. Thus, modernization that would improve efficiency and reliability would have a stabilizing effect on the economy, national security, and the energy-dependent critical infrastructure.

Smart Grid Benefits

By contrast to the deficiencies of the existing grid system, the Smart Grid is a dynamic and more resilient electrical and communications delivery system that utilizes energy that the existing system wastes through inefficiencies. The Smart Grid creates incentives for conservation, fortifies the reliability of homeland and military security forces, improves the carbon footprint of the grid, reduces systemic maintenance, prevents outages and mitigates restoration in the wake of those outages that do occur, and improves reliability of supply.

RESILIENCE AND NATIONAL SECURITY

The electrical transmission and distribution system is vital to national security and global economy. Improvements to the electrical grid have successive benefits to the national security, as an effort to exploit the vulnerabilities of this electrical grid would have a catastrophic impact.

Economic turmoil would lie in the wake of cascading blackouts, and total power loss would render critical infrastructure and essential services nearly useless. The energy resilience of the Smart Grid means that hospitals, first responders, fire stations, police departments, and homeland security and military forces always possess the requisite power to fulfill their missions of protecting and caring for citizens.

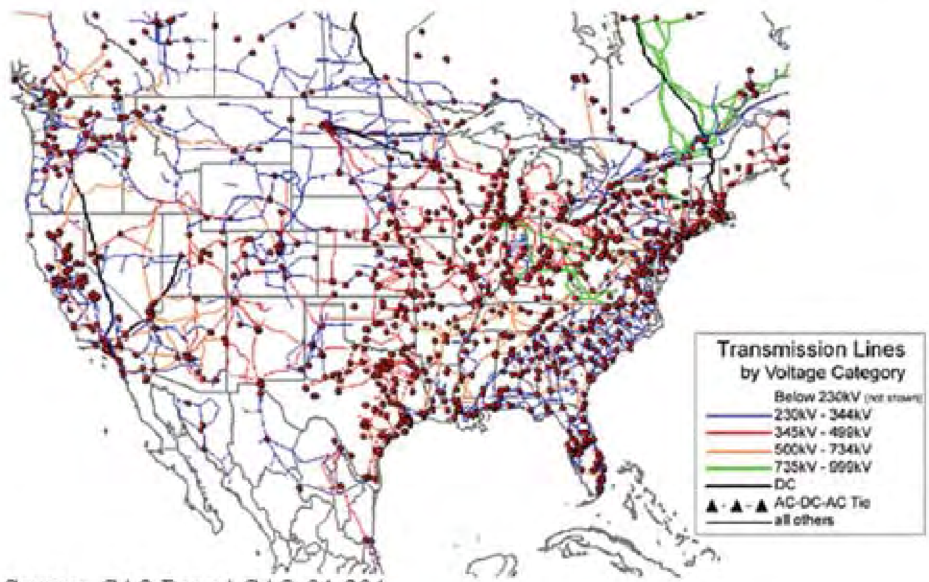
Businesses would also be able to continue operations in the event of a crisis, moderating the adverse consequences of a catastrophic event on the economy.

Notable anecdotal evidence of the fragility and vulnerability of the U.S. electrical grid system can be found with the power outage five years ago in the Northeastern United States and parts of Canada. On August 14, 2003, a combination of high heat and demand caused a sagging high-voltage power line near Cleveland, Ohio to come in contact with trees that had not been trimmed by the local utility. The U.S.-Canada Power System Outage Task Force later concluded that this contact caused the first of a series of cascading power failures resulting in a loss of electrical power to approximately 50 million people located in a 9,300-squaremile area throughout the region. A simple contact of a high-voltage power line caused more than 265 power plants and 500 generating units to shut down, including 22 nuclear plants. Full power was not restored from these sources for a period of nearly two weeks.

The consequences of the summer of 2003 power failure were significant, as delivery systems for oil and water were shut down, rail and air travel was disrupted, homeland security and communications capabilities were unavailable, and lives were placed in peril as residential homes and businesses were without air conditioning.

And, of course, the negative impact on productivity caused a drag on the economy.

While some may argue that the grid functioned as designed in 2003 in that it sensed a problem and disconnected to avoid greater damage, most would agree that this incident served as a warning we must move to modernize its methods of energy delivery and make the system more resilient. This outage was mild in that it did not cause damage to transmission or distribution infrastructure, which allowed for the system to be restored in a fairly short period of time. However, a natural disaster, or a physical or cyber attack certainly would cause more damage and result in prolonged outages.



Source: GAO Report GAO-04-204

The employment of Smart Grid technologies would minimize the consequences of an attack or catastrophic event by providing energy providers with an enhanced ability to identify the location of the failure and quickly re-route electricity to locations where demand is most critical.

