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Electric Energy T&D MAGAZINE

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GRIDLINES

Michael A. Marullo, Editor in Chief

Build it and they will come… or maybe not.

Most everyone is familiar with the cliché: *Build it and they will come*. But for those who might have somehow missed that one, the phrase was made famous by the movie "Field of Dreams" about two decades ago in 1989. The overarching message in those few simple words was that if you want something badly enough, sometimes you have to be willing to move forward on nothing more than your own faith in its merits. This is a concept that a friend of mine used to call willing suspension of disbelief. It's a popular concept these days, especially as regards the Smart Grid.

For those of us involved in the electric power industry, we eat, sleep and breathe this stuff. Let's face it, you can hardly pick up a magazine or newsletter, glance at an advertisement, attend a conference, tune into a webinar or read a blog without being bombarded by that Smart Grid thing. But hey, we're used to it, right? We just take it for granted that Smart Grid is the de facto centerpiece of the industry, and as such, we expect to hear about it – a lot! But what about the rest of the world? You know, the ratepayers – how much do you think they know about Smart Grid? (If you guessed "not very much" you're getting warm.)

While perhaps it isn't all that hard to believe that average people don't know a whole lot about Smart Grid – after all, it's still a relatively new term – wouldn't you think that the basic rudiments of electricity would be well rooted in the minds of most folks by now? After all, it's been around for over 100 years, and we all use it everyday. Well, that's what I used to think too… but not anymore.

The more the Smart Grid topic has heated up over the past few years, the more occasions I've had to talk with average people about it. As soon as they find out what I do professionally, the conversation almost always leads to a mini-tutorial – not necessarily about Smart Grid, but usually about the basic principles of electricity.

What I've found in these various conversations conducted on airplanes, over dinners with friends and family, at sporting events and almost anywhere people gather for casual conversation is that most people don't really understand much about why their lights come on when they flip the switch in their homes and businesses.

Sure, most people know that power is produced in some type generating plant, whether fossil or nuclear and whether it's coal-fired, gas-fired or whatever. They also know that there are lots of wires around that transport electricity from those plants to various customer premises and they know that it enters their homes, schools, businesses or other facilities through some type of meter – and, that that meter somehow measures how much power they'll pay for at the end of the month. But that's about where the understanding drops off sharply or ends.

Don't ask your neighbor what a substation is, or what it's for – and definitely don't be thinking that many (any?) of them can tell you the difference between transmission and distribution. Why do the lights sometimes flicker? What are those big metal cans hanging on the power poles? How does the power company know when my lights are out – or DO they even know until I call and tell them??

On average, most consumers are pretty clueless about these things. But it really isn't their fault. They aren't just a bunch of dummies incapable of understanding anything about how electricity is made and delivered. The real reason they don't know is because they haven't had to know – at least not until now.

In a tightly regulated environment, where no choice of power supplier existed for over a century, what would be the point of spending time and money to learn about something for which you have absolutely no say? That would have been like teaching every person with a car the principles of the internal combustion engine just because they all drive – pretty pointless unless you plan on being an automotive mechanic or engine designer rather than just a driver. So the result is that most consumers actually know very little about electricity – or energy in general, for that matter. What they do know is that they need it and, of course, that they don't want to pay a lot for it.

The point of all this is that when it comes to Smart Grid – and especially Smart Metering – we seem to be expecting consumers to just do that willing suspension of disbelief thing and quietly accept these initiatives whatever the scheme and whatever the cost. Build it, and they will come? 'NOT happening, folks! People won't just accept paying a lot of money for something they don't understand and for which they perceive no immediate benefits. There's a big learning curve involved here that simply cannot be ignored and that isn't going away.

There are no simple answers and no shortcuts to this. The fact is that it will take a lot of time and an enormous amount of resources to create this thing we call the Smart Grid. But it will also take a lot of time and an enormous amount of resources to educate consumers about why we need it, how they will benefit from it – and perhaps most important – why they should be willing to underwrite it even before seeing any tangible benefits.

Build it, and they will come? Well, maybe; but until and unless we accept this as a teaching challenge in addition to the obvious economic and engineering challenges, let's not kid ourselves. If we fail to provide the education needed to thoroughly answer those questions for consumers, we shouldn't be surprised if they don't show up for the start of the game. – ***Ed.***

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Industry NEWS

World Energy Congress - Montreal 2010

An event not to be missed

Montreal will host the 21st Congress of the World Energy Council from September 12 to 16, 2010. At the event more than 3,500 delegates from over a hundred countries, representing all energy sectors, will meet to discuss the challenges the energy sector will face over the next 25 years. Some 200 exhibitors will gather at the Montreal Convention Centre to display their know-how and the results of recent technology research as well as educate the public about the challenges we must all face if we are to maintain our societies' standard of living and development.

The Montreal Congress also comes at a strategic moment for the energy industry. Nine months after COP15, in Copenhagen, and just two months after the G8/G20 Summits, where energy will be front and center on the agenda. Taking place barely two months before COP16 in Cancun, Mexico, the Montreal Congress is de facto THE key moment for all leaders and decision makers in the energy sector.

Energy is the issue of the day. Pressure to reduce carbon dioxide emissions is increasingly stronger, even though 86% of world supply still comes from combustion of fossil fuels. That being said, the challenge of climate change and reduction of greenhouse gases is only one of the important issues.

At this time, more than one third of the world population (2 billion persons) have no reliable energy supply. Moreover, between now and 2020, world energy needs will grow steadily and prices will rise significantly as the pressure mounts from economic recovery and growth of developing countries. It is expected that the world demand for energy will double by 2050. Added to this, the energy sector now faces overwhelming problems of environmental, social, and political acceptability while the world economy is also coping with major disruptions.

The Montreal World Energy Congress is currently seen by the global energy community as a pivotal event. No fewer than 13 international organizations will be associated with the Congress, including the annual WEC-FT Energy Leader Summit which will be held outside London for the first time, special meetings of Energy Ministers from French-speaking countries and their Commonwealth counterparts, and extraordinary meetings of organizations with an interest in the energy sector, such as the World Bank and the e8.

Some 250 high-level speakers from industry, government and research and academia will talk about key issues facing the energy sector today, divided into four central themes to be discussed during the four-day event: day one addresses ACCESSIBILITY (meeting worldwide energy demand); day two addresses AVAILABILITY (what is the right energy mix for long term stability?); day three addresses ACCEPTABILITY (energy solutions for a healthy planet), and; day four addresses ACCOUNTABILITY (policies, regulations and financing).

It is very urgent to work on efficiency and invest in research and development to ensure a steady supply as well as more efficient consumption. It is extremely important for people to know what's going on right now, and be aware of the tremendous challenges we all face in terms of energy – poor countries and developing countries, as well as rich countries – everybody, right down to the consumer.

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Many were skeptical the 220 mile Arrowhead-Weston transmission line could even be done, but it was completed seven months ahead of schedule! Doing so required a talented team of people and partners willing to communicate and commit to achieving success. With more than 1500 structures and a very challenging right of way, there were many obstacles to overcome in the progression from planning to Power-Up!

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Acier Profilé SBB is proud to announce it is has moved its head office from St-Eustache (QC) to Terrebonne (QC). The new 80,000 sq. ft. facility sits on 390,000 sq.ft. of land and will allow SBB to double its production capacity and improve the efficiency of its operations.

SBB is a leader in the manufacturing and supply of steel and aluminum towers, structures and structural elements to power transmission companies or contractors. It is particularly successful on the international market with its Emergency Restoration System (ERS) that is sold in over 25 countries worldwide.

ERS are useful to quickly restore power when power transmission lines or power transmission towers are damaged and need replacement. SBB ERS can be erected very quickly (a few hours) and are supplied on a turnkey basis with all the equipment required for the erection and operation of the towers (tools, insulators, training, etc.) during the time of the emergency.

Acier Profilé SBB has been growing exponentially in the past 5 years and has now become a global leader in their field of expertise. Since the beginning of 2010, SBB has been awarded contracts in Mexico, Malaysia, Canada, United Arab Emirates, Philippines, Paraguay and Ivory Coast.

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Southern California Edison Installs 1 Million Smart Meters

Redondo Beach, CA – Southern California Edison (SCE), an Edison International company, installed its one millionth smart meter at the home of a customer in Redondo Beach. SCE started installation of smart meters in Sept. 2009 as part of its Edison SmartConnect program. The company will install approximately 5 million smart meters for residential and small business customers by the end of 2012.

"Reaching the one million meter mark today (July 12) is a milestone in the deployment of our smart meter program," said Theodore F. Craver Jr., chairman, president and CEO of Edison International. "After years of extensive research, we have made careful decisions to invest in technologies, systems and devices that provide a full range of customer benefits. We look forward to making available to all of our customers the valuable features smart meters provide, enabling them to closely monitor and manage their electricity usage to help them save energy, money, and the environment."

"Our region was green before green was cool, and I can think of no better place to install SCE's one millionth smart meter than here in the 36th congressional district," said Congresswoman Jane Harman (D-Venice). "Smart meters empower customers to make better choices about their energy usage – lowering electrical bills, reducing demand during peak hours, and preserving scarce resources. Kudos to Southern California Edison for this ambitious and innovative program."

Edison SmartConnect meters are digital, secure, two-way communicating devices that replace traditional mechanical meters and provide a key step in transforming the electric system to a smart grid. Smart meters measure a customer's electricity usage up-to-the minute and, later this year, customers will be able to view their energy usage online to track how much they use and how much it costs.

By the end of the year, SCE will introduce new programs and services that will empower customers to make better-informed decisions about their energy use. In the near future, when advanced features are fully activated, the smart meters will be able to communicate with the next generation of smart thermostats, appliances and other devices.

Edison SmartConnect is a $1.6 billion program authorized by the California Public Utilities Commission. SCE anticipates customers' use of the information provided by the new meters will reduce demand on the electricity grid by about 1,000 megawatts, the amount of energy produced at an average power plant.

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Sustained energy conservation resulting from customer response to their energy use information is also expected to reduce emissions of greenhouse gases and smog-forming pollutants by a minimum of 365,000 metric tons per year – the equivalent of removing 79,000 cars from the road.

Customers can find more information at *www.sce.com/smartconnect*.

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Texans Can Use Smart Phone to Control Home Temperature

TXU Energy iThermostat mobile website is compatible with most handhelds

Dallas, TX – Texans can now use their smart phone to manage their home's temperature, no matter where they are.

TXU Energy's latest innovation allows users of its popular TXU Energy iThermostat to manage their home's heating and air conditioning through a new mobile website that lets them view real-time temperature settings and even adjust the temperature setting, all from a handheld.

The new TXU Energy iThermostat mobile website (txu.com/control) is compatible with the latest models of Apple® iPhone®, Apple® iPod touch®, Apple® iPad™, BlackBerry® Tour™ and Android™ smart phones (all brands).

"Our new mobile website allows our customers to use their smart phone to control their home's temperatures from virtually anywhere in the world," said Jennifer Pulliam, director of innovation for TXU Energy. "Customers want more control and information about how they're using their energy, and our mobile website is one way they can do that."

With triple-digit temperatures already having arrived in the state, TXU Energy reminds Texans to take advantage of technology designed to give customers more control over their home's temperature.

The TXU Energy iThermostat is a fully Web-enabled programmable thermostat that lets customers monitor and manage their home's temperature through the Internet.
For more information, go online at *txu.com/iThermostat*.

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Nova Scotia Signs MOU with Maine on Energy Co-operation

– Premier Darrell Dexter and Governor John Baldacci of Maine on July 12 agreed through a Memorandum of Understanding (MOU) to co-operate on renewable ocean electricity generation.

"Nova Scotia has always enjoyed a strong economic, social, and cultural partnership with Maine and this MOU is another example of how our governments will work to grow the economy, create jobs, and protect the environment in both our regions." said Premier Dexter.

"This MOU will help facilitate discussions between Maine and Nova Scotia around the research and development of renewable off-shore energy resources, and will enhance Nova Scotia and Maine's already strong relationship," said Governor Baldacci.

The objectives of the MOU are to:

- Investigate opportunities and areas for co-operation on furthering off-shore wind and tidal energy technology and application
- Co-operate on tidal energy research and development to ensure the maximum contribution to renewable electricity standards for both regions. "Tidal technology is an emerging field, with many challenges and opportunities," said Doug Keefe, executive director of Fundy Ocean Research Centre for Energy. "Our research work will depend on the strength of many partnerships and this MOU is a welcome development. Maine was the first region in North America to consider generating electricity from tidal energy, and may have an important role to play in its future."

In order to fulfill the objectives of the MOU, both governments agreed to the following: share research information on renewable electricity, including tidal energy and offshore wind production, bring together experts from both jurisdictions to participate in the upcoming Offshore Energy Environmental Research meeting in October, host Nova Scotia's Tidal Energy Symposium in conjunction with next year's New England Governors and Eastern Canadian Premiers conference, discuss the possibility of expanding the MOU in the future to include other provinces and states, and ensure information is shared with one another in a timely manner. "Signing this MOU with Maine is an important step in making sure Nova Scotia capitalizes on every opportunity to further develop renewable electricity for this province that will have real economic benefits for Nova Scotians now and in for years to come," said Premier Dexter.

A copy of the MOU can be found at *www.gov.ns.ca/energy*

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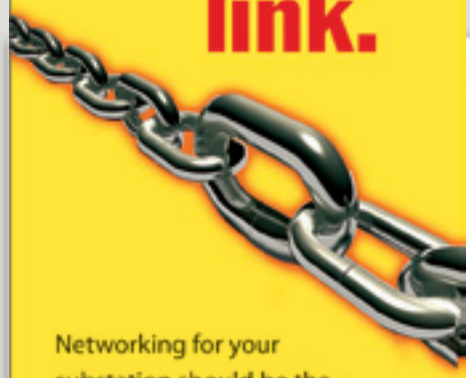

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Seattle City Light Expanding Powerful Neighborhoods Pilot Project

Leak Tests, Dryer Vent Checks Added to Energy Efficiency Outreach Effort

Seattle, WA – Following early success in helping South Seattle customers who do not use English as their primary language, Seattle City Light is expanding its Powerful Neighborhoods pilot program to help people save energy, water, and money.

"Energy efficient light bulbs and low-flow fixtures might sound like small steps, but they do make a difference, especially for families living with tight budgets," City Councilmember Bruce Harrell said. "This program also shows how energy conservation can create green jobs in every community."

"This door-to-door effort is breaking down barriers that can limit participation in traditional energy efficiency programs among senior citizens, low-income families and residents with limited English skills," program manager Andy Silber said. "We're trying to make it as easy as possible for them to save money by reducing their energy and water use."

Powerful Neighborhoods was launched in April to provide direct installation of compact fluorescent light bulbs, faucet aerators and smoke detectors while also providing low-flow showerheads residents could install themselves. Now, City Light is adding leak testing for toilets and checks for proper installation of clothes dryer vents to the program.

While the pilot project is open to anyone living in the Seattle portions of ZIP codes 98126, 98106, 98134, 98108, 98144, 98118, 98178, it targets senior citizens, low-income residents, and households where English is not the primary language. The project has served more than 1,900 households. Two thirds of those customers are seniors, low-income residents or have limited English skills.

City Light is contracting with the Smart Energy Collaborative and the Environmental Coalition of South Seattle to canvass the neighborhoods door-to-door and make the installations. Installers for the community organizations speak more than a dozen languages and many live in the area.

One of the early lessons from the pilot is how important existing relationships can be for reaching residents with limited English skills. The environmental coalition, in particular, is leveraging its community connections to get those residents to participate. Nearly half the households served by that community group use something other than English as their primary language, including Spanish, Chinese, Tagalog, Vietnamese, Amharic and Cambodian.

The goal is to improve the energy and water efficiency of 10,000 homes by the end of the year, which would save about 25 million kilowatt-hours of electricity each year. That's an average savings of about $40 a year for each household. If the pilot project continues to be successful, it could be offered in other neighborhoods.

The project is being paid for with $500,000 of federal stimulus package money and about $1.2 million from City Light. Smoke detectors are being provided by the Washington State Department of Health under a grant from the Centers for Disease Control and Prevention.

Seattle City Light is the ninth largest public electric utility in the United States. It has some of the lowest cost customer rates of any urban utility, providing reliable, renewable and environmentally responsible power to nearly 1 million Seattle area residents. City Light has been greenhouse gas neutral since 2005, the first electric utility in the nation to achieve that distinction.

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LightsOn

YOUR SMARTER ENERGY ECOSYSTEM
Starting the Journey to Successful Smart Grid Development

By Larry Cochrane, Microsoft Corporation (Redmond, WA USA) and Scott Neumann, Utility Integration Solutions (Lafayette, CA USA)

Like many others, one large U.S. utility has its plan in progress to deploy two million smart meters over the next two years. Its goals are two-fold: more accurately meter retail electricity consumption and enable retail consumers to react to changing real-time electricity prices. While billing is a vital function, there are multiple processes and system connections beyond billing to address. Is there scalable storage and are systems performing efficiently? Are meters connected with marketing systems for pricing programs? Do customer relationship management systems and call center staff have real-time data access to answer customers' billing questions? These are valid questions that deserve answers...

Desire for energy independence and cleaner energy sources along with the growing interest in climate change are driving a fundamental shift toward the use of smart technologies such as meters. At the same time, smart technology brings on numerous first-time issues for utilities. How do utilities interact with customers as they become active participants within this ecosystem? How will utilities and customers take advantage of capabilities service providers offer? How do they use and secure the exploding volumes of data? These issues will continue to grow.

Utilities face three main challenges:

1) successfully completing smart grid initiatives;
2) taking advantage of new opportunities a smart energy ecosystem enables; and 3) doing it all while still keeping the lights on.

Achieving all three is not an easy task. For most utilities, it means simultaneously deploying smart meters and launching programs such as demand response, tiered pricing and price sensitive load response without wavering on reliability. They also have to determine each program's effectiveness and profitability. While utilities may have programs in place and are progressing faster on the commercial and industrial side, achieving the depths required for the consumer side is more complex. No single utility or industry solution provider can achieve all three without help.

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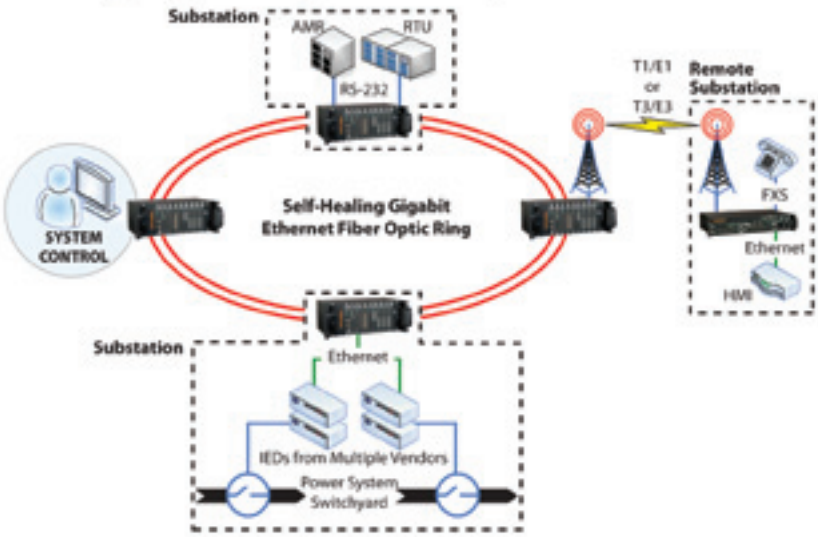

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Demand response extends to wholesale markets

Integration of the retail segment with wholesale markets will be significant. If time-varying retail electricity prices are not directly linked to real-time wholesale prices, then retail consumers will not react to the right signals. According to Stu Bresler, vice president of market operations and demand resources for PJM Interconnection, one of PJM's roles as a regional transmission organization is ensuring that wholesale prices are transparent, stable and rational. "Price transparency is key so that time-varying retail rates use real-time wholesale prices to stimulate retail customers' responses in a way that's consistent with grid conditions," Bresler said.

To do this, PJM works continuously with its members, other stakeholders, federal regulators and state utility commissions to ensure wholesale market rules efficiently facilitate competition and wholesale prices accurately reflect supply and demand balance. "Connectivity and automation allows us to integrate more types of generation and storage while maintaining reliability and price stability," he said.

PJM Interconnection also recently completed one of the largest and most sophisticated demand response software system deployments in the world for its wholesale electricity markets. The new system expands its demand-side resources and improves demand-side operational efficiency by linking and automating wholesale powermarket transactions that involve PJM, utilities and demand response curtailment service providers.

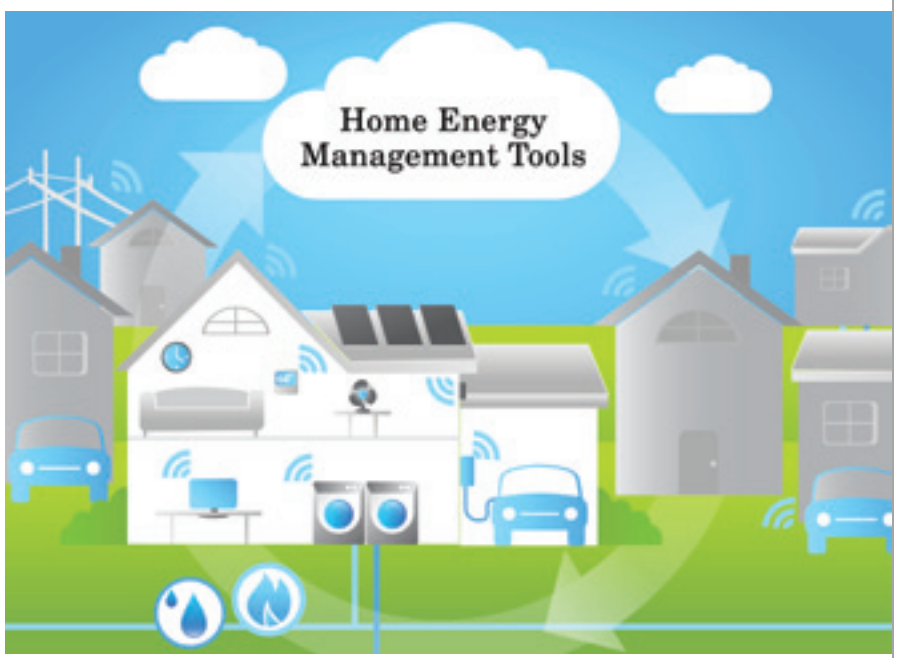
"Price transparency is key so that time-varying retail rates use real-time wholesale prices to stimulate retail customers' responses in a way that's consistent with grid conditions."

– Stu Bresler, Vice President of Market Operations & Demand Resources, PJM Interconnection

Smart grid reaches all the way to the customer

The smart grid extends into the premise bringing utilities closer to customers than ever. While the commercial side may be more open to direct utility control, more and more consumers will actively participate in decisions. And, they'll make more informed energy consumption choices by following utilities' pricing signals and using device and Internet-based home automation tools. Most consumers won't limit themselves to services through their utility's advanced metering infrastructure (AMI) when they can have Internet access and make decisions by setting up a predefined preference profile, for example.

What does this mean for utilities that typically want to own their customer relationships? Utilities should seek out and offer things like home energy management tools for their customers. Then utilities can complement these tools with their own services to help customers use energy in smarter ways. They can also add services such as solar panel installations, replacing major appliances or insulation upgrade programs. First, utilities have to achieve the integration needed to manage these new things.



Home energy management tools enable active and convenient consumer participation in the smart grid for the first time.

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A man works atop a wind turbine at the Delaware Mountain Wind Farm in Culberson County, Texas. Zero carbon sources amplify the need for effective enterprise-wide integration.

Distribution management drives integration

In *Microsoft Worldwide Utility Industry Survey 2010*, 70 percent of utility executives responding said the most important technology for successful smart grid implementations is distribution management. Smart metering came in second at 64 percent, followed by integration of renewable energy sources into the smart grid at 43.5 percent.

These statistics confirm that the real challenge is managing data flow, processes and workflow at the distribution level as utilities move toward zero-carbon energy sources. More electric vehicles hitting the roadways will intensify the challenge – and no utility can precisely predict when, where or how many electric vehicles they'll have to support.

BC Hydro recently started its distribution management system implementation. While only in early stages, Vidya Vankayala, BC Hydro's chief IT architect believes the new system will help ensure their customers have a safe, secure and reliable energy supply. "Since we provide power to 1.8 million customers – the majority of British Columbia – there is a tremendous responsibility to look to their future needs. We believe this DMS will help to manage new initiatives like renewables and distributed generation," he said.

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– Vidya Vankayala, Chief IT Architect, BC Hydro

While wind and solar farms are relatively easy to construct as compared with coal, nuclear, gas or hydro plants, matching load with variable sources and ensuring reliability is very complex, and takes a lot of units to match size and capacity. To ensure the lights remain on, these distributed generation sources require storage, sophisticated energy balancing as often as every minute, and transmission enhancements to transport power.

As utilities adopt more renewable sources, integrating real-time decision tools also become more important. Since renewables do not provide reliable capacity, grid operators need the ability to predict availability and respond to unavailability better. Real-time decision tools provide information that guides workers to a more optimal and fiscally and socially responsible generation mix.

Utilities must also consider that it takes more than units and geographical diversity to generate wind or solar power. No matter how many units are built at sites like State Line in the Pacific Northwest's Columbia River Gorge where units are highly correlated, when the wind dies, it dies for all.

Too much dependence on renewable sources can also have adverse effects. For example, tariffs in Germany make wind power desirable. However, with the use of wind, base-loaded units such as gas and coal have to be put offline, an expensive process. As a result, generators offer negative price energy bids to guarantee their base-load units remain running until the next day when they will be needed again. Some believe the net effect is higher energy usage. However, if significant demand can be shifted to the nighttime when wind is often most abundant, utilities can achieve considerable efficiencies.

The case for integrating it all – from fuel source to home

More than half of the respondents to the Microsoft survey say their utility hasn't yet started a smart grid initiative – even at the planning stages. And more than 90 percent of respondents believe their utility's technology architecture is not adequate to support new business processes and technologies. This says there's still a lot of work to be done.

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In fact, the Microsoft survey revealed 36 percent of respondents anticipate their organizations will need to be completely restructured if the vision of a fully integrated smart grid occurs. For example, if 30 percent of a city's residents install rooftop solar panels, utility revenue would potentially drop by 30 percent. Since utilities may be major contributors to city incomes, city revenue would also fall.

The Pecan Street Project, a community-wide effort in Austin, Texas, is addressing new business models to avoid a revenue crunch like this – including renewable and distributed energy, smart grid pilots, a new rate structure and more.

These figures imply a staggering number of utilities will soon prepare to operate in the smart energy ecosystem. A significant part of the journey is integrating across the full scope of the ecosystem – from fuels to homes. To do this, utilities need to look at three strategic areas: how data flows through the enterprise, business processes and workflows and the best ways to help people use information.

Beginning the journey to integration

The first step to becoming an integrated utility addresses more than systems. It starts with mapping the flow of information through the enterprise to establish data mastership and, where possible, consolidate master data. It's important to establish who owns the data source to avoid confusion from multiple versions, prevent information duplication and protect the confidentiality of sensitive information. This sort of mapping also makes it easier for users to locate information.

While some start with a business process review, it's difficult to predict what tomorrow's processes might look like. Utilities don't want to get locked into these changes. By mapping information flow, companies can pinpoint integration points and create the flexibility and adaptability that will move with business processes as they change.

Utilities must consider each item on this integration checklist:

- User experience and information mash-ups such as Web 2.0
- Modeling
- Business processes
- Data integration and enterprise-wide data mapping/flow
- Master data
- Business intelligence and analytics
- Enterprise-wide eventing and complex event processing (CEP)
- Security
- Governance, risk and compliance
- Software + Services (cloud computing) and making new developments location agnostic

For example, the T&D operations data store is the source of operations data. While the information technology department would have a copy of that data, the operations data store is the common location where users would access and use that data even though the mastership resides with operations in the control center.

Once the data flow is mapped, utilities should create or review their enterprise workflow so generation, transmission, demand and other data are accessible to the authorized systems and people. For the first time, meter data will help drive demand management and new pricing programs. Also, utilities can identify and repair a potential outage before it happens, and transmission and distribution systems can be more self-healing.

This step also makes sure the utility's strategy includes complex event processing that will trigger critical business processes. When this occurs, the event is passed around the utility network. It is more efficient to move event processing as close to the edge of the utility network and equipment boundary so operational condition changes can be detected and addressed in the timeliest manner. This move reduces network data loading and improves data processing responsiveness – even if the data is eventually passed and stored for historical purposes.

To evaluate their smart grid readiness against Smart Grid Maturity Model criteria, utilities can complete an assessment called Smart Grid Maturity Model Assessment Survey, which can be found on the Carnegie Mellon Software Engineering Institute[1] website.

[1] Carnegie Mellon Software Engineering Institute website: *http://www.sei.cmu.edu/smartgrid/tools/index.cfm.*

Translating data deluge into intelligent information

Smart technology and renewables can also bury utilities in data. Wind turbines and solar farms feed data almost by the minute, significantly changing the data management landscape. By moving from one customer billing sample per month to 15-minute samples for a 30-day month, smart meters supply a 2,880-fold increase in data.

Here's an extreme example: The British government has a goal to install more than 6,000 wind turbines across British waters to fulfill a third of Britain's electricity needs by 2020. This is a huge leap from the country only getting 1.3 percent of energy from renewables in 2005. In this scenario, extracting and storing data and translating it into usable information to help utilities optimize performance and make better decisions will be a daunting task.

The real art is making data intelligent and presenting information in ways that utility employees can access and use. One strategy is to use a content management system as the utility's repository for structured and unstructured data. Utility workers then use enterprise search to navigate the information in a manner consistent with their role. Then information aggregation can enable users to analyze information to create business intelligence.

As long as information is managed and aggregated well, the right people will be able to access information in a manner and format that works for them. For example, users should be able to gather information using familiar tools such as spreadsheets and mash-ups that can be accessed in a virtual container where the data is stored.

Finally, the ability to collaborate is critical. For example, utility workers can access asset histories and collaborate directly with subject matter experts to solve problems saving time and effort.

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A pragmatic start to a complex journey

Any recommended solution should be interoperable with existing technology. Without interoperability, the smart energy ecosystem would be too expensive, too complex and will go unfulfilled. In a report called *Smart2020* the consulting firm McKinsey identifies ways to apply information technology to reduce energy use in factories, buildings, transportation and homes. The study shows that smart application of existing technologies could reduce global greenhouse gas emissions 15 percent by 2020. But it is too complex to complete quickly.

Utilities are generally unwilling to risk swapping out wholesale parts of their infrastructure. Therefore, they need to begin the journey with a planned migration to reach full integration. This approach allows utilities to carefully maneuver changing business models, market structures and varying starting points where utilities begin the journey.

There are pragmatic integration approaches that allow utilities to deploy new components without custom integration thus realizing value more quickly. By developing interfaces between systems that are easy to extend, and simple to start and stop from the source, utilities can avoid unnecessary re-engineering. They can also achieve something called shallow integration. This means establishing the proper balance between integrating a business process to the fullest extent possible, versus the resulting complexity and potential short life resulting from the inability to modify the process without breaking the initial deployment. This approach is practical because it addresses and allows flexibility for business processes that change often.

It's easy to get caught up in the "wow" factor of the smart grid. While incorporating smart technologies and adjusting to autonomous consumer behavior and variable renewables will challenge the value chain status quo, there is good news. New visibility, diversity from additional generation sources and the broader integration across the value chain will provide many new levers to control the power system. And, there is guidance available from industry solution providers that have researched and documented how to make this happen.

The industry is beginning a journey certain to be full of new regulations, challenges and opportunities. Utilities embarking on this journey will achieve better reliability and efficiency to meet their needs for the next decade and beyond.

About the Authors

As Microsoft's Worldwide Utilities Industry's technology strategist, **Larry Cochrane** works daily with the global utilities community using Microsoft's Smart Energy Reference Architecture, which he co-authored with Scott Neumann and others, as a guide to help utilities prepare for the future's energy ecosystem. He brings with him two decades of utilities information technology and operations systems R&D, product development and support experience. Cochrane holds Bachelor of Science degrees in mathematics and electrical engineering and a Master of Business Administration, all from the University of Washington.

Scott Neuman is chief technology officer of Utility Integration Solutions (UISOL), an information technology integrator. He has 30 years of experience in system design and architecture related to transmission, markets, distribution operations and demand response for electric utilities. Neumann is the technical advisor for IEC TC57 and co-leader of the group's Smart Grid Task Force. He is also secretary of the D2.24 CIGRE working group focusing on next-generation EMS, market and DMS architectures. Neumann has an electrical engineering degree from the University of Minnesota and is a senior member of the IEEE.