This advanced capability would serve to shorten power restoration times, which is the essence of resilience. By mitigating the consequences of an attack affecting the electrical grid, the Smart Grid would serve as a deterrent for such attacks, thereby strengthening and insulating our energy dependent critical infrastructure.

The U.S. Department of Defense (DOD) is the single largest user of energy in the United States – consuming more than 3.8 billion kilowatt-hours (kWh) of electricity each year. That total represents nearly one percent of the total electricity consumption of the Nation, and 75 percent of the Federal Government's consumption. The DOD's principal concerns are not the availability of energy to ensure the reliability of its missions, but rather the fragility of the existing electrical grid and its susceptibility to extended outages. The DOD's national strategic and command authorities rely on 99 percent of their energy supply from "outside the fence".

In its February 2008 report, the Defense Science Board Task Force Report found that "critical national security and Homeland defense missions are at an unacceptably high risk of extended outage from failure of the grid." The report indicates that the grid is not designed to withstand a coordinated multi-pronged attack, and insurgents in Iraq and Afghanistan commonly and effectively have coordinated attacks on the power grid as part of their tactics.

The deployment of Smart-Grid technologies would provide the necessary reliability to DOD to fulfill its critical missions, as well as reduce the agency's energy consumption and costs.

An important subcomponent of national security that can be addressed by a commitment to the implementation of the Smart Grid is cyber security. Committing to the Smart Grid enables the architecture of the grid to be designed with security in mind. The extensive amount of data that can be utilized by the Smart Grid in real time means that a comprehensive cyber security program can be integrated from its inception. The Smart Grid provides an enhanced bandwidth and computing power to enable more sophisticated grid protection software and encryption to thwart attacks on power infrastructure. In this manner the Smart Grid offers greater security for a critical infrastructure as it ensures that power is readily available while anticipating and avoiding threats to the integrity of the system.

CONSUMER EMPOWERMENT

The Smart Grid provides enormous benefit to the energy consumer, besides those of national, economic, and environmental security. Some experts estimate that the existing inefficient electrical grid system costs consumers hundreds of billions of dollars per year in hidden costs and waste. In a global economy that provides consumers with endless product choices and prices, they are left guessing what type of energy they consume, and how much it costs when they consume it. The Smart Grid, in essence, grants consumers control of their personal energy footprints, allowing them to choose not only when they consume power, but what source of power they wish to consume. This is achieved through the demand response capabilities of the Smart Grid. Demand response ensures that supply and demand is balanced. Demand response allows consumers to place megawatts back on the grid at times of peak demand, and reduces the need for more generation plants, thereby reducing costs to consumers and eliminating waste.

During peak hours of the day, for example, a consumer will be able to see that the price of running a dishwasher or setting a thermostat at a certain temperature may be high during a period of peak demand and, therefore, may choose to use power during non-peak hours. Such a scenario improves the stability of the grid and reduces waste.

When fully implemented, the Smart Grid will provide consumers with the ability to sell power from a plug-in vehicle, solar panels, or any type of stored energy back into the grid for general consumption, and choose what type of energy or mixture thereof they desire to purchase from the grid. The real time, two-way capacity of a Smart Grid offers consumers more flexibility and the freedom to tailor demand response options to their own needs – instead of turning air conditioners completely off multiple times a day, smart appliances can be turned down and managed through a ready "gateway" system that maximizes consumer control.

With the Smart Grid, consumers are able to "program demand-response meters from their homes to grant permission" to utilities to adjust their power depending on systemic need. This empowers utilities to readjust and reroute supply depending on demand, and raise the temperature slightly in your house, or alter the way your appliances are performing to suit the interest of the supply source. While consumers would not have to submit their systems to this, they would have the option if they desire.

All of these consumer benefits,

when taken as a whole, will yield the most important function of a consumer-friendly electrical grid system, which is a dramatically more reliable power delivery system susceptible to fewer power fluctuations and blackouts. As discussed throughout this paper, the occurrence and length of blackouts are threats to a nation and to consumers who depend on reliable electricity for their everyday lives and wellbeing.

When demand overwhelms capacity due to a catastrophic event or simple overload, the system can be smart enough to alter its behavior and adjust accordingly. This is resilience. And consumers willing to alter their behavior can be rewarded through incentives.

IMPACT ON INDUSTRY

As U.S. industry in the digital age becomes more dependent on high-quality energy delivery, economic security becomes more dependent on reliable energy. For this reason, we must promote energy continuity and reliability.

The full deployment of Smart-Grid technologies will mitigate dramatically the billions of dollars lost by businesses each year as a result of power fluctuations, congestions, and failures of the current electrical grid. Increasing energy efficiency and reliability will be crucial to improving the competitiveness of American businesses in a global economy.

The capacity optimization offered by the Smart Grid will improve energy delivery reliability, lower business costs, and reduce waste.