Volume 2 No. 3

The Bigger Picture

Bringing Renewable Energy into the Transmission Grid

By Gregory K. Lawrence, Partner, McDermott Will & Emery LLP (Contributing Editor)

On January 21, 2010 the Federal Energy Regulatory Commission (FERC) issued a Notice of Inquiry (NOI) to examine the integration of variable energy resources (VERs) into the wholesale power grid of Independent System Operators (ISOs) and Regional Transmission Organizations (RTOs). FERC pointed out that 18,000 MW of renewable energy generation came online in 2008 and 2009 alone, and that expanded renewable energy output will involve major reliability and stability challenges for the transmission grid. These include the inability of VERs to store and control their power output, the negative correlation of that output with the demand curve, and regulatory policies regarding VER grid access. FERC sought comment on how to eliminate unnecessary barriers to VERs grid and market access and to increase the efficiency of VER utilization.

Although pointedly excluding transmission planning and cost allocation, the NOI covered such issues as VER power forecasting, scheduling flexibility and incentives for VER output, reliability and day-ahead market participation concerns, capacity market and real-time barriers to VER use, and coordination among balancing authorities. During a comment period that ended April 12, 2010, FERC received input from more than 250 industry participants. Critical to the future direction of VER integration were the concerns and recommendations from several key sectors, which are briefly sampled below. Comments like these indicate the complexity that lies ahead for any FERC efforts, including rule changes to facilitate VER integration.

VER Associations

The organizations that represent the two largest VER segments, wind (American Wind Energy Association, AWEA) and solar (Solar Energy Industries Association, SEIA) were above all concerned that VERs be treated in what the SEIA called a "just, reasonable and not unduly discriminatory manner." AWEA pointed out that much of FERC's current regulatory structure was developed at a time when power generation was dominated by dispatchable power resources.

To promote a level playing field, these VER organizations urged a combination of faster (sub-hourly) power system dispatch and scheduling, larger and more geographically diverse balancing areas, and promotion of region-wide load following markets and ancillary services markets, particularly in regions where no ISO or RTO exists.

VER Producers

Two of the largest individual VERs – BP Energy and NextEra – generally supported the industry association positions. Each, however, emphasized that "one size fits all" access and market solutions are not possible. BP Energy noted that a "combination of technologies [can] drive market transformation on a far greater scale than the individual technologies would do," while NextEra noted that all energy generation sources vary by their technology, fuel type, emissions, location, and use (baseload, mid-merit, peaking, and variable).

NextEra reminded FERC that "numerous existing market rules are tailored to the needs of non-VERs," particularly RTOs that typically do not encompass VERs. The Commission's goal, NextEra asserted, should be to "ensure that market rules are just and reasonable, and to *remedy* rules that are *un*just and *un*reasonable."

ISOs and RTOs

Many of the comments from the VER perspective implied that regulations favoring ISOs and RTOs need to be redressed to encompass the unique needs of VERs. The ISO-RTO Council, comprised of the ten current North American ISOs and RTOs that work collaboratively together, acknowledged that VERs will be increasingly important in helping states meet their mandatory Renewable Portfolio Standard (RPS) goals and asserted that its member organizations are doing much to facilitate VER growth.

However, the Council gave reminders that uncertainty, variability and lack of dispatch control over VER output remain major impediments to integration. Efforts to smooth out the average VER production profile "may also result in ever more complex operational requirements," the Council reminded. The Council did not view this as an impediment, but emphasized that "because of different regional scope of each market and different generation mixes (especially the availability of faster ramping resources), there will be different operational and market needs and impacts" for VER integration into the grid.

Electric Utility Industry and Other Power Suppliers

This regional variation was emphasized by the electric utility industry. The Edison Electric Institute (EEI), representing shareholder-owned electric companies, held that VER integration should be determined primarily on a regional basis, with robust coordination across regions. EEI reasoned that because the grid regions are organized differently in terms of market structure and have varying amounts of VER potential, the regional level is the best perspective to determine how to most effectively integrate VERs into the transmission grid and wholesale electric markets. EEI pointed out that FERC excluded regional transmission planning from the NOI, and implied this was a mistake given the fact that much current grid system maintenance is done in off-peak hours. If VERs are allowed to use the transmission system more intensively off-peak, EEI warned that "planning assumptions for the transmission system may need to change."

The Electric Power Supply Association (EPSA), representing competitive power suppliers, including generators and marketers, generally agreed. It asserted that transmission planning and cost allocation, smart grid development, demand response and maintaining grid reliability are all issues that need to be addressed along with, and not apart from, a new VER regulatory structure.

One of the largest investor-owned utilities, Exelon, identified operational concerns about VER integration. The company asserted that, "... it is economically harmful to shut down baseload plants at night to accommodate wind generation and then run fossil-fired peakers during the day because the baseload is not there." Exelon was as concerned about the issue of regulatory fairness as VERs, but from a 180-degree direction, warned that FERC "...must not put its finger on the scale in order to subsidize VERs," because this "...will distort markets and make them much less efficient and will ultimately harm electricity consumers.".

Other Industry Voices

Not surprisingly, other industry voices matched the VERs, system operators, utility industry and other power suppliers in identifying their own turf. For example, the California Public Utilities Commission (CPUC) reminded FERC that, given state and local jurisdiction over long-term power development and transmission, the most effective solutions for VER integration must be "developed and supported within, and are likely to vary across, different regions and sub-regions across the country" and urged FERC to "move forward cautiously and collaboratively" in setting new policies.

Moreover, although virtually all commentators offered at least some support for the notion that direct VER transmission integration is the wave of the future for technology, one group – the Coalition to Advance Renewable Energy Through Bulk Energy Storage (CAREBS) – held itself out as an alternative. CAREBS reminded FERC that, because lack of adequate transmission capacity is a key hindrance to VER integration, bulk energy storage using compressed air and hydroelectric technologies can also be effective integration tools. The organization also identified as an important incentive the idea that, "...an energy storage device performing transmission functions should be eligible for transmission rate treatment, including applicable incentives."

Conclusion

There is clearly much more work that needs to be done in order to develop a consistent regulatory framework for VER integration. That need for (and speed of) that integration is unquestionably accelerating due to state and possibly federal RPS requirements and the possibility of carbon emissions pricing. The comments highlighted here and many of the remaining 250 comments filed will likely help shape FERC's expected issuance of rulemaking efforts to formalize its policies for the integration of VERs into the wholesale energy markets. What shape that notice will take to balance political, economic and technological issues remains to be seen. ■

About the Author

Gregory K. Lawrence is a partner in the Energy and Commodities advisory group, and leads the Renewable Power practice area of global law firm McDermott Will & Emery. Mr. Lawrence focuses his practice on regulatory proceedings, market structure and trading, project development and contract negotiations relating to the wholesale and retail electricity and natural gas industries.

The 2010 Automation/IT Leadership Series

Karim El Naggar
VP Network Management

Hervé Amossé
VP Strategy & Innovation

ALSTOM GRID

Paris, France

EET&D: Sometimes it can be challenging to know where to begin these interviews... I must say, this is definitely not one of those cases. With the new ownership resulting from the sale of AREVA's T&D business hanging in the balance for nearly a year, the recent announcement dividing ownership between two other French-owned companies – Alstom and Schneider Electric – almost seems anti-climactic at this point, especially in view of the fact that Areva had originally acquired the T&D unit from Alstom in January 2004. So far, details of the arrangement have remained few and far between, so perhaps we can start by addressing the question that seems to be on nearly everyone's mind lately: How is the Alstom Grid business organized, and what is its mission/vision?

Amossé: Alstom Grid was launched on June 8th of this year. This new sector of Alstom is formed from the transmission activities of Areva T&D and becomes a natural third pillar, alongside Alstom Transport and Alstom Power. Alstom Grid – as the name suggests – is a specialist in the electrical grid, and in particular, we would say the Smart Grid. Its products, systems, automation and services are supplied throughout the world to utility and large industrial customers. With leadership positions in several markets and technologies, this sector comprises over 20,000 employees and has a turnover in excess of 3.5 billion Euros. Products include Power Transformers, Gas-Insulated Substations (GIS), Circuit Breakers, Instrument Transformers and Disconnectors up to 1,200kV AC. Systems include turnkey AC and DC substations, grid interconnections, advanced power electronics and special power systems for industry.

EET&D: And how does the former Areva T&D automation business fit into the new Alstom Grid?

Amossé: Grid Automation solutions range from energy market network and generation management systems to substation automation, protection and control. Moreover, the Alstom Grid Service business supports the installed base throughout the life cycle of the equipment, around the world.

EET&D: Moving on, the energy industry is in a state of flux – to use an electrical term – right now. Between Smart Grid initiatives, Stimulus Bill funding, renewables projects, clean energy legislation and a host of other changes currently taking shape, challenges abound. What do you feel are the most daunting and/or highest priority issues the industry is facing today?

El Naggar: Making the grid smarter is a game changer in the energy world. The challenge to energy utilities, vendors, suppliers – and governments around the world – is to create integrated network solutions and apply advanced computer software and communication technologies to improve the automation, protection, monitoring and control of the power grid. Simply said – a smarter grid.

EET&D: Which part of your new organization will be taking the lead on accomplishing that task?

El Naggar: Automation's Network Management Solutions leads our Smart Grid initiatives. Over the years, we have grown our portfolio of smart network solutions for transmission and distribution grids through technology innovation.

EET&D: Technology innovation is a pretty broad term. Can you give us some examples of what you mean by that?

Amossé: Sure. PMUs – or Phasor Measurement Units – are a good place to start. PMUs send measurements to the control center at up to 60 samples per second. Sudden changes in these measurements alert a control center operator to changes in grid conditions. If a potential problem occurs, the operator is then able to locate, isolate and fix the problem quickly. The challenge is to combine fast measurements with advanced network management applications, which can execute fast controls to protect the grid in an automated manner.

EET&D: Can you briefly explain how this PMU approach is different from the traditional methods currently in use?

Amossé: This is a key departure from traditional – and far more elementary – SCADA control, which simply samples network measurement at a typical 15-minute interval, thereby missing some of the critical transient behaviors of the grid. Very often these are the only early warnings of potentially catastrophic failures, such as the one witnessed in the U.S. Northeast Black-out in August 2003.

EET&D: So, in that respect, I guess PMUs open up a whole new opportunity of on-line stability control of the grid?

Amossé: Yes, by collecting PMU data from across the grid, integrating and analyzing that data and then holistically presenting it to the operator on a single screen utilities can have a much better level of system awareness and the ability to react more quickly to potentially catastrophic events. In the United States, the Department of Energy has allocated over $200 million for deploying 700 PMUs over the next three years, in addition to the existing 200 PMUs, making this one of the most significant increases in grid intelligence we've seen in quite some time.

EET&D: Renewable energy resources are another hot topic these days. There has been a lot written about renewables – especially wind and solar – from an investment and development standpoint, but not so much about the integration of these resource additions into the traditional G, T & D equation. What can you tell us about how these new resources are being harnessed and integrated into the existing grid?

El Naggar: Let's look at Wind Power, for example. The build up of large-scale wind farms definitely creates a significant challenge to transmission operators because an increasing portion of the production of electricity becomes less predictable and highly variable. New technology is needed both to help utilities forecast production more accurately and to allow the grid to cope with rapid fluctuations of generation. Renewable integration includes advanced real-time calculation and estimation techniques, 'look ahead' network security analysis functionalities and realistic environment simulation driven by wind production forecasts.

EET&D: Is this the sort of thing that utilities can expect to handle today, or are we talking about the future development of renewables?

El Naggar: This is happening today; it isn't just a pie-in-the-sky concept or R&D project. We have partnered with one of the largest utilities in Europe which has the largest share of renewable energy production in Denmark. The country has more than 6,300 individual wind generators that produce more than 20% of the country's total generation. We provided a SCADA/EMS for the Danish National Control Center including a comprehensive Wind integration component, which allows the utility to safely and efficiently operate the grid even when Wind energy peaks at 50% of the total country power generation.

EET&D: As we all know, the Stimulus Bill will provide quite a lot of funding for Smart Grid and Grid Transformation projects over the next few years. To what extent will Alstom play a role in these projects?

El Naggar: Our North American unit is deeply committed to several Stimulus initiatives. For example, we have created a task force to develop and implement smart grid solutions in line with the U.S. government's Smart Grid Stimulus Package. To date, we have identified 70 Smart Grid Stimulus opportunities in consultation with our utility customers and submitted Smart Grid Worker Training proposals to seven universities.

Amossé: We are also participating in the Pacific Northwest Smart Grid Demonstration Project, one of the most unique and innovative Smart Grid projects currently under way. This $178 million project is one of 16 regional smart grid demonstration awards, funded in part by the American Recovery and Reinvestment Act (ARRA). The purpose of the project – managed by the prestigious Battelle Memorial Institute – will expand upon existing infrastructure and test new Smart Grid technology with up to 60,000 customers in Idaho, Montana, Oregon, Washington and Wyoming. Alstom is a technology and vendor partner on the project team.

EET&D: A substantial portion of the ARRA funding is, of course, directed toward research and development for renewable energy resources. Does your participation here in North America extend into the work you are doing in Europe that we discussed previously relative to the renewables sector?

El Naggar: Absolutely, the U.S. seeks to achieve 20 percent wind energy generation by the year 2030. A research grant from the U.S. Department of Energy for work to prepare the U.S. electrical grid for growth in wind power will help to achieve that goal. This research will focus on best practices for managing wind energy in control room operations and on the effective use of wind forecasts. Alstom will leverage its experience in Europe to develop recommendations to effectively manage this dramatically increased amount of wind power in the U.S. energy mix over the next two decades and beyond.

EET&D: It seems as though the next generation of electric power systems will be much more regional in scope and that coordination across power pool operators and constituents will be dramatically increased and improved. Can you offer any examples of this shift?

El Naggar: The Western Electricity Coordinating Council (WECC) is the regional entity responsible for daily coordination and long-range planning needed to provide reliable electric service in 14 states, Alberta, Canada and British Columbia, and the northern portion of Baja California, Mexico. Some 40 electric power systems are part of this consortium. Our solutions offer WECC a unique opportunity to tightly integrate the participants of their program and implement coordinated grid management across all 14 of the member states. And as you pointed out, this type of regional approach is expected to become increasingly prevalent in the future.

Editor's Note: Details about reorganization of the low-voltage ("distribution") portion of the Areva T&D business unit were unavailable at press time. Please watch the *Industry News* section in future issues of *Electric Energy T&D Magazine* and our *ElectricEnergyOnline.com* eNewsletter for further details about the reorganization. Also, since the time of this interview, Hervé Amossé has been appointed as Alstom Grid's Vice President Substation Automation, in charge of the Substation Automation Solutions Product Line.

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Balancing Consumer and Utility Requirements for the Adoption of PHEVs and EVs

By David Mulder, Director-Green Grid Initiatives
Capgemini America

The development and growth of the plug-in hybrid electric vehicle (PHEV) and electric vehicle (EV) market is completely dependent on the parallel development of the recharging infrastructure. Although there has been significant effort lately in identifying and resolving the issues associated with public charging stations, the simple reality (and one of the key customer value propositions) is that most charging in this nascent industry will occur at the customer's premise. Unfortunately, there has been relatively little industry discussion and identification of the key technical and operational issues that may face customers and utilities with respect to PHEV/EV home charging. This article begins to identify some of the more immediate and practical issues.

Base Scenario for Discussion Purposes

To facilitate discussion of the key issues below, I have assumed that the market segment purchasing PHEVs or EVs over the next five years will exhibit the following general traits:

- **Affluent** – PHEVs/EVs are more expensive than conventional vehicles, even with the tax credit
- **Urban** –Most individuals purchasing EVs live where they will not have the need to drive more than 70-100 miles a day
- **"Impatient"** - Given a choice, customers would prefer shorter charge times, whether at home or at a public charging station
- **Higher than Average Electric Consumption** – Affluent families live in homes that are larger than average, and have more appliances in them

Issues Differentiation: The "Home" Grid versus the Utility Distribution Grid

The issues identified below can be separated into two general areas: The Home Grid and the Utility Distribution Grid. The Home Grid is essentially the electrical infrastructure within the home that is owned and maintained by the customer. The distribution grid is the utility infrastructure spanning from the customer's home to the utility substation. **Table 1** below provides an initial list of components and issues that may need to be resolved early in the PHEV/EV adoption cycle.