While residential consumers suffer what typically amount to minor inconveniences resulting from power blackouts, the impact of power inconsistency on industry can be devastating. One 2005 power outage in southern California disrupted an estimated $75 billion dollars in economic activity.

Businesses necessitate not only electrical resilience, but electrical continuity of the sort the current grid cannot provide.

Massive power outages are occurring at an unprecedented frequency and industry is an unfortunate casualty. The Smart Grid's ability to optimize system reliability and resume electrical normalcy in short order, or avoid a disruption entirely, will provide the energy security that industry requires to sustain an energy dependent economy.

As with residential consumers of electricity, businesses will reap similar benefits from Smart-Grid demand response capabilities. But, by consumer and corporate empowerment, as well as its environmental impact, the Smart Grid is creating new markets as private industry develops energy efficient and intelligent appliances, smart meters, new communications capabilities, and passenger vehicles. The Department of Energy predicts that Smart Grid deployment will open a $100 billion market in smart technologies. These new market technologies will lower consumer and corporate electricity costs, and have a dramatic impact on the environment through efficiency and resourceutilization gains. The same study suggests that implementation of the Smart Grid should create $2 trillion per year additional GDP. Thus, industry is not only made more competitive and secure by the adoption of the Smart Grid, but it is afforded new market opportunities.

ENVIRONMENTAL BENEFITS

The environmental impact of Smart Grid deployment is multi-faceted, but often difficult to quantify – this despite studies projecting a 5:1 return on investment. But for the most part, the returns from Smart Grid technologies in the form of positive environmental benefits are often intangible and realized by a dispersed set of beneficiaries. Justification for Smart Grid adoption suffers from an inability of its advocates to make "rate-of-return" arguments on its behalf. But its environmental benefits cannot be denied.

According to the Modern Grid Initiative, every kilowatt-hour saved by the efficiencies of the Smart Grid will result in reduced expenditures on pollution controls at power plants. One study by the Electric Power Research Institute suggests that implementation of the Smart Grid could reduce CO_2 emissions by as much as 25 percent by the year 2020 through improved electrical efficiency. As some experts argue, the cleanest form of energy is the energy that is saved.

A stable environment is critical to the resilience of any nation. By improving the efficiency of energy delivery systems and diversifying fuel sources – primarily to cleaner fuels and technologies – we will improve the environment and enhance energy sustainability, thereby mitigating the adverse consequences caused by a changing climate. The Smart Grid can be a critical component in improving both climate and national resilience.

The Smart Grid's system optimization and demand response capabilities, as well as its conservation incentives serve to reduce energy consumption, thereby lowering the CO_2 emissions caused by the generation of energy. Because of its ability to manage energy variability, particularly with wind power, the Smart Grid enables and encourages the development of alternative fuel sources and their integration on the grid.

This added market for alternative and renewable energy suppliers also will serve to lower carbon emissions by replacing a percentage of the fossil fuels currently utilized. And, by improving the utilization of the exiting grid assets through smarter energy management, the Smart Grid also reduces the need for new generating units built to meet increasingly higher peak demand.

The consumer benefits of Smart Grid appliances and vehicles also contribute significantly to the improvement of the environment. "Smart" appliances, including plug-in hybrid vehicles and energy efficient heating and cooling, have the added benefit of again lessening CO_2 emissions and having a less detrimental impact on the global environment. These new technologies will communicate with the grid and be capable of powering down when sensing a stress on the system. This will reduce the occurrences of adverse grid events and conserve energy.

IMPEDIMENTS TO DEVELOPMENT

Despite its projected overwhelming return on investment, the deployment of the Smart Grid indubitably will not be realized without traversing significant regulatory and stakeholder challenges. The U.S.'s electrical transmission and distribution system is regulated mostly on a state-by-state basis and involves the participation of a litany of stakeholders – state and federal regulators, utilities, consumers, investment entities, energy suppliers, and infrastructure providers. The implementation of the Smart Grid is a process that will take several years and not without a coordinated effort among these stakeholders.

Because transmission lines often cross state, and sometimes national borders, a comprehensive commitment to implementation of the Smart Grid is required to become a reality. While the Federal Government regulates interstate transmission, the bulk of transmission

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occurs intrastate and is regulated accordingly. Only through collaboration among all stakeholders can all the benefits of the Smart Grid be achieved.

It is essential to the realization of the Smart Grid that state and federal regulators take a leadership role in its deployment. Because the design of the Smart Grid places energy consumers – both residential and industry – as the primary benefactors of lower costs and energy security, it is the utility companies that must be compelled to invest and participate. In addition, the Smart Grid – or any grid efficiency capability for that matter – is a double-edged sword for energy providers, as their business model dictates selling the maximum amount of energy possible without an incentive to conserve. Thus, regulators must devise a system of benefit sharing to provide incentive to all stakeholders.