Table 1: The Home Grid versus the Smart Grid – Components to Address

The Home Grid	The Utility Grid
Meter	Meter
Service Entrance/Panel	Transformer
PHEV Charger	Transformer Monitoring
Other Appliances attached to the Home Grid	Feeder/Conductors
Home Energy Management System	Utility Coincident Peaks and "Grid Peaks"
Customer Portal	Time of Use (TOU) Rates
Customer Coincident Peak Management	Demand Response Programs

The Home Grid – Summary of Issues

The Meter

To the extent that there are discussions about the effect of PHEV/EVs on the utility grid, the solution is always to charge the vehicle "off peak", and introduce TOU rates and demand response programs. The fact is, unless the customer has a smart meter, neither the customer nor the utility has the knowledge required to successfully manage load.

A smart meter will provide internal data (as granular as every 15 minutes) that will allow the utility to deploy – and the customer to react to – TOU rates. However, even with a smart meter, the utility only sees usage for the entire home, not for individual appliances or circuits. For reasons outlined below, it may be necessary to meter the PHEV/EV load separately. Some utilities have discussed the pros and cons of installing a separate meter with a remote disconnect, so they could remotely shut off a charger in the case of emergency.

The Service Entrance/Panel

The first and - potentially the most costly – issue to address immediately is whether the customer has a large enough electric service to accommodate a new PHEV/EV load. Most states require all new and remodeled residences to have their electric service upgraded to 200amps. However, there are still a significant number of residences with 100 amp, even 60 amp services. Although the probability is small that that initial market segment will be living in a home with less than a 200 amp service, it is an issue to address up front. Upgrading the electric service can cost anywhere from $2,000-3,000.

The PHEV Charger

The customer will need to decide which charger he/she wants to have installed at their home. **Table 2** summarizes the two major choices; if the "Impatient" assumption above holds true, most customers will opt for a Level 2 charger. Nissan specifically recommends this over the alternative of "trickle charging" using a 120 volt outlet. The major issues to explore with the Level 2 Charger are 1) cost of installation; 2) whether your electric service can support a 7+ kW load; and 3) the local permitting process, as a permit may be required to install a Level 2 Charger and dedicated circuit breaker.

Table 2:
Home Charger Characteristics

Metric	Level 1	Level 2
Phase	Single Phase	Single Phase
Voltage Requirements	120	240
Amps	16	32
kW Load	1.9	7.7
Circuit Breaker Size	20 amp delicated	40 amp delicated
kWh usage		
Approximate Hours to Charge (24 kWh Nissan Leaf)	12	3.5

Source: Coulomb Technologies Website *(www.coulombtech.com)* – Note: specifications above are for their commercial products; home charging systems will be similar, if not slightly lower.

Other Appliances Connected to the Home Grid

Things may become interesting for the customer if they have an "electric intensive" home (i.e. electric water heater, central air, multiple refrigerators and freezers, etc). The higher the loads, the closer the customer is to overloading his/her electrical system and the more disruptive the additional PHEV/EV will be on the customer's daily activities.

Home Energy Management System (HEMS)

Utilities are exploring the feasibility of offering HEMS to customers as a way for customers (and utilities with permission) to remotely manage their appliances to curtail electric load when the electric grid is constrained.

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HEMS will play an increasingly important role in allowing customers to manage their electric demand to accommodate the addition of a PHEV, and not solely for the benefit of the utility.

Customer Energy Portal

Some customers will not opt to install a HEMS. However, they will still need to have means of monitoring their energy usage and PHEV charging status. Some utilities have begun offering this to their customers as a value-added service. The challenge in the near term will be to have the capability to integrate PHEV data as well.

Customer Coincident Peak

A coincident peak loosely defined is the point in time during the day where the demand for electricity is highest. For the utility – this is the daily system peak – the hour where the sum total demand for all of its customers yields the highest generation capacity requirement. This phenomenon also occurs for each individual customer, and it may vary significantly based on demographics, usage characteristics, etc. Why is this important now? Simply put – adding a PHEV/EV charger to the household may change when these peak occurs for the customer. The customer coincident peak is what the electric service panel is designed to meet as a maximum load. Here's another law of unintended consequences: the coincident peak of an all-electric home typically occurs when the electric heat (another high load) is running, which occurs during the evening. So, what happens when the electric heat is on, the electric water heater is running, and the customer is charging a vehicle on a Level 2 charger? In short, between the new loads and new rates, the customer may need to become very proactive in managing his/her loads.

The Utility Grid – Summary of Issues

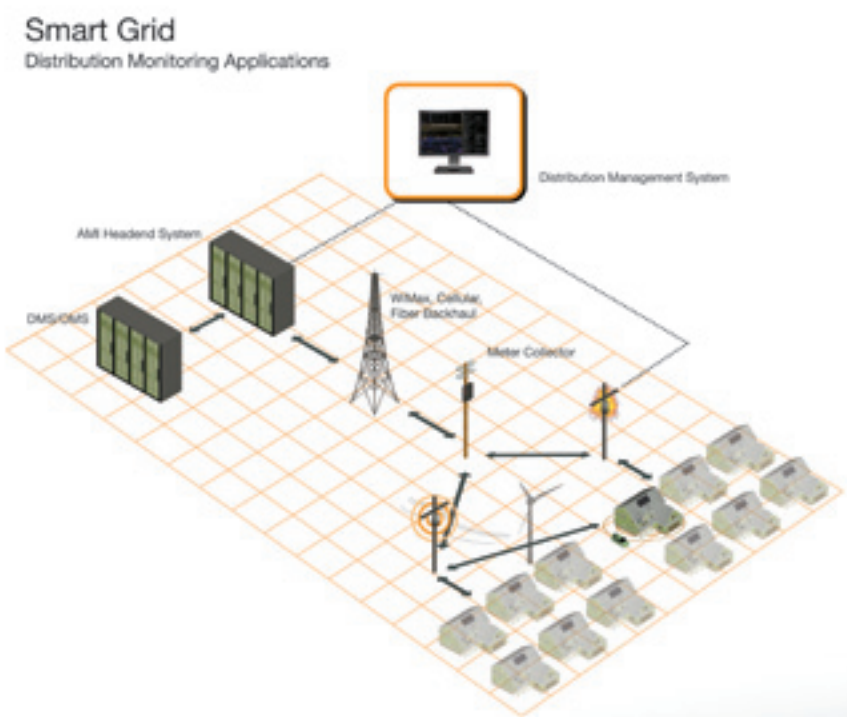
The utility will need to be able to proactively monitor many elements of its distribution grid if it plans to accommodate new loads (like PHEVs and renewable generation) and programs (such as HEMS, TOU rates, and advanced demand response programs). In short, the utility will need to deploy a variety of components of a "smart grid". Below are several components that specifically affect the ability to manage PHEV/EV loads:

The Meter

Many utilities are installing or contemplating installing smart meters. Smart meters provide utilities visibility into the energy use patterns of individual customers. Without them, they will have no idea (unless they set up an individual meter for the PHEV Charger) when the customer is charging their vehicle.

The Transformer

Utilities typically oversize transformers to accommodate the gradual growth in customer electric loads. Unfortunately, most utilities have little insight into the loading of their transformers. Therefore, some of the transformers currently in operation (especially those over 20 years old) may be approaching their capacity loading with the existing growth. PHEVs/EVs represent a major addition in load on the transformer.



Although transformers are relatively inexpensive and straightforward to replace compared to other distribution equipment, excessive loading can lead to a failure, outages and decreased reliability. Exacerbating this issue is the reality that "urban" transformers tend to serve more customers than their suburban and rural counterparts, and may be more heavily loaded.

Transformer Monitoring

Utilities who are installing smart grid infrastructure will have the foundation in place to implement real time transformer monitoring. This can be accomplished two different ways, depending on the extent of the smart grid infrastructure: 1) by aggregating the meter data of customers being served via the transformer; or 2) by measuring the voltage and current at the transformer and calculating the transformer loading. In both cases, data is collected at regular intervals and a transformer load profile is created. This profile can be compared against the rating of the transformer and alerts could be sent to the utility distribution operations team if a transformer is approaching an overload situation. This application exists today.

Feeders/Conductors

Transformers aren't the only devices than can be overloaded; the lines that transport electricity to consumers are also at risk. Similar to transformers, with proper planning these can also be replaced. However, re-conductoring a feeder is obviously more complicated process for underground systems than overhead ones.

Utility Coincident System Peaks and "Grid" Peaks

The primary focus of utilities – whose product historically has not been able to be stored – was to plan for its system peaks. These peaks typically occurred less than 200 hours a year, yet failure to match capacity with demand creates significant problems. Since PHEV/EVs represent a significant potential new form of customer demand, the immediate concern was how to manage the charging of vehicles to minimize the creation of new peaks. As a result, utilities are considering the creation of new rates and demand response programs to manage this issue; these are discussed below.

However, the other and potentially more immediate issue is identifying and managing the peak demand usage that may occur on different points of the grid where PHEVs will be located. The "grid peaks" in these cases may or may not correlate with the utility system peak. In short, utilities will need to proactively monitor all points of their distribution grid for potential "peak" times.

Time-of-Use (TOU) Rates

TOU rates have been repeatedly touted as the "silver bullet" to convince customers to charge their PHEVs off-peak. However, there has been limited experience with TOU rates through the U.S., where the majority of utilities still use fixed rate tariffs. Since it easily takes six months or more to file a rate case for a new tariff, utilities who believe they will see an increase of PHEVS should be investigating now the ramifications of a new rate.

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Furthermore, unless the PHEV is metered separately, implementation of a TOU rate would affect the total customer electric load. As an unintended result, the customer may have to alter his/her lifestyle and move additional load off peak to avoid electric bill increases from the adoption of a TOU rate required for the PHEV.

Demand Response Programs

The value of demand response programs increases with the addition of PHEV loads, and in different ways. Obviously, the original intent of demand response programs remains intact: to reduce customer loads in times of tight capacity. These programs can help utilities manage loads at their system peak. However, they will also help them manage issues that may arise on the distribution grid that may be caused by excessive load build up on lines, at transformers, even with potential phase overloading.

Conclusions and Recommendations

The Automotive Industry is clearly focused on developing vehicle and batteries that meet the customer's value propositions. The Recharging Industry is focused on the installation of public infrastructure. These are both critical components to a successful industry. Unfortunately, there has not been enough attention paid to one of the most basic – yet critical assumptions: the customers will charge their vehicles at home the majority of the time. It is in the best interest of the utilities to begin to lay the groundwork with their customers regarding the operation and "fueling" of PHEVs and EVs. Moreover, utilities are in a unique position to provide significant value to the industry and its customers through innovative marketing and energy management programs that will help customers optimize the use of their PHEV. It just needs to start now, while there is time to establish policies and programs.

Below are several recommendations a utility may consider if they are faced with the reality of PHEV/EV growth in its service territory:

Develop a PHEV Evaluation Service

Most utilities have developed energy audits programs that were offered to customers as a way of helping them learn about and manage their energy usage. This program could be expanded to include PHEV advisory services, and could cover 1) an electrical inspection to determine if their service entrance could accommodate the addition of a PHEV; 2) a "PHEV Energy Audit" that would give the customer an idea of the electricity costs associated with owning and operating a PHEV/EV; 3) an expanded home energy audit that would take into account the new PHEV, with an analysis of the customer's potential coincident peak, and recommendations for managing electric loads more efficiently; and if applicable 4) a TOU rate comparison and recommendation, which would simulate customer electric costs under different rate scenarios.

Determine a strategy for proactively influencing the customer's PHEV charging habits

The full spectrum of options have been anecdotally discussed recently from the implementation of TOU rates to the implementation of a HEMS to the installation of separate meter with a remote disconnect switch. Each option requires a unique (and sometime overlapping) set of activities to complete. Furthermore, they may intersect with activities underway today. The more proactive the utility, the better it will be able manage customer – and industry expectations. Finally, managing PHEV/EV charging habits will need to occur at the public charging stations as well as the home chargers; since these are already being installed today, utilities in certain areas may need to accelerate its strategy development.

Investigate – and then Implement – a Smart Grid

Most utilities have some sort of smart grid planning activity underway. Unfortunately, it takes a long time – years – to complete the business planning, technology research and testing, and regulatory filings to implement one. Fortunately, it will take several years for the PHEV/EV industry to get established in the United States. The hypothesis remains that PHEVs will have a more disruptive affect on the utility's distribution grid, than it will its generation capacity. In order to effectively manage the disruptions, the utility will need the ability to dynamically monitor the grid. ■

About the Author

David Mulder is the Director of Green Grid Initiatives at Capgemini. He focuses on the integration and operation of renewable resources and demand response programs on the utility's smart grid.

Dan Rastler

Haresh Kamath

Energy Storage: A Critical Asset to Enable Transformation to a Smart Grid

By Dan Rastler, Program Manager Energy Storage Program, and Haresh Kamath, Project Manager, Technology Innovation
Electric Power Research Institute (Palo Alto, California USA)

A confluence of industry drivers – including increased deployment of variable renewable generation, the high capital cost of managing grid peak demand, and investments in grid infrastructure for reliability and smart grid initiatives – is creating a new interest in utility-scale electric energy storage systems. Just as transmission and distribution (T&D) systems move electricity over distances to end users, energy storage systems can move electricity through time, providing it where and when it is needed. Energy storage systems can help balance variable renewable generation and, properly deployed and integrated, can help increase electric grid reliability and improve asset utilization. With improvements in the cost and commercial availability of energy storage technologies, electricity storage systems may play a pivotal role in influencing the impact of these industry drivers.

Operational Uses and Applications for Energy Storage

Energy storage systems can provide a variety of operational and energy management solutions, leading to various societal benefits along the entire electrical system value chain. Those solutions range from generation support to transmission and distribution support to end-customer uses. The Electric Power Research Institute (EPRI) is currently analyzing several key applications, as summarized in **Figure 1**, below. Of course, this list is hardly comprehensive; other energy storage applications exist, and still others may emerge in the future.

Figure 1: Energy Storage Applications along the Electric System Value Chain

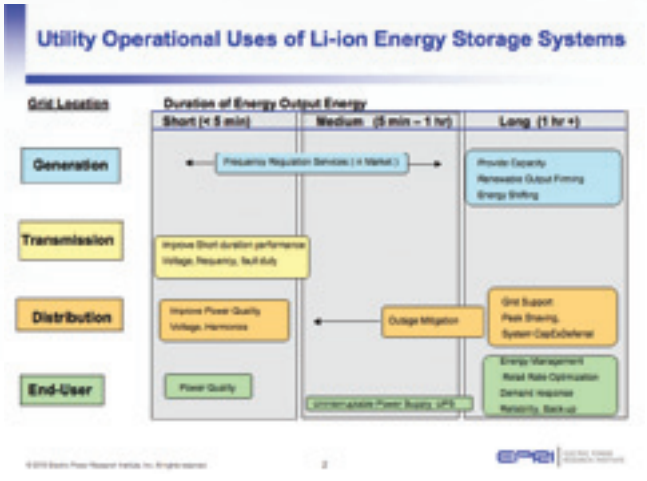
Accommodating the Variable Characteristics of Renewable Resources

Renewable energy is fundamentally changing the electricity industry's strategic landscape. The Energy Information Administration estimates that renewables could account for 17 percent of the electricity produced and delivered in the United States by 2035. Energy storage is one way to give system operators enhanced control over the grid, providing increased operational flexibility to accommodate the increased penetration of renewables. Storage products can provide a variety of services, depending on their power rating, storage capacity, and location.

Bulk storage technologies such as pumped hydro and compressed air energy storage (CAES) systems allow grid operators to store wind and solar energy produced during off-peak periods, for later dispatch into the grid during peak periods when the energy is needed. This capability gives operators control to respond to grid needs across a variety of time frames: From hour-to-hour to meet operational scheduling requirements to ensure power generation capacity is available when required; over a period of several minutes for load following; minute-to-minute for regulation; or in seconds to enhance grid stability.

Although distributed energy storage is more expensive on a per kW basis than bulk storage, it can provide many of the same functions – and more – on a smaller, distributed scale. Flexible, responsive and quiet, batteries and similar storage technologies can be located in distribution systems closer to end users to improve power flow control and grid reliability.