Private industry has realized the market opportunities presented by an advanced electrical delivery system and has taken action.

Currently there are efforts underway across the U.S. to research and conduct test beds that, when taken as a whole, have the potential to become the Smart Grid.

Many of these efforts involve the utilization of "smart meters" on residential homes and businesses.

Smart meters – a component of the Smart Grid – possess the advanced energy consumption monitoring capability of the Smart Grid, without the total integration of coordinated communications devices. Smart meters tied to low-bandwidth, high-latency systems that are addressable only a few times a day do not offer the same profound empowerment of the consumer as does the Smart Grid.

While smart metering is certainly an improvement of the current electrical transmission and distribution system, it lacks the scope and far-reaching societal benefit potentially offered by adoption of the Smart Grid.

Congress, in the Energy Policy Act of 2005, took a significant first step toward modernization of the U.S. electrical grid by requiring that states consider implementing smart-metering technologies for residential and small commercial customers. However, in the wake of that Act the general ambiguity over which costs correlate to transmission, and hence federal regulation, and which costs are distribution related, and thus subject to state jurisdiction, left a regulatory uncertainty that served as a deterrent for Smart Grid investment.

Congress again addressed grid modernization in the Energy Independence and Security Act (EISA) of 2007 when it declared, "It is the policy of the United States to support the modernization of the [N]ation's electricity transmission and distribution system to maintain a reliable and secure electricity infrastructure...."

EISA is a significant public policy step forward for several reasons. First, the law is a pronouncement of national policy signaling to all stakeholders that a smart electrical grid is the direction in which the Nation is progressing. This Congressional action provides private industry with the confidence needed to invest in and work toward the realization of the Smart Grid and the optimization of its capabilities. Second, Congress also indicates in EISA that federal incentives would be provided in the form of federal funding for investment in the Smart Grid. Third, the law organized the responsibilities at the federal level by establishing several entities accountable to the Department of Energy. And, fourth, EISA encourages state regulators to consider requiring utilities to use Smart-Grid technologies.

> The Department of Energy predicts that Smart Grid deployment will open a $100 billion market in smart technologies and create $2 trillion per year additional GDP

While EISA may have opened doors for the possibility of realizing a Smart Grid, utilities – which rely on maximizing their energy sales – and private industry are apprehensive about investing in expensive systems that may serve to affect their bottom line at the same time that the possibility of carbon emissions legislation looms at the federal and state levels. If passed, federal legislation mandating either a cap and trade system or a carbon tax could result in significant costs for industry. Thus, it is imperative that investment in the Smart Grid by utilities and private industry be rewarded by providing carbon credits for the resulting emissions reductions realized downstream – particularly to the extent that such investment is in enabling infrastructure for emissions-reducing technologies such as plug-in electric hybrid vehicles. It is unrealistic to believe that energy providers can absorb the losses associated with federal and state emissions mandates and simultaneously expect significant private investment in advanced electricity delivery technologies.

SUMMARY AND CONCLUSIONS

The U.S. is at a crossroads as energy dependence and vulnerable critical infrastructure become significant liabilities to security and resilience. The current electrical grid is outdated and inefficient and the demand for reliable electricity is increasing at a rate that overburdens the current electrical system. The consequences of the increasing number of power fluctuations and failures illustrate a microcosm of the chaos that looms over the economy and national defenses should a deliberate attack on the electrical grid or a natural disaster take place.

The Smart Grid is designed to optimize efficiency and stability. The adoption and implementation of the Smart Grid would address many current societal concerns through empowering consumers, securing the economy, hardening national security, and lessening the impact on the environment. The scope of its benefits justifies a regulatory and private-sector commitment to the implementation of Smart Grid technologies. Whatever the means, the practical adoption and implementation of the Smart Grid should be a priority as we advance further into the digital age.

The domestic electric grid is so fundamentally plaited within all aspects of life that any discussion of building a resilient nation must begin with securing and strengthening the vulnerable electric grid. The Smart Grid will enhance America's resilience by strengthening the ability of the energy infrastructure to withstand a catastrophic event without serious disruption to critical systems and activities, making the power grid a less attractive target for enemies.

Implementing a next-generation grid will also be instrumental to developing a secure and sustainable energy system. The Smart Grid demonstrates the importance of innovation, collaboration and leadership in homeland and energy security.