This is especially important in the presence of distributed renewable generation such as rooftop photovoltaic systems. The same storage systems can provide reserve, regulation, and load shifting control to system operators. In the future, it may be possible to aggregate large numbers of dispersed battery systems in smart grid designs to cost-effectively achieve bulk-storage operation.



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The Value of Energy Storage Systems

The ability to monetize and bundle energy storage benefits and capture all potential values to support a related business framework acceptable to regulators and utilities is one of the most challenging areas in supporting the business case for storage. In part, this is because the traditional methods used to evaluate the value of conventional generation sources do not adequately capture the range of benefits potentially provided by energy storage systems. On the one hand, storage systems are typically faster and more responsive than conventional generation. On the other, they are "energy limited" resources with limited discharge duration, in contrast to conventional generation systems, which provide power as long as they are provided with fuel.

A recent EPRI study estimated the range of values for the benefits of storage systems. **Table 1** (following) presents a summary of the potential range of key benefits identified in the study.

Benefit	Estimated lifetime value $/kWh	Estimated lifetime value $/kW
Distribution CapEx Deferral	150-700	200-1500
Transmission Congestion	40-190	370-1800
Transmission Access Charge	130-670	230-1150
Local Capacity	350-1750	670-3350
Regulation	300-1500	375-1800
Retail TOU	380-1900	540-2700
Retail Demand Charges	140-700	460-2300

The value of each benefit in this table is calculated for a system delivering 1 MW of power; 2 MWh of storage capacity; 15-year life; and a 10% discount rate, operated so as to provide only that single benefit.

Regulation, system capacity, and deferring capital expenses for transmission or distribution investments potentially provide the highest value for using storage systems. From a customer perspective, using storage to reduce retail time of use charges and demand charges could bring significant value. A key finding confirms that energy storage systems must deliver multiple benefits to justify their relative high cost.

Policy Challenges

The value of energy storage to its users will also be strongly affected by policy. Energy storage systems have characteristics of generation, grid assets, and load, without falling clearly into any of the three categories. This complicates rules for ownership and operation by various entities related to the power industry. Regulatory agencies have not yet defined rules for ownership when storage can be used.

Policy rules regarding allocation of costs incurred by adding storage systems to the grid have not been clearly developed. The bi-directional energy flow complicates fitting storage applications into the range of existing market products, and ultimately, economic benefits will strongly depend on adopted policy and their regulation.

Grid Ready Storage by 2015

No single storage technology can meet all of the applications needs of the power grid, and a wide variety of options are being proposed for utility-scale storage uses. EPRI has identified two leading energy storage technologies for near-term demonstrations: compressed air energy storage (CAES), which could be the most cost-effective bulk storage technology for long discharge (8-10 hrs) duration, and lithium-ion batteries, potentially the most cost-effective option for shorter durations (< 4 hrs). While other energy storage technologies also have technical and economic promise, lithium-ion and CAES each have a clear, broad path to scale production based on other markets, which will bring down the costs of these technologies.

Automakers have turned to lithium-ion batteries to power the new generation of electric vehicles and plug-in hybrid electric vehicles, which are currently being commercialized and readied for mass-market deployment. As a result, lithium-ion batteries have attracted billions of dollars in research and development money, as well as enormous investments in production capacity. Annual production of lithium-ion batteries is projected to achieve more than 30 GWh of storage capacity by 2015.

This new production capacity is expected to drive battery module costs down to less than $300 per kWh, making lithium-ion highly attractive for distributed utility applications. Grid applications can also take advantage of the high energy density, long cycle life, and high efficiency of modern lithium-ion technology.

Regardless of technology, the challenge, in the short term, will be to confirm that the storage products available for utility application are "grid-ready;" that is, they must have a proven track record of safety, performance and reliability in grid-connected applications as well as contain communication and control features required by a smart grid. EPRI's research aims to answer the questions that utilities, system operators, power producers, and other stakeholders must ask, to enable energy storage products to meet the goals of balancing renewable generation while enhancing grid reliability and asset utilization.

About the Authors

Dan Rastler is the Technical Leader of the Distributed Energy Resources, Energy Storage, and Hydrogen-Electric programs within the EPRI Power Delivery and Utilization Sector, where responsibilities include development, execution, and management of EPRI's R&D programs focused on distributed resources, energy storage, and hydrogen. He has managed research efforts involving technology assessment and market analysis, electrical integration, and distributed generation and energy storage hardware demonstration projects. Rastler is a world-recognized authority on distributed generation and emerging alternative clean energy technologies. He holds a BS degree in chemical engineering from the University of California at Davis and an MS degree in mechanical engineering from the University of California at Berkeley.

Haresh Kamath is currently serving a stint as a Strategic Program Manager in EPRI's Technology Innovation Program, where he manages a program investigating advanced materials technologies for grid transformation. He is also a Senior Project Manager in the Power Delivery and Utilization (PDU) Sector where his current research activities focus on the development, assessment, and application of energy storage technologies for both transportation and grid storage applications.

Kamath joined the EPRI Power Electronics Applications Center (PEAC) in 2002 as a project engineer in energy storage and distributed generation. His responsibilities grew to include management of the energy technologies group, encompassing EPRI Solutions efforts in energy storage, distributed generation, energy efficiency, and electric transportation. Kamath was an author for the DOE-EPRI Handbook of Energy Storage and serves on the board of directors of the Electricity Storage Association. He received his Bachelor's and Master's degrees in chemical engineering from Stanford University.

Martine Hamel

Charles Sarthou

Integration of innovative technologies in Hydro-Québec's Utility Vegetation Management (UVM) Program

By Martine Hamel, F.Eng., Ph.D. Hydro-Québec Distribution
Charles Sarthou, F.Eng., Hydro-Québec TransÉnergie

Technological innovation is a powerful engine for growth and performance, and Hydro-Québec is counting on new technologies to remain on the leading edge of its industry, improve customer services and further enhance its performance. That is why Hydro-Québec will continue to integrate leading-edge technology tools into its Utility Vegetation Management (UVM) programs, an area of technology development and deployment that is becoming one of the main thrusts of it's innovation efforts.

Hydro-Québec TransÉnergie (HQT) and Hydro-Québec Distribution (HQD) operate extensive transmission and distribution systems with more than 30,000 km (18,600 miles) of transmission lines and 110,000 km (68,350 miles) of distribution lines serving 3.3 million customers within the Province of Québec. In addition, Hydro-Québec has 15 interconnections with neighboring transmission systems in the US as well as in other Canadian provinces. These transmission and distribution systems need efficient Utility Vegetation Management (UVM) programs in order to reach the uppermost level of reliability. These two UVM programs can be summarized in six activities; which are: 1-Planning, 2-Inventory, 3-Prescription, 4-Tendering and Contracting, 5-Operations & Monitoring, and 6-Reporting. This article gives some examples of what actually is – or could be – HQT and HQD choices for improving the efficiency of each element (i.e., T&D) in the near future.

Planning

"Technology is already an important component of our vegetation management plans. But in the near future, we plan to integrate even more geospatial information (most derived from high-resolution aerial photography) to our program which will help improve the reliability of our six level of activities – a vital issue to Hydro Quebec."

– Charles Sarthou, Forest Engineer, Hydro-Quebec

The main philosophy of Hydro-Québec's UVM programs is the better the information you have, the better you can plan. Electric grid information, vegetation inventories, environmental issues, topographic information, land ownership and access roads, are the kind of information that feed Hydro-Québec's Geographic Information Systems. The analysis of this information is essential to determine the optimal vegetation cycle for each span.

To improve its planning, HQT will use a highly detailed ecological type layer provided by the Québec Ministry of Natural Resources to divide the territory. This information is then combined with new and existing field information to develop reliable local vegetation growth or vegetation density projection models into Right-of-Ways (ROWs). As field data is used to refine the different types of ecological layers, the model processes will be improved at each treatment cycle as field information is gathered, with the goal being accurate micro-models for each span.

For HQD, an interesting research avenue to improve the workload planning is to use macro level functional vegetation groups. First, the creation of these groups – around 10 for the entire province of Québec – is based mainly on digital imagery and existing dendrometric information, the latter pertaining to tree growth models. Those functional groups are then linked to climate, soil and growth competition to form a composite growth algorithm. This new layer of information can then be integrated into the GIS.

Inventory

Hydro-Québec's transmission ROWs are spread across the Province of Québec. To be as efficient as possible, HQT's vegetation specialists developed inventory methods that use aerial, high-resolution digital images to see the details of the vegetation without actually being in the field. These aerial images are used to quickly evaluate and map the vegetation along the HQT ROWs. Those images allow stereoscopic viewing directly on computer screens to evaluate vegetation height, density and composition and to map that information directly into a GIS.

Light Detection and Ranging (LiDAR) technology and high-density point cloud extracted from aerial photography – two promising new tools – are used for vegetation inventory on a test pilot basis to obtain the most accurate information about clearances between transmission lines and vegetation. These tools are expected to be of great help in identifying potential vegetative threats in a near future.

For distribution lines, ground patrols are performed to evaluate vegetation control needs. Each vegetation control technician is equipped with a laptop computer feeding local data storage that is synchronized with the central database on a daily basis. But even if this system works well, real-time database access may also be needed to reduce reaction times, alleviate time constraints, meet deadlines and help preserve data consistency.

Prescription

A decisional matrix is being developed by Hydro-Québec's vegetation specialists to help with selecting vegetation control interventions in transmission Right-of-Ways.

The first step in this process is to input the physical components of an intervention area into the matrix. These components include land occupancy, vegetation height and density, distribution of physical areas, vegetation dynamics, sensitive components, and access and movement into the ROWs.

Second, the integrated vegetation management objectives are entered into the matrix. Typical objectives might include promoting compatible vegetation, protecting the environment, optimizing the growth cycle and cost effectiveness, etc. Of course, each of these objectives is carefully evaluated to reflect Hydro-Québec's many operational priorities.

Based on these inputs, the matrix helps to produce the best treatment prescription for effectively and economically controlling vegetation. These kinds of tools also provide technical assistance in determining and applying the proper treatment at the right location at the best time. Moreover, the development of this kind of matrix facilitates an efficient and effective dialogue between the planning team and field personnel.

Tendering and Contracting

Formal tendering documents are created from prescription information. The Internet is used extensively by Hydro-Québec to optimize the tendering process by reducing document transmission times and maximizing the information needing to be broadcast to potential contractors and other suppliers.

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In the near future, Hydro-Québec may also use the Internet for online reverse auctions for certain bid opportunities. Hydro-Québec is also exploring the possibility of giving access to bidders for GIS data and aerial images via an online GIS tool. With better information, Hydro-Québec can give its contractors tools that can help them to better evaluate vegetation control jobs, and minimize unforeseen risks. By doing so, contractors can develop more accurate pricing that more closely relates to actual field conditions and requirements.

Majors changes are also in sight regarding the management practices of silviculture companies. A new certification program has been developed by the Bureau de normalisation du Québec (BNQ) with the objective of eliminating unfair labor practices. The implementation of this certification program and the inclusion of a registration management system will be in force by September 2010 and mandatory for all silviculture work performed in the Province's public forest domain. HQ intends to also implement this policy within its UVM programs in the near future. In a context of labor scarcity, HQ believes in the importance of avoiding unhealthy competition like moonlighting, subcontracting chains and health & safety noncompliance. Technology can help us cope with these new management trends.

Operations & Monitoring

As Kevin Eckert, Arbor Global's founder, President and Managing Director, once said, "You get what you inspect; not what you expect!" Indeed, the main purpose of monitoring is to support day-to-day operations, but there are also additional reasons for monitoring. For example, monitoring should ease the tracking of productivity and facilitate environmental awareness as well as help to improve public relations by doing a better job, both at the planning and at the execution stages. It is also the starting point to make the basic data available for the service evaluation process, which is why, in Hydro-Québec's opinion, this part of any UVM program greatly benefits from available technology solutions. For example, HQT technical personnel will use tablet-PCs to bring the office to the field, providing access to data, work orders and other information they require to maintain a complete and comprehensive monitoring posture.

> "You get what you inspect; not what you expect!"
>
> **– Kevin Eckert, Arbor Global President & Managing Director**

This field monitoring application has five main modules...

The first of these is called *Command* and generates the tree structure where each folder contains the data related to each contract. This module also allow us to enter the work progress schedule of each contract.

The second module is called *Areas Monitoring*. As the name suggests, the goal is to document the completed areas as well as the method in which they were performed using the GIS data generated in the Inventory process. If non-compliant, to project specifications, the area is rejected and policy dictates that the work be retaken.

The third module is called *Production Follow-up*. Although, it should be mostly useful for Time and Material (T&M) contracts, this module allows a precise monitoring of the productive and unproductive activities, very useful to rectify potential problems.

The fourth module is called *Expertise & Know-how*. This new module will be tested this summer. Its goal is to documented the "soft" parts of contracts like report consistency, workers performance, respect of the living environment, compliance with health & safety plans, business relations, customer orientation, etc. In fact, we believe that "soft" can be scientific if you obtain quantifiable data, rely on a systematic method and focus on objectivity.

The last module, called *Qualification Process Monitoring*, will integrate data from *Areas Monitoring* and from *Expertise* and Know-how to give facts oriented rating of global ("hard" and "soft") contractor's performance. The main challenge of this module will be to find the right rate for each test point.

Reporting

The reporting component captures and documents the facts needed to insure that what has to be done is actually being worked on and completed. But it takes more than just of rows and columns of data, tables and graphs to represent key indicators like cost and surface area. In fact, surface area by itself is the kind of indicator that is no longer sufficient for HQT. Complying with clearing rules – specifically NERC Standard FAC-003-1 – necessitates an increased frequency for measuring and monitoring vegetation reliability threats. Thus, a close link must be made with all the previous parts, including data warehouses that are designed to facilitate reporting and analysis.

It is also important to close the entire UVM program cycle. One way to do that is by integrating many tools into a single software package – a promising new trend that is quickly gaining momentum. By combining powerful databases with GPS technology, LiDAR data and high-resolution orthographic photos, a much more encompassing UVM program can be undertaken and more complete results can be obtained as a result.

Finally, the reporting system – or data warehouse – should measure overall work efficiency. This is closely linked to the related cost per unit (e.g., ha, km, span), but it should also reflect compliance with the updated workload as progress is made and the cycle is completed. This type of continuous monitoring is also a first step toward appropriately adjusting UVM funding and spending, rather than basing such budgeting and expenditures solely on historical practices and amounts.

Conclusion

Utility vegetation management is a vital reliability issue. The immediate impact of the Northeast Blackout of 2003 was not only the loss of 80% of the energy load in New York, but also the birth of the fear that it may append again and again. The investigation joint task force, formed by the governments of Canada and of the United States, concluded that the main cause of the blackout was a failure to trim trees. We, the system foresters, understood the lesson. Since then, a considerable amount of field work is being carried out each year and a great deal of "brain power" is currently at work on the issue.

We think that finding new ways to save time, money and be more effective using innovative technologies for vegetation management programs are all important ingredients in continuous improvement of UVM programs from both a budgeting and an execution perspective. The integration of environmental and social concerns is also a fundamental prerequisite that can be more easily accommodated with a little help from technology. Hydro-Québec is counting on its strategic and technical personnel to carefully choose (and skilfully) use innovative technologies to improve its performance in the UVM area. All six parts of UVM programs can be supported by these tools. ■

About the Authors

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Finding Convergence: What Will Make or Break the Smart Grid

Capitalizing on the indelible impact of developer, utility, regulatory, and consumer convergence on Smart Grid infrastructure design and engineering

By David L. Bassett, PE

The long-term success of the Smart Grid hinges on the intersection of numerous essential factors: timing, vision, determination to overcome daunting challenges, and the willingness of key stakeholders – private corporations, government entities, and the general public – to come together to realize its full potential and benefit. And it is our ability to once again find and leverage this convergence that will make or break the Smart Grid.

On the Edge of Occam's Razor

The old adage of "a rising tide lifts all boats" has never been truer than in the case of the emerging Smart Grid. The Smart Grid offers nearly limitless opportunities and advantages; it is an open door to the creation of a safer, more durable, and more efficient global power grid. The Smart Grid holds the promise of greater energy independence, increased economic prosperity, and improved stewardship of our finite natural resources. For all of this boundless potential, there are very real risks and obstacles that may yet impede its execution, stalling its current groundswell of forward momentum.

As a critical infrastructure component, the Smart Grid is by its very nature, a multifaceted organism layered with manifold interdependencies and symbiotic relationships. With this inherent complexity, global Smart Grid architectures cannot be developed and deployed by any one single, isolated entity. Rather, its successful design and engineering can only be achieved through an ongoing, evolutionary process that takes into account and is influenced on all sides by a myriad of individuals and organizations – developers, utilities, standards bodies, regulatory agencies, and consumers alike. But with so many different forces in play, there is a very real risk that the timely design and deployment process for mission-critical Smart Grid infrastructures may be profoundly impacted by unexpected changes in focus and scope – or worse – gripped by inertia and entropy.

So how do we as developers, engineers, and architects, meet the challenge of developing and deploying effective Smart Grid technologies and infrastructures without the process stagnating and deteriorating into discord? How do we gain buy-in from key constituencies without falling into unproductive battles over philosophy differences and minutiae? Paraphrasing and applying the principles of Occam's Razor – the simplest route is usually the best – can keep the Smart Grid infrastructure design and engineering process moving forward. Or, as better stated by David Henry Thoreau, *Simplify, simplify...*

- Present all stakeholders unambiguous and concisely stated goals, objectives, and requirements laid out in simple, clear language;
- Provide ample, easily accessible channels for providing input and feedback
- Pursue The Three C's: Communication, Collaboration and Consensus

It is essential to find a way to simply approach, communicate, and engage with these converging constituencies now, in the formative stages of infrastructure development, in order to capitalize on the full potential that the Smart Grid offers.

C is for: Communication

With this continued convergence of key Smart Grid stakeholders set to permanently shape its future, open and uncomplicated communications are increasingly important. "Communications" here is a play on words, referring not only to the act of imparting information or exchanging thoughts and opinions between constituencies, but to the physical systems that interlink the diverse elements within the Smart Grid, as well.

Nearly every aspect of the Smart Grid is dependent on communications in some fashion. It is absolutely essential that information and data can be generated, collected, and transmitted across all points on the grid, including utilities, regulatory agencies, and consumers. But just as important as the ability to transmit, is the type of data that is passed on.

All key stakeholders have data that is important to their own interests. Utilities need to gather and analyze critical real-time information – consumption volumes, central versus distributed resources, and load levels. Regulatory agencies and government entities need guidance on overall supply availability, environmental impacts, and grid security conditions. Consumers want to know about factors impacting their life, such as rates and pricing, and potential effect on monthly utility bills.

Architecting an artful solution addressing all of these needs and conditions is challenging, at best. However, with careful consideration and open lines of communication, Smart Grid developers and engineers will find that it can indeed be done by:

- Leveraging existing and emerging standards and technologies promoting greater interoperability, integration, and communications between fundamental elements such as SCADA systems and installed devices
- Adopting a long-tailed view that anticipates changes in regulatory operational and reporting requirements, future-proofing Smart Grid infrastructure design by incorporating flexible, scalable frameworks that can be easily adapted for these changes
- Emulating and integrating best-of-breed consumer product technologies, such as touch screens and Short Message Service (SMS), to deliver customer information intuitively across familiar channels, such as email, the Web, and mobile devices

Communication is just as critical in the physical operation and control of the global Smart Grid as it is in its creation. Without establishing secure, forward-looking, flexible communications channels between grid control systems and installed devices, the Smart Grid may wind up as yet another piece of crumbling infrastructure needing extensive overhaul or replacement just years down the road. By the same token, without clear and open lines of communications between all stakeholders, the infrastructure design, development, and engineering process can easily be stalled, bogging down under the weight of conflicting priorities and disagreements.

C is for: Collaboration

As noted by celebrated industrialist and philanthropist, Andrew Carnegie, "Teamwork is the ability to work together toward a common vision. It is the fuel that allows common people to attain uncommon results." In our world today, some of our greatest inventions and discoveries are the result of collaborative efforts – without the process of collaboration, neither would diabetes sufferers have insulin to control the affects of their disease, nor would we have Hypertext Transfer Protocol, better known as HTTP, which facilitates the transmission of information over the Internet. Collaboration is a proven path to success for those daring enough to walk it.

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While not every collaborative effort bears fruit, the Smart Grid, with its interdependent, multifaceted nature, offers fertile ground for successful collaboration between stakeholders. The easiest parallel for the modern power ecosystem is that of an interlocking chain. Each link – equipment suppliers, technology developers, utilities, policymakers, and consumers, for example – relies on the next, forming an unending circle that benefits all involved. Previously, collaboration and cooperation between these diverse players was often an uneasy affair, occurring only when absolutely necessary. Success was often accidental in nature, an unexpected and rare result coming only after extensive, laborious, and costly trial-and-error processes had been exhausted.

The electric industry is in the midst of a paradigm shift in the way that its product is produced, delivered, managed, and consumed. Technology developers, utilities, standards bodies, and regulatory agencies, backed by needed funding from policymakers and fueled by consumer acceptance and understanding, must work side-by-side to ensure the global Smart Grid moves from the conceptual to the concrete, facilitating an accessible, affordable, reliable, and clean supply of power:

- Technology developers, energy producers, and standards organizations must work together in the development of best-practice methodologies, standards, and architectures for producing a cleaner, and more secure and efficient energy network, as well as devising new ways of incorporating renewable energy sources
- Cooperation among policymakers, regulatory agencies, and utilities will enable greater long-term capital investments and funding for new Smart Grid initiatives and infrastructures
- By educating and engaging with consumers about the benefits of the Smart Grid, utilities and regulatory agencies can achieve a better understanding of consumer needs and concerns, and devise strategies for addressing them

Only with all stakeholders working collaboratively towards a common goal in a public-private partnership, can we realize the creation of a secure, interconnected power generation, transmission, and distribution network, unhampered by interoperability challenges and consumer mistrust.

C is for: Consensus

The final of the three C's stands for consensus – or perhaps more appropriately, consensus-building. While better lines of communications and greater stakeholder collaboration are both critical to the success of the Smart Grid, this final element is the one that may ultimately make or break the Smart Grid, particularly when it comes to end-user acceptance of Smart Grid technologies.

According to the U.S. Department of Energy, if the nation's grid could achieve just five percent greater efficiency, the energy savings would be equal to permanently eliminating fuel and greenhouse emissions from 53 million automobiles. But with this remarkable potential benefit, consumers are skeptical of and even resistant to Smart Grid technologies, such as smart meters, which are being rolled out in select markets across the country and around the world. Smart meter deployments in California and Texas have become lightning rods for controversy, drawing vocal complaints over utility bills, potential health and safety impacts, and privacy concerns. The fevered pitch of consumer complaints even led Fairfax, California – a usually tranquil community in Marin County – to ask for a moratorium on smart meter installations in its city. It is a powerful reminder that positive customer perceptions of the Smart Grid are critical to its ultimate success.

Many consumers today are conscious of the benefits that increased energy efficiency brings; witness the recent success of "cash for clunkers" appliance rebates rewarding consumers for replacing inefficient appliances with new Energy Star-compliant ones. With tangible cost savings bolstered by effective educational initiatives, consumers have come to not only accept, but demand energy efficient appliances for their homes. Yet these same energy conscious consumers are vocal in their objection to smart meters, skeptical of the idea of a Smart Grid.

Because of this inherent consumer mistrust of smart meters and doubts about whether a smarter grid is even within the realm of possibility, the energy industry and policymakers have some work to do in building a consensus between themselves and consumers.

Industry and public sector stakeholders must address consumer concerns, educating them about the full potential and opportunities offered by deployment of the global Smart Grid before it can work to its ultimate capabilities. Some of these steps are:

- Engage in customer education initiatives in channels and mediums where they are most comfortable, such as via email, the Internet and Web, or town hall-style meetings
- Provide consumers with ample opportunities to register their concerns and provide feedback, then provide a meaningful response to these concerns such as hands-on demonstrations of smart meters and other Smart Grid technologies
- Continue to provide participation incentives, much like the successful appliance rebate programs; consumers are more likely to accept smart meters and Smart Grid technologies if there is a clear and direct financial benefit

Achieving ubiquitous consumer acceptance is not a luxury; it is an imperative if the Smart Grid is to reach its apex potential. With intelligent, proactive outreach, it is possible to turn consumers into actively engaged proponents, laying a firm foundation for the future of the Smart Grid.

Make-or-Break Time: Getting Serious About the Smart Grid

Although serious attempts at developing technologies to support a smarter power grid have been ongoing in one form or another since the 1980s, only now has the emerging global Smart Grid truly become a priority. As the world's power grid infrastructures continue to age and deteriorate, the reality is that this is make-or-break time for the Smart Grid.

All stakeholders must understand that current grid infrastructures are not effectively able to keep pace with challenges and issues such as security threats, increasing demand both in industrialized and developing nations, and the need for better use and management of dwindling natural resources. Therefore, now is the time to invest the time, money, and effort needed to bring the global Smart Grid to fruition. By finding, achieving, and leveraging the combined strength of all constituencies, we can successfully develop and deploy the robust infrastructure needed to support the Smart Grid, thus securing and preserving accessibility to a dependable, uninterruptable power supply – not just for today but for generations to come. ■

About the Author

David L. Bassett is a Senior Member of IEEE, as well as a Senior Staff Engineer/Scientist for PPL Electric Utilities (www.pplelectric.com). David's IEEE activities include acting as Vice Chairman of the 1547.2 application guide for IEEE 1547 series of standards and guides, being a participant of the working group of IEEE 1547.4 Guide for Design, Operation, and Integration of Distributed Resource Island Systems with Electric Power Systems, as well as an active participant in all of the IEEE 1547 standards and participating as an active member of the IEEE Standards Board.

His current responsibilities at PPL Electric Utilities include a wide variety of projects including design of 500 kV protection systems, application of PLC equipment in substations, standards for connection of Non-Utility Generation (NUG) and IPP (Independent Power Producers) to the electric grid. David is a recognized technical specialist in the area of protective relaying, particularly in the protection requirements for NUGs and IPPs.

David graduated from Penn Morton College (now Widener University) with a Bachelor of Engineering degree. He has held registration as Professional Engineer in the State of Pennsylvania continually since 1977. He also holds a software patent for PLC logic and is the author of several papers related to substation control systems.

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Energy Storage for the Grid

By Chad Hall, Chief Operating Officer
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In the past decade, the topics of energy production and storage have become a high priority for business and government, both of which have increased concerns relating to the environment and the sustainability of energy sources for the future. The latest policies are designed to reduce the use of fossil fuels in favor of clean, green electrical energy, and current government policy is designed to promote this approach by encouraging energy conservation and the utilization of more renewable energy sources for the production of electrical energy. With the shift toward renewable sources of energy such as wind and solar comes a new set of technical problems. The primary shortcoming of such sources of power is their intermittent nature. The history of power quality problems on the existing, aging system will only continue to worsen as intermittent, renewable energy systems are added. With intermittence comes the urgent need to develop reliable, fast-acting energy storage.

The main source of stored energy is fossil fuel in its various forms. These include crude oil, natural gas, and coal, which are used to fuel all forms of transportation, as well as for the generation of electrical energy. Nuclear fuels are used to a lesser extent in the production of electrical energy. In 2008, for example, coal or natural gas-fueled plants produced approximately 70 percent of all electrical energy, whereas nuclear plants produced only about 20 percent. Both sources of fuel have fallen into disfavor due to environmental concerns and the unsustainable reality of fossil fuels. Recently, more emphasis has been put on wind and solar sources as favor shifts to renewable energy sources, which are perceived to have little or no environmental impact.

Symbiosis of Wind and Solar

In 2008, only about 3 percent of electrical energy in the United States was from renewable sources, but according to the American Wind Energy Association (AWEA), 20 percent of the nation's supply of electrical energy will come from wind energy by 2030. In 2008 alone, an additional 8,500 MW of capacity was added, increasing the cumulative total of wind-generated electrical energy by nearly 50 percent.

Photovoltaic systems have not achieved the degree of prominence for commercial energy production as wind generation, however there are efforts underway to make it another potential of "green" energy. In the end, the sun shines during the day and the wind blows at night. Both have intermittency problems – the clouds reduce solar production and wind speed and direction changes constantly. A storage system with high "cycle-ability" and high energy and power density is required to provide stability to the system.

Demand Changes

The challenge to any commercial producer of electrical energy is the requirement to meet current demand, which is to a great extent because it is difficult and expensive to store electrical energy. Demand changes come in two flavors: long- and short-term. The long-term changes are those that occur at a gradual rate, illustrated by the summertime increase in demand that accompanies a period of sultry weather and resulting in the widespread use of air conditioners. This type of demand increase can be handled by the utility, provided it has sufficient capacity or can buy reserves from a neighboring utility via the grid network.

Far more ubiquitous are short-term increases in demand that result from a sudden change in load that might occur when large machinery is brought online in a manufacturing facility. Indeed, the majority of fluctuations occur for a period of less than two seconds, and such momentary changes in demand represent the biggest headache for utilities as they lead to reduced power quality.

The Power Quality Drain

Power quality is another major issue, as most customers require high power quality to ensure the proper operation of their equipment; in the 2007 report, *Providing Power Quality for 21st Century Needs*, the National Energy Technology Laboratory for the Department of Energy estimated that power quality problems cost U.S. companies more than $100 billion per year.

Power quality is also affected by the aging delivery infrastructure. The transmission lines in many areas are overloaded, leading to higher line and power losses due to reactance created by an ever-increasing inductive load. With the proliferation of more and more electronic devices and electric motors, inductive load is increasing, which in turn requires more and more reactive power to reduce the real power that is delivered by utilities.

This trend not only reduces profits to operators but also exacerbates the problems associated with the efficient delivery of quality power to the end user. The power grid in the United States can be thought of as three regional grids that are loosely connected. The Northeast portion, the Western portion, and Texas are more or less integrated grid networks, loosely coupled in the sense that they operate in a semi-autonomous fashion. Regulations have changed, and it would now be far more advantageous for independent system operators to have a fully integrated grid network so that power can be dispatched between locations that are separated by great distances. However, the grid that is currently in place is not integrated, and trying to use it as if it were is also a problem in terms of power quality.

The grid has evolved with no real long-range plan, and as a consequence, the current grid network is a patchwork of transmission lines. All things considered, it works remarkably well; however, unless the problems of the grid are addressed in the short term, the situation will worsen, resulting in more frequent and widespread power outages, reduced power quality and the possibility of equipment damage.

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Plugging the Drain

If one makes the assumption that the electrical power grid is going to remain, at best, fragile for the foreseeable future, other methods for mitigating power quality losses must be considered. Two readily apparent methodologies that could alleviate this problem would be: 1) Reduce the demands placed on the grid infrastructure; and 2) consider alternatives that would allow end users (or localities) to improve power quality in ways that do not depend on the grid infrastructure. Ultracapacitors, in combination with either or both of the foregoing methodologies would function well with an associated power electronics interface to address the short-term interruptions.

Energy Storage Alternatives

Spinning reserve, pumped-hydro, flywheels, and high-pressure air are all used to provide energy storage to electrical utility operators.

Spinning Reserve

Spinning reserve is the practice of having a generating station running – but offline – until demand increases require additional generating capacity to be brought on line. Spinning reserve is expensive and inefficient, requiring the utility to use fuel to run a generating station that may be idling for long periods of time.

Pumped Hydro

The pumped-hydro method allows a utility to produce energy at a relatively constant rate and use periods of low demand to pump water into an elevated holding area; when demand increases, the water can be used to produce hydro electricity by recapturing the gravitational potential energy.

Flywheels

The flywheel system uses power during periods of low demand to put energy into flywheels whose energy is recaptured when demand increases, and in a like manner, high pressure air is accumulated when demand is low and used to drive a turbine under conditions of increased demand.

Smart Grid Enablement

But these methods all require specialized conditions and are expensive. For example, in the case of pumped-hydro storage, a facility with a large reservoir is required along with the ancillary hydro generating equipment. High-pressure air is generally stored in a large, natural cavern or abandoned mine, and as these are not readily available, the usefulness of this approach is limited. And flywheel farms require high maintenance causing several prototype facilities to be taken out of service for that reason. All of these methods have significant drawbacks, and due to their expense and limited availability, require a smart grid network to make them viable.

The investment, for example, in a high-pressure air system requires a cavern or abandoned mine, the installation of the machinery to operate the system, and a cost benefit analysis to ensure the system will be cost efficient. This will then require that the energy produced can be conveyed to regions of the country in need of the extra capacity and thus the need for a reliable and efficient grid network.