IMPLEMENTING THE PURE DIGITAL HIGH-SPEED SUBSTATION

By Augustus Johnson IV, Substation Communications Engineer, Dominion Virginia Power

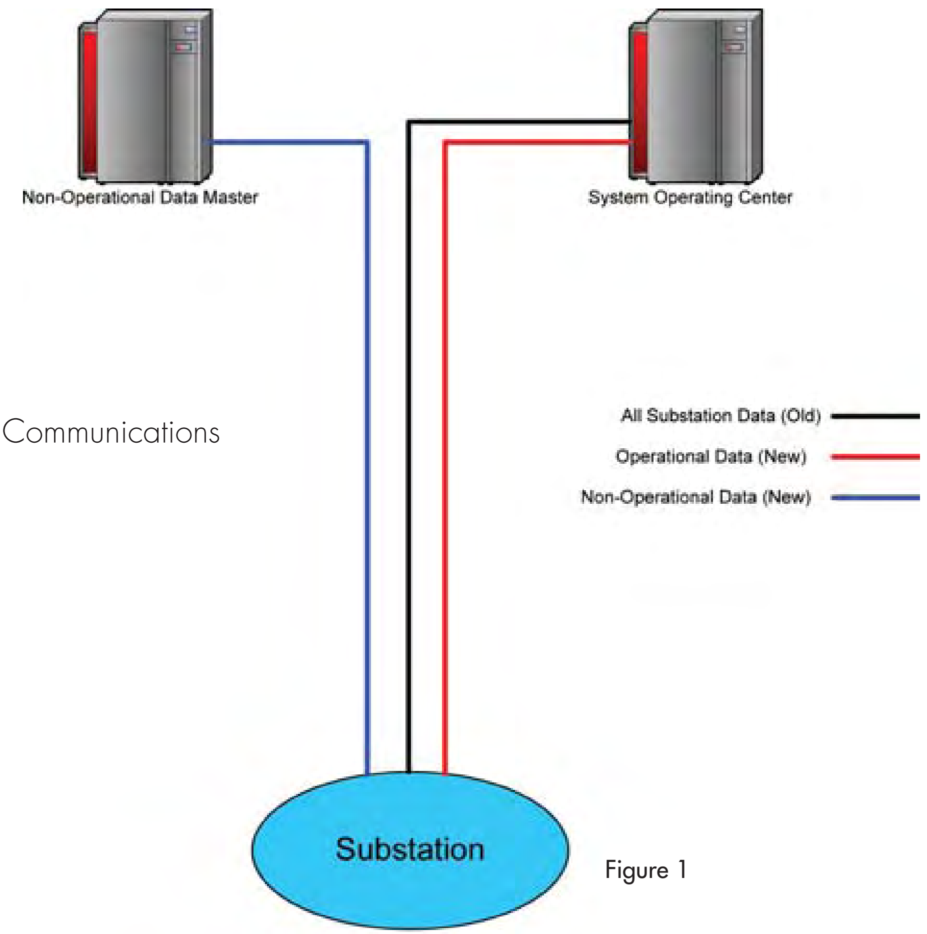

Figure 1

Over the last two and a half years Dominion Virginia Power has made a concerted effort to make significant upgrades in the three major areas that affect the information coming from the substations: SCADA, data integration architecture at the substation, and communications pathway. Realizing that the knowledge base for these areas was spread out over many areas of the company, we decided to bring in KEMA consulting to do a comprehensive evaluation of our system as a whole, and provide a fresh look at a communications system and architecture that we knew was quickly becoming obsolete.

As a result of this evaluation, we were able to get all of the right people into one room, look at our system as a whole, and make several key decisions that would shape the face of our communications systems for years to come.

WHY DIGITAL?

There are several reasons for the transitioning to a high-speed communications pathway. For us, the most prevalent reason was a desire to maximize our existing infrastructure and make our substations more intelligent by providing faster, more reliable access to all substation information. This migration path not only improves our substation communications in the immediate future but also ensures that we will have the flexibility to easily transition into newer methods and protocols such as IEC 61850, should we choose to move in that direction.

The term "Pure IP" will be used throug out this article, and for the purposes of our discussion, Pure IP communications will be defined as: A high-speed, purely digital, IP-based communications pathway where traditional analog communications are no longer used.

The first step in eliminating analog communications from the substation communications environment is the transition away from the Time Division Multiplexed (TDM) architecture and into the world of Pure IP communications. This transition allows for a more intelligent, efficient and dynamic use of resources.

The implementation of a fully dynamic high-speed pathway has several advantages, the first of which is the full utilization of all available bandwidth. In the traditional TDM architecture, through the use of a Channel Bank, sections of the communications pathway are partitioned off and allocated for specific uses: a portion for voice communications, a slower (in our case 1200 BAUD) analog portion for SCADA communications, and a section for some high-speed traffic (telnet, ftp, other IP-based communications). The problem with this architecture is that it leaves you almost no flexibility and locks you into specifically allocated sections for specific types of communications. In times of high traffic this can lead to communications delays in one region while other regions sit with little to no traffic. The implementation of the Pure IP architecture eliminates this problem by allowing for dynamic allocation of the entire communications pathway. This dynamic allocation allows all communications processes to acquire and use the bandwidth that is needed without worrying about hitting allocation barriers.