A Better Way

The systems described thus far are not portable, require an expensive infrastructure and added transmission, and are not efficient for addressing the short-term sags described above. More suitable solutions for short-term sags are batteries and/or ultracapacitors. Both are portable, allowing them to be installed in virtually any location or substation, are efficient for short-term sags, and provide for faster return-on-investment than large installations. It is relatively easy to build a megawatt of capacity using batteries, ultracapacitors, or a combination of both that will function well with an associated power electronics interface to address the short-term interruptions previously mentioned.

The parallel combination has both high energy and power density. Ultracapacitors, like all capacitors, have a high power density. What differentiates ultracapacitors from their traditional counterparts, electrolytic capacitors, is their high energy density, allowing them to store a vast amount of energy in a small package. The capacitors with which most design engineers are familiar have short time constants, which mean that their voltage cycles quickly.

By contrast, ultracapacitor arrays have time constants of the order of tens of seconds to minutes. The large capacitance and extremely low frequency time constants allow ultracapacitors to be used in applications that have not been practical or economical for other types of capacitors. Using such supplies in concert with power electronic techniques make the design and cost of power conditioning equipment available to most volume users of electrical energy. As the sophistication of power conditioners increases, their costs will come down, and it is possible such systems will be available for a much wider spectrum of power consumers. Since ultracapacitors have a much lower internal resistance and much faster charge rate than batteries, they can make a battery-powered system run much more efficiently.

An array of ultracapacitor cells in series coupled to a load in parallel with a storage battery creates a hybrid power source with higher power and energy density than either device in a stand-alone configuration. By gradually taking on a load, batteries are insulated from high current drains that cause thermal, chemical, and mechanical stresses.

By reducing current spikes, the internal temperature of batteries is decreased substantially, extending the life of the batteries by as much a 400 percent, depending on the application. Additionally, there are times when a battery simply cannot deliver the current needed for an application, and in particular when you need to continually charge and discharge, such as is needed for load leveling. Conversely, there are times when an ultracapacitor alone will not work, in particular when there is a need for extended discharge for minutes or hours.

Conclusion

As the electrical infrastructure evolves to utilize renewable sources of energy, the arsenal of storage devices will need to be increased. With this increase in renewable energy sources of electrical energy, it is apparent that solutions will be required to include an intermediate storage media that can function in the short term and longer term increase in demand, making the production of local electrical energy more practical. Financial drivers dictate this trend; local production that utilizes renewable sources will go a long way to relieve stress on the grid infrastructure and will use resources more efficiently. In order to make this a reality, it will be necessary to develop robust energy storage media that will likely include improved batteries and high-energy density ultracapacitors.

About the Author

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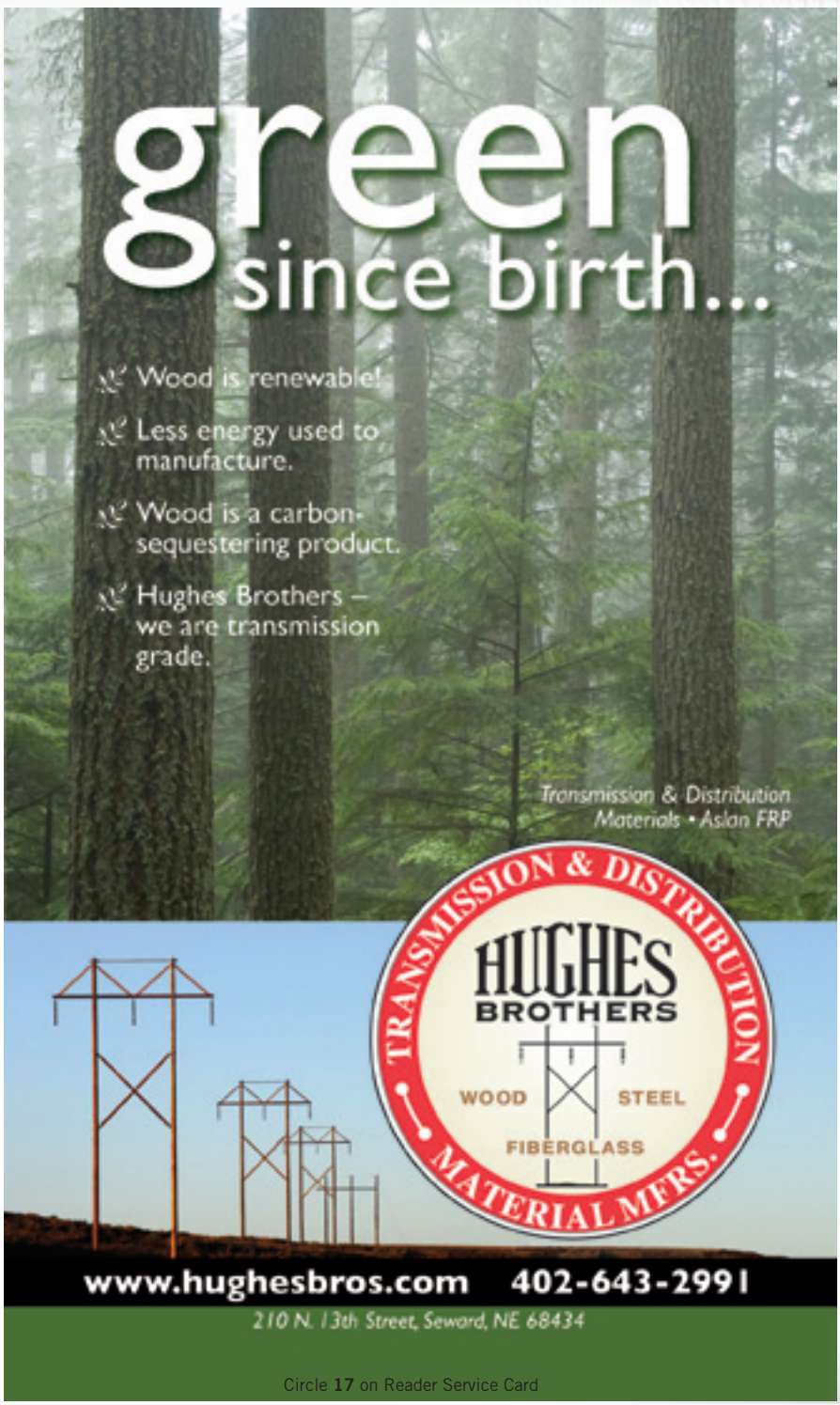

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Build a Smarter Smart Grid with a Multi-Technology Communications Approach

By Philippe Guillemette, Senior VP-Advanced Technology, Sierra Wireless and Michael Longrie, Vice President-Product Management, Elster Solutions

Knowledge is power. It's a lesson that the energy industry has taken to heart, as utilities around the globe build out new "Smart Grid" technologies to optimize antiquated grids. Smart grids hold the potential to transform the way electricity is generated, distributed, and consumed. With end-to-end intelligence about electricity transmission and demand, utilities will be able to reduce peak consumption by shifting demand loads, and boost efficiency through improved diagnostics – all of which will help to improve forecasting. Utilities have been quick to recognize this potential, and are rapidly making smart grids a reality. According to international market research firm, IDC Energy Insights, North American spending on intelligent grid technology will reach $17.5 billion by 2013[1]. And, ABI Research – another noted research firm – projects that about 212 million smart meters will be deployed worldwide by 2014... up from 76 million in 2009[2].

Current smart grid investments span a broad range of technologies, but operators are focusing particularly on distribution systems. They are making investments that will modernize the power grid. One such area of investment is advanced metering infrastructure (AMI). AMI uses smart meters to help modernize the grid by providing the ability to remotely monitor and transfer energy consumption and power quality information more frequently and reliably, allowing utilities to work with their customers to manage the distribution network more efficiently.

By combining smart metering with home-area network (HAN) applications, consumers will soon be able to link "smart" thermostats, appliances and even electric vehicles with the metering infrastructure. Ultimately, they will be able to respond on a minute-by-minute basis to energy pricing changes, and remotely shift demand into off-peak periods when energy is more available and less expensive.

To make these benefits a reality, however, utilities need robust and flexible communication systems to meet the diverse network requirements throughout their service territory. It's a given that communication is central to the basic concept of the smart grid, but there is no "one-size-fits-all" communication technology, and smart grid communications will ultimately encompass several. Options include private radio frequency (RF) mesh solutions that connect meters via a concentrator; point-to-point (under glass) communications with individual meters using public cellular networks (which also provide the backhaul for mesh networks); Power Line Communications (PLC); Wi-Fi; and several others.

In the past, utilities have most often considered AMI networks that offered a single (typically private) communications technology, referred to as a "single AMI technology solution." In today's market, however, utilities have other good options as well. Cellular networks have made significant progress in 2010, and can now offer lower airtime rates and tighter service-level agreements. In this environment, the best solution may be to recognize that there is no one "best" solution, and no need to choose between one metering communication technology and another. To unleash the full potential of the smart grid, utilities should be implementing metering communications platforms that encompass multiple communication technologies. These types of AMI solutions, referred to as "multi-technology AMI solutions," can include both private radio and public cellular networks to suit a variety of environments and requirements, while still using a single AMI head-end. Let's explore how modern cellular communications can fit into a multi-technology smart metering initiative, and the benefits that utilities can realize by implementing this multi-technology approach.

[1] Torchia, M., Feblowitz, J., Nicholson, R., *North American Intelligent Grid Utility Spending Forecast*. (Dec. 2009). IDC Energy Insights

[2] *Smart Meters for Smart Grids*. (Jan. 2010). ABI Research.

Achieving an Industrial-Grade Smart Metering Infrastructure

Utilities historically may have viewed cellular-based metering communications with skepticism, but the truth is that cellular technology is already widely deployed in the electricity grid. Many utilities rely on wireless technology to communicate with cellular-enabled meters at large commercial and industrial customers. In fact, the majority of utilities in North America today use public wireless networks (i.e., networks owned by carriers such as AT&T or Verizon Wireless) to backhaul metering information collected at the neighborhood-area network (NAN) level to a central location. Now, perceptions about using cellular technology all the way to the meter are beginning to change, as public carriers work closely with operators and vendors to introduce more attractive rate plans and demonstrate that they can meet the utilities' stringent requirements.

Addressing Modern Metering Challenges

Any communication technology that will serve as the foundation for electricity metering must meet several core requirements, including:

- Life span. Smart meters are designed to stay online for 10, 15, or even 20 years, without requiring that components be replaced or directly maintained.
- Ruggedness. Meters – and all the technology within them – need to be highly reliable. Today, most common cellular technologies (such as the removable plastic Subscriber Identity Module, or SIM cards, used in some cellular networks) have been driven by the mobile phone market. Focused on general consumer use, these technologies are designed for a projected lifespan of just a few years. Smart metering communications, however, must be designed with industrial-grade specifications to meet extreme environmental conditions of shock, corrosion, temperature, vibration and humidity to which consumer devices are not typically exposed. Fortunately, industrial-grade cellular solutions are now a reality. For example, in extreme environments SIM cards can be embedded into the wireless module used in the meter or concentrator device to create a much more ruggedized design.
- Remote manageability. During the 10- to 20-year life span of a smart meter communication device, the communication module's firmware will likely be upgraded—for example, to add new features, enhance security, or maintain compliance with the latest wireless communication standards. Having to make such changes manually, through a field service call for potentially millions of meters, would be an enormous burden. Utilities need to be able to remotely manage, configure, test, validate and upgrade firmware over the air using secure wireless device management services that the utility or service provider can easily deploy.

These are real and important considerations, and modern cellular technologies effectively address the issues. Ruggedized cellular solutions are now widely deployed in the automotive and industrial segments, where extreme temperatures, vibration, dust and humidity are the "norm."

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Applying these same types of specifications to smart meters, vendors are now achieving industrial-grade reliability and life spans. Public wireless coverage is also now more than sufficient to support multiple smart metering applications, with approximately 97 percent of North America's population, for example, covered by cellular networks today.

Modern cellular solutions are also designed to be flexible and upgradeable. For example, today's state-of-the-art wireless modules can perform firmware upgrades as patches. That means wireless providers can distribute upgrades by transmitting only those parts of the firmware that have been changed (i.e., a software package of a few kilobytes), rather than transmitting a new version of the entire software stack (one megabyte or more). When utilities are paying airtime rates for millions of end devices, patch upgrade capability equates to a significant bandwidth and cost savings.

Addressing Security

When there is a two-way command and control system embedded into an energy management system, several security threats need to be addressed, including consumer privacy, data integrity and maintaining continuity of service throughout the grid. Fortunately, utilities don't have to reinvent the wheel to enable secure wireless communications. Wireless and cellular infrastructures already include strong and proven security technologies (technologies capable of supporting critical public safety and government applications), in addition to the security measures provided by multi-technology AMI vendors.

For example, the U.S. armed forces, the Central Intelligence Agency, and President Obama use highly sophisticated Federal Information Processing Standard (FIPS) 140-2 software in their wireless smart phones. As a more mundane but ubiquitous example, people use robust, readily available and cost-effective encryption technologies millions of times each day to protect retail and financial transactions over wireless networks.

Modern cellular solutions provide:

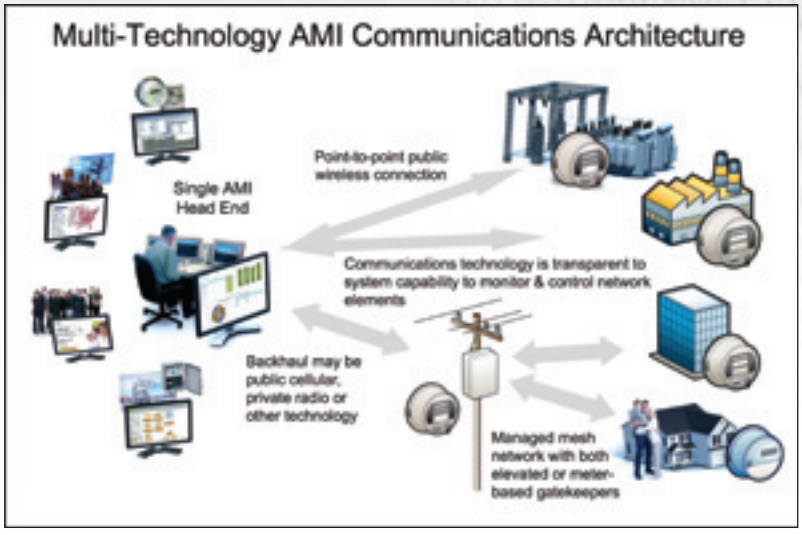
- Secure connectivity. In any communication system, it is essential to ensure that sensitive information reaches its intended recipient, and that it cannot be intercepted or understood by an individual or device attempting to intercept it. This is especially true when the information is contractual data used for billing purposes. Strong authentication processes are also mandatory to prevent hackers from accessing sensitive data, uploading malicious software, or turning meters on and off. Modern wireless communication systems employ strong and mature encryption protocols such as Secure Sockets Layer (SSL), which is already widely used to protect retail and web-based payment card transactions.
- Jamming detection. In some higher risk environments, defensive systems are needed to thwart deliberate network attacks, such as denial-of-service attacks that attempt to jam all frequencies to block the wireless connection. Modern smart meters can be equipped with wireless technologies that quickly detect such attacks and take appropriate actions, such as triggering an alarm, sending an alert through another communications channel, recording the event for further investigation, etc.
- Ability to operate autonomously. Another important requirement for secure smart metering communications is the ability to continue metering even in the event of a breach of communications. Today's industrial-grade, cellular-enabled smart meters are intelligent devices that are capable of continuing to operate even if they lose connectivity with the wireless communications network.

Clearly, modern wireless security technologies are up to the task. The challenge is to adopt an industry-wide standard that will ensure interoperability within the vendor community. Standards-making bodies such as the National Institute of Standards and Technology (NIST) are in the process of developing standards, but no agreed-upon standard is approved at this point. The process is complicated by the broad variety of metering communications technologies in the market today, including multiple proprietary and open technology platforms.

Naturally, utilities are concerned about how this standards process unfolds, as they want to be able to ensure they are ultimately in compliance. The key once again is to make sure that any smart metering communications technology is flexible and upgradeable.

Reaping the Benefits of Multi-Technology AMI Deployments

As we've seen, public cellular communications are ready to meet the demands of modern smart metering deployments. But what do utilities gain by employing them? As many utilities are now discovering, incorporating cellular communications as part of a multi-technology smart metering architecture unlocks a variety of advantages. These include:



AMI solutions architected for multi-technology communications offer the utility cost efficiency and future flexibility.