Analog signals are also highly susceptible to electromagnetic interference which can lead to poor signal quality, which in turn can severely degrade communications, and cause significant problems. The Pure IP architecture, by virtue of the fact that it is end-to-end digital communications, provides a high quality signal, with error checking, and provisions for data retransmission, which vastly increases noise immunity.

While the Pure IP architecture provides for increased flexibility and allows for the dynamic allocation of resources, as with anything, there are limits to the amount of total available resources. To assure that high priority processes are always available, Quality of Service (QOS) is used to determine a "pecking order" and assure that in times of high traffic processes like SCADA traffic and voice service are always available.

SEPARATION OF OPERATIONAL AND NON-OPERATIONAL DATA

Another important benefit of implementing high-speed communications is the gained ability to fully separate operational and non-operational data.

Recent industry trends have shown a strong migration towards the use of Intelligent Electronic Devices or IEDs.

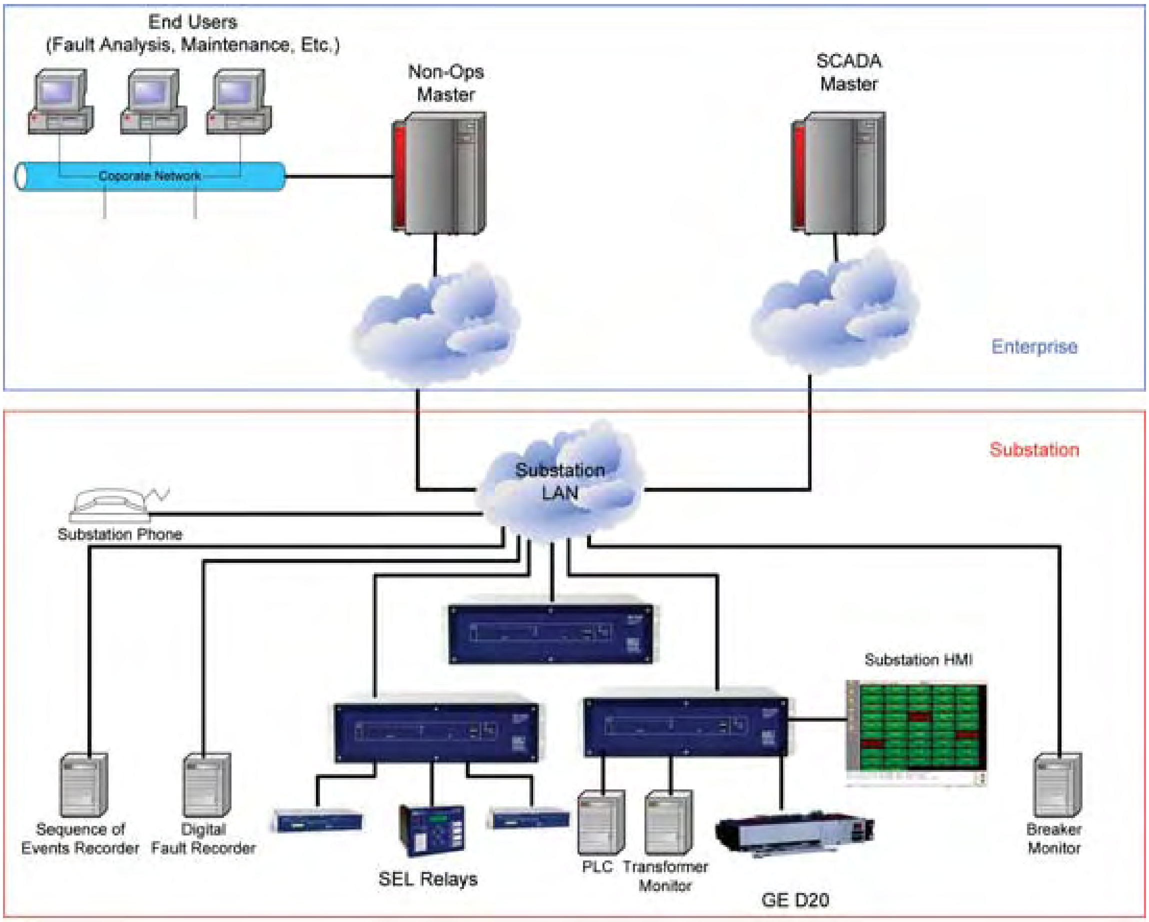

Figure 2

A natural by-product of the increased use of IEDs is an increase in the amount of information that can be retrieved from the substation. In the past we've been able to utilize our slow speed SCADA pathway to retrieve some of this non-operational data with relative ease, but the amount and variety of data available at the substation over the last couple of years has increased exponentially. This increase has fueled the need to utilize our high-speed infrastructure, and forced us to shift our thinking towards the separation of operational and non-operational data at the substation.

THE CHANGE

Now that we've talked about what this transition is about and what it means, let's look at what we've done to bring this concept to life.

The question of what to do with the SCADA traffic is a very large part of the change; in fact, it was a major driver in the decision to upgrade and overhaul our communications architecture.

Given the fact that we have all of this bandwidth, putting our SCADA traffic on the high-speed network was the next logical step. We explored options for compressing and wrapping the existing CONITEL protocol in a TCP/IP packet or tunnel, but ultimately decided that that was not the most effective use of our resources and efforts. After taking all of our options into account, we decided that the best course of action was to begin the migration away from CONITEL and move towards DNP TCP/IP.

To secure this connection, we've locked our substations completely, implementing firewalls at all substations and utilizing encryption technologies to secure our substations and communications pathways.

The new question is: what do we do with the existing devices in the substation that have traditionally utilized dial-up methods to provide access into and out of the substation? In line with our desire to make all communications in and out of the substation high-speed digital, we chose to do one of three things with these devices:

1. Connect them to a substation data concentrator (SEL-

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ELECTRICITY DISTRIBUTORS CAN PLAY AN IMPORTANT ROLE IN ACHIEVING ONTARIO'S CONSERVATION AND RENEWABLE TARGETS

By Charlie Macaluso, President and CEO, Electricity Distributors Association

In recent years Ontario's local electricity distribution companies (LDCs) have evolved to take on additional roles and responsibilities in the delivery of conservation and demand management (CDM), the implementation of the government's smart meter initiative, and the connection of distributed generation and renewable projects.

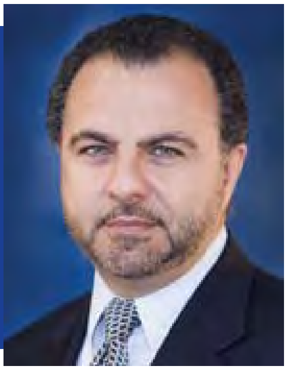
These additional responsibilities can be viewed as the initial steps in a fundamental shift away from the narrow, 'delivery only' utility focus that Ontario's distributors were relegated to back in 1998. A pragmatic public policy that emphasizes a 'greener' approach to energy sustainability and the emergence of new technologies are – quite sensibly - opening doors to new possibilities for distributors.

Bringing new and renewable generation online is a fundamental part of a long-term solution to addressing Ontario's supply issues, but curtailing demand through conservation measures continues to represent an equally prominent place in the province's energy strategy.

Earlier this fall, the Minister of Energy and Infrastructure directed the Ontario Power Authority (OPA) to review key elements of the province's proposed long-term energy system plan - specifically, those portions of the plan that pertain to renewable generation and conservation, amongst others. The Ontario Energy Board's hearing on the proposed Integrated Power System Plan (IPSP) has since been adjourned to allow the OPA to respond to the directive and re-file its revised plan, expected in March 2009.

The Minister's directive reflects the government's desire to accelerate the province's 'green' efforts, not only by taking a second look at the viability of bolstering electricity conservation measures, but also by stepping up efforts to connect renewable supply and clean energy, and the possible acceleration of the utilization of smart meters. It is a scenario that presents some viable opportunities for Ontario's electricity utilities to build on their proven leadership in the delivery of conservation and demand management (CDM), the implementation of smart metering and the connection of distributed generation projects.

Using $163M in OEB-approved CDM dollars, LDCs efforts were instrumental in laying the building blocks for establishing focussed conservation activities in communities across the province.



The province's distributors have a proven track record in the delivery of CDM. LDCs were the first to answer government's call in 2005 to help 'create a culture of conservation' in Ontario by stepping to the plate to deliver over 500 custom, locally driven CDM programs and activities. Using $163M in OEB-approved CDM dollars, LDCs efforts were instrumental in laying the building blocks for establishing focussed conservation activities in communities across the province. More recently, distributors have continued to work in conjunction with the OPA to deliver a series of province-wide programs for residential and business customers, tapping into $400M in funding from the province's global adjustment mechanism.

LDCs support the government's desire to re-examine the viability of accelerating conservation targets and are ready to assist in this pursuit. In fact, the government's directive comes at a time when Ontario's distributors are looking to re-align their roles and responsibilities in delivering CDM more effectively to the marketplace.

The EDA is currently in discussions with the Ministry of Energy and Infrastructure and the OPA on the administration of CDM in Ontario. The province's LDCs are calling for a new relationship with the OPA that sees distributors assuming their originally-identified role as stated in the Minister's directive to the OPA in 2006, which says: "LDCs have a legitimate and unique role in CDM delivery. They should be key conservation delivery agents, helping to grow the culture of conservation." The directive named the OPA as overseer of the administration of the province's CDM policy, while distributors were assigned a primary responsibility of operational fulfillment of the policy. In LDCs view, the key elements of this fulfillment role include the design, delivery and procurement (of 3rd party service providers as required) to ensure the success of CDM in each of their service territories.

Even as these CDM discussions continue, Ontario's electricity distributors are also committed to assisting the Provincial Government to achieve its goal of deploying over 4 million smart

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Substations

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3332 or SEL-2032) capable of acting as a terminal server/port switching device.

2. Install a stand-alone terminal server/port switching device (GarrettCom DynaStar 2000)

3. Completely replace the existing equipment with an Ethernet-ready equivalent device.

4. Connect a serial-Ethernet converter.

As with most other utilities, we've traditionally employed an RTU-centric architecture with an RTU of some sort being the master device at the substation that reports directly to the SCADA master. Since most RTUs do not support an Ethernet protocol, they could no longer function as substation master devices; in essence they have become no more than hardwired I/O modules.

The architecture of substations has been transitioned to a data concentrator-centric architecture, and two migration plans were developed to handle the RTU:

1. Smart RTUs (GE D20) are upgraded to support DNP Protocol and now report to the substation data concentrator just like any other substation IED.

2. Legacy RTUs that cannot be converted to support DNP protocol are replaced with a simple I/O module (SEL 2411)

And last but not least traditional dial-up voice communications are replaced with Voice over IP (VoIP).

CONCLUSIONS

Taking a step into the future and completely shifting philosophies is no small feat, but with carefully thought-out planning, it can be accomplished efficiently and effectively. What I've presented is a look at what we at Dominion have done to address an aging and increasingly obsolete philosophy and infrastructure. My advice to anyone looking to do the same at their company is to first understand that the future of utility communications is going to encompass multiple areas of your company, most of which are not used to working together. Second, take the time to evaluate the system as a whole and get a picture of all of the pieces that you have to work with on the system. Finally, tailor your solution to meet your individual company's needs; only then can you find the best solution for your company.

Electricity Distributors

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meters to every residence and small business by 2010, which our sector is on target to achieve. Importantly, once smart meters are fully utilized, they will provide consumers and utilities with the tools to engage in load shifting and electricity usage management.

The government's Smart Meter Initiative (SMI) is the initial step in what electricity distributors' hope will be the creation of smart local grids whereby 2-way communications will transmit user information freely between customers and distributors. Similarly, our industry is preparing to take additional steps in smart grid development, to accommodate 2-way power flows between distributed power producers and the distribution grid. This evolution of the grid is essential as the Province is actively encouraging new options for meeting future load through distributed generation (DG) and renewable energy which, in turn, is motivating LDCs to connect small scale projects to distribution systems more frequently. A number of regulatory and operational challenges remain in connecting DG to local distribution systems, including the necessity to change the system's current one-way power flow to a 2-way power flow that allows producers to feed new generation back into the grid. Our sector is working closely with industry stakeholders and regulators to rectify these issues and accelerate the province's ability to connect renewable and DG projects to the grid.

Ontario's LDCs are quickly modernizing to take advantage of smarter metering systems that are being deployed throughout the province.

Overall, at this critical junction in the evolution of Ontario's power sector, distribution companies are uniquely positioned to make an even greater contribution to our province's energy future, and we are prepared to do so via partnerships with our municipalities and by working with the government, regulators and key stakeholders.

To this end, the LDC sector undertook a visioning exercise in 2008 intended to define and promote a long-term vision for the future role of Ontario's distributors. The vision supports the building of sustainable communities that will benefit electricity consumers, municipal shareholders, and support the energy policy goals of the provincial government. The government's strategy provides many elements of consistency with the direction that is set out in our vision. This includes the importance of strengthening community-based conservation measures and smart meter utilization, and expanding the availability of distributed generation for renewables in order to build the sustainable communities of the future.

For the province's electricity distributors, the ability to adapt, innovate, and deliver on key provincial initiatives has been key to the sector's success. With this in mind, LDCs are poised and willing to play an important role in the potential acceleration of the province's conservation and renewable targets as set out in the Minister's review directive to the OPA. The sector looks forward to further dialogue and a productive partnership with government on how LDCs can best assist in delivering successful outcomes on these 'green'/sustainability issues. We also look forward to working with the OPA and other industry stakeholders as it relates to fine-tuning Ontario's long-term energy plan in the weeks to come.

Charlie Macaluso is President and Chief Executive Officer of the Electricity Distributors Association. He is also the LDC representative on Electricity Today's Editorial Board. The Electricity Distributors Association (EDA) is the voice of Ontario's local electricity distributors, the publicly and privately owned companies that safely and reliably deliver electricity to over four million Ontario homes, businesses and public institutions.

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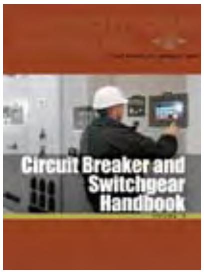

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