- Flexibility. A smart metering infrastructure that supports multiple technologies can be more easily extended across a variety of regions and environments, out to the edge of the network. For example, a utility could serve some neighborhoods on the network using RF mesh, while serving others through a cellular carrier's wireless network.

- Improved visibility. One challenge utilities have faced in the past when incorporating multiple communication technologies within an AMI network was the perceived headache of managing and integrating multiple technologies, because each technology would require a separate head-end. However, in today's multi-technology AMI networks, a single head-end can manage multiple technologies. Additionally, modern cellular modems used in a meter can now provide valuable information to the AMI head-end about the operation of the cellular network, just as is done with the private radio network.

- Distribution automation. In the past, utilities have had little visibility into major segments of the distribution system, particularly transformers within neighborhoods. While utilities have long recognized that the ability to collect information from those devices would be valuable, the cost of creating an infrastructure specifically to support that communication would have been exorbitant. Now, with communications extending to the meter over a variety of communication technologies, utilities can piggyback on those communication infrastructures to connect previously inaccessible devices and distribution points. Cellular modems in meters can effectively communicate with these devices, and as with the multi-technology AMI deployment itself, utilities can choose the communication technology that is most effective for each situation. As a result, utilities are now empowered to monitor and automate distribution all the way to the consumer home, for little additional expense on top of the existing smart metering investment.

- Cost savings. Using multiple technologies allows operators to choose the least-expensive solution for each environment across a region. For example, while cellular metering communications may not have made good economic sense in the past, cellular carriers are now actively courting utilities and will work with them to aggregate services under one rate structure. Utilities can also realize savings by consolidating their mobile workforce, supervisory control and data acquisition (SCADA), and enterprise accounts. In some cases, carriers will also offer utilities service-level agreements, when accompanied by managed machine-to-machine service platforms that give the carrier and the utility more visibility into and control over their wireless devices.

Ultimately, a broad number of business scenarios are emerging in which the multi-technology approach provides the most options for extending smart metering intelligence across the grid, and realizing the most value from smart grid deployments.

A Versatile Foundation for Smart Grid Communications

Choosing the right communications solution for a smart metering initiative is critical, but just as critical is recognizing that there may be no single "right" answer. The best solution may, in fact, be to build an architecture that is capable of supporting multiple technologies.

Public wireless communications will play an increasingly important role in smart grid implementations, and utilities should be evaluating those areas where cellular technologies can provide real value to the overall smart metering initiative.

To succeed in this, however, utilities need to ensure that smart metering solutions (whether employing cellular or any other technology) are rugged, secure, flexible, and remotely manageable and upgradeable.

Utilities should also make sure they are working with technology partners that are:

- Well established with strong financials (i.e., able to continually support smart metering technologies throughout the 20-year or longer lifespan of the metering devices)
- Broad-based, with the ability to accommodate a variety of wireless technologies and platforms, and service all regions
- Experienced, with broad expertise in smart metering devices and communications, and established relationships with public wireless operators
- Proven, with a track record of delivering reliable, industrial-grade communication technology

By following this strategy, utilities will deploy far more flexible and cost-effective smart metering infrastructures, and more rapidly reap the rewards of their smart grid implementations. ■

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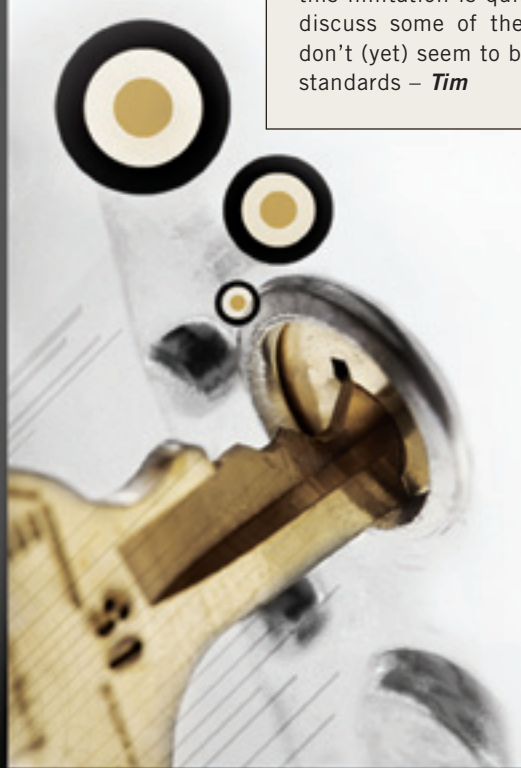
SECURITY SESSIONS

Volume 2 No. 4

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

How is a DCS different from a conventional SCADA/EMS – and why should we care?

Welcome to this installment of Security Sessions, a regular feature focused on security-related issues, policies and technologies. In my work I deal extensively with the NERC-CIP standards. One of the things that has always bemused me is that although the focus of those standards is on protecting industrial automation systems (i.e., EMS/SCADA and now, generating plant DCS systems), the standards – despite now being in their third major revision – still draw almost exclusively from IT-focused methodologies. When the standards initially aimed their protection at EMS/SCADA systems, the deficiencies weren't so noticeable, but now that generating plants and transmission substations are part of the mix, this limitation is quite problematic. In this column we'll discuss some of the Industrial Automation issues that don't (yet) seem to be very well addressed in the present standards – ***Tim***



When the initial Urgent Action 1200 standard was issued by NERC following the 9-11 attacks, it was primarily focused on protecting Energy Control Centers (ECCs) and their associated SCADA/EMS systems. With the issuance of Standard 1300 (where it was inferential) and the subsequent conversion to the individual NERC-CIP standards (where it is explicit), the standards coverage was expanded to include transmission substations and generating facilities. But nothing was specifically added to address the differences between the automation technologies employed for those facilities versus those of the ECCs. The fact is that for the most part, generating plants employ Distributed Control Systems (DCS) and Safety Shutdown Systems rather than EMS/SCADA systems. Not to say that SCADA technology can't be found in generating facilities, but the primary systems needing protection in the generation environment tend to be DCS systems.

DCS systems have been around since the late 1970s when Honeywell (and then EMC Controls) introduced the first generation. In the intervening years, many vendors entered (and exited) the market and extensive technological changes have been made to DCS systems during the decades since. The most recent DCS systems utilize high-speed, fiber-optic Ethernet LANs and IP communications, in place of the earlier, proprietary data highways. But a lot of those vintage proprietary systems still exist. Current systems use PCs, running Microsoft Windows, as operator workstations. But there are still a lot of old systems using Sun workstations and DEC VAXstations (now H-P), as their operator consoles and engineering workstations.

Most DCS systems also support "gateways" that allow instrumentation networks to be interfaced and integrated. These include standards such as *Foundation Fieldbus, Profibus, HART*, etc. and even certain PLC networks. There are also a lot of "smart" instruments that communicate using serial EIA RS-232 interfaces and MODBUS (or similar) protocols. Most DCS systems support serial ports and drivers for connecting to such instruments.

The possibility of attacking or compromising a DCS system, and taking down a plant, through an attack on an instrument bus or serial interface is a topic of debate, but it should be remembered that a control system reacts to the inputs it receives. If inputs can be manipulated to make it seem as if an unsafe condition existed, it might be possible to 'trick' the control system into triggering a unit trip. But the NERC CIP standards do not speak to the issue of the instrument bus or non-TCP/IP networks. In a way this is understandable since these networks don't exist in the IT world – or in the SCADA/EMS world where these standards originated.

In order to address the corporate desire to have vertical integration of information (presumably so that some executive "dashboard" filled with KPIs can be 'automagically' updated from plant data), most DCS suppliers have incorporated separate Ethernet/IP LANs – isolated from the controller networks – and added more gateways. These gateways may offer OPC connectivity to business and engineering applications and feed them plant information in a (one hopes) controlled manner. In large facilities, where it makes sense to have several independent DCS systems, it is still common to create a plant-wide LAN, with a connection to each DCS system, so as to enable having "supervisory" workstations that display plant-wide information.

Often this same plant LAN will interface with numerous independent subsystems such as continuous emissions monitoring, fuel metering skids, water treatment subsystems, turbine monitoring subsystems and many others. There might even be a plant-wide data historian attached to that upper level LAN. And of course, at some point the plant LAN will be interfaced to the corporate WAN and eventually, to the Internet. This multi-layered architecture and inter-layer gateway design leads to complications when trying to establish an electronic security perimeter (ESP). You can end up with either lots of 'access points' into that ESP or lots of equipment within the ESP that is subject to the various requirements of the CIPs. ISA Working Committee SP-99 has been looking at this issue and has been devising security strategies based on segmentation and layering of plant systems into "zones" with "conduits" established to control inter-zone communications. None of this work seems to have caught the attention of the people at NERC yet, however.

Today, we are also seeing a growing interest in the use of wireless technologies due to safety issues and the cost of running wire in an operating plant environment. Wireless often includes new wireless versions of instrument networks (e.g., wireless HART, vendor-specific wireless instruments and the new ISA-100 wireless standard). Plants are also installing wireless Ethernet mesh networks to support integrated voice, video and data communications. Some large plant facilities may also use point-to-point radio or microwave links to connect with outlying facilities. Securing wireless communications is a tough problem, especially with all of the incompatible wireless technologies available; most of which have no intrinsic security features or functions. So far, however, the NERC-CIP standards don't specifically address the issues of wireless technology.

The point I am making with all of this is that large generating plant facilities do not easily conform to the simplistic notion of a single, centralized computer system that can be easily enclosed in a physical and electronic security perimeter. Large plant facilities also use a myriad of wired and wireless communications that may not be Ethernet and/or IP based and thus, not readily manageable or easily monitored using conventional IT strategies.

I mention the large installed base of legacy systems because of a general industry problem: staffing and expertise. The fact is, most electric utilities have reduced their engineering and support staffs to minimum levels over the past decade or so. A generating plant may have a couple of people on staff who can make simple repairs to a DCS system and even configure a new operator display or control loop. But most utilities are depending on their suppliers to provide support for things like implementing virus scanning or adding an intrusion detection package to their systems. On the other hand, the vendor community is also struggling because, in many cases, they too have made substantial staff reductions in recent years. Many of the older DCS systems are no longer under active support by their original suppliers, meaning that no further updates, patches, enhancements – or even bug fixes – will be forthcoming.

Some of those DCS vendors would have relied on their original equipment suppliers (e.g., Sun, DEC, H-P or others) for much of that support, and those suppliers no longer exist. Under these circumstances it is unlikely that a plant will be able to fully implement all of the requirements established in the CIP standards; at least not until the time when they can replace those legacy systems with newer and more current technologies. Until then, many will likely resort to tampering with these legacy systems, and because of the lack of the necessary technical expertise, may inadvertently cause unforeseen system failures and threaten plant safety and operational availability. So maybe it's time to gather up the old-timers that originally built those legacy systems and assemble a task force to address those issues. (Hmm, better be careful what I wish for... that could be me!) – ***Tim***

About the Author

William T. "Tim" Shaw (PhD, CISSP) has been active in industrial automation for more than 30 years and is the author of Computer Control of BATCH Processes and CYBERSECURITY for SCADA Systems. Tim has contributed to several other books and is a prolific writer and presenter on a range of technical topics. He is currently a senior security consultant for SecuriCon, an information security solutions firm, based in Alexandria, Virginia. Tim has been directly involved in the development of several DCS and SCADA system products and regularly teaches courses for ISA (International Society of Automation) on various topics. Inquiries or comments about this column may be directed to Tim at *Tim@electricenergyonline.com*.

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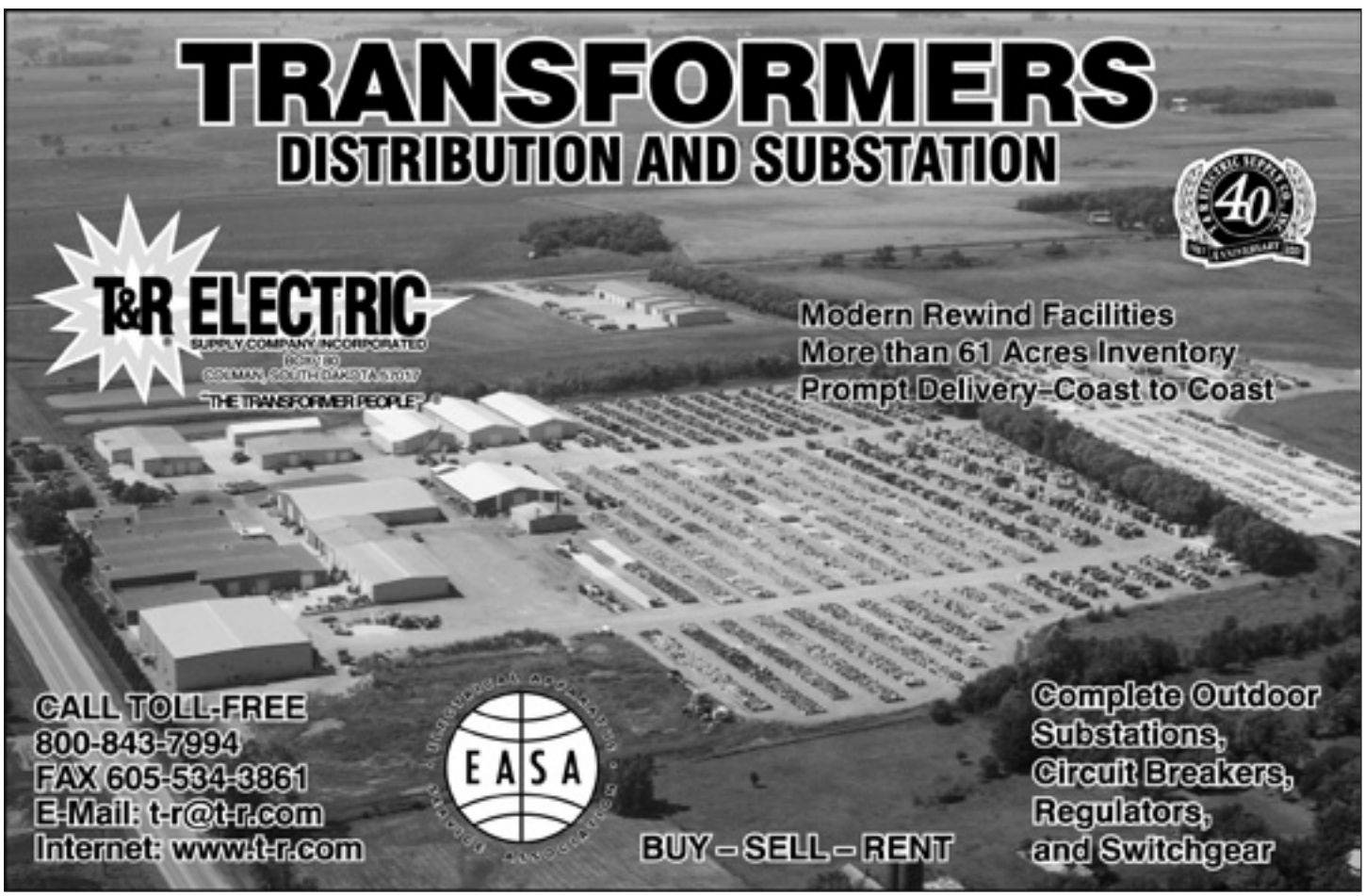

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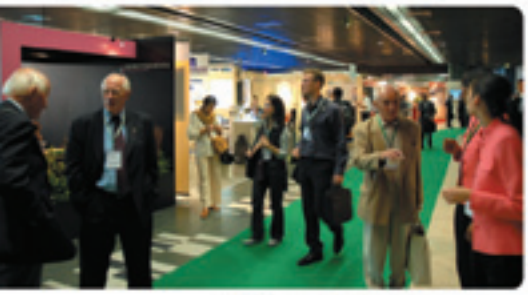

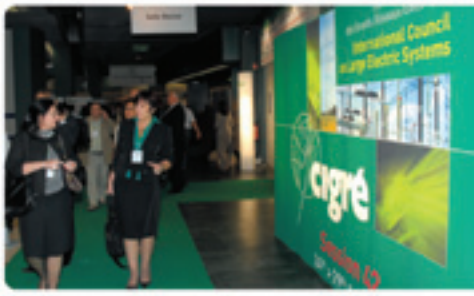

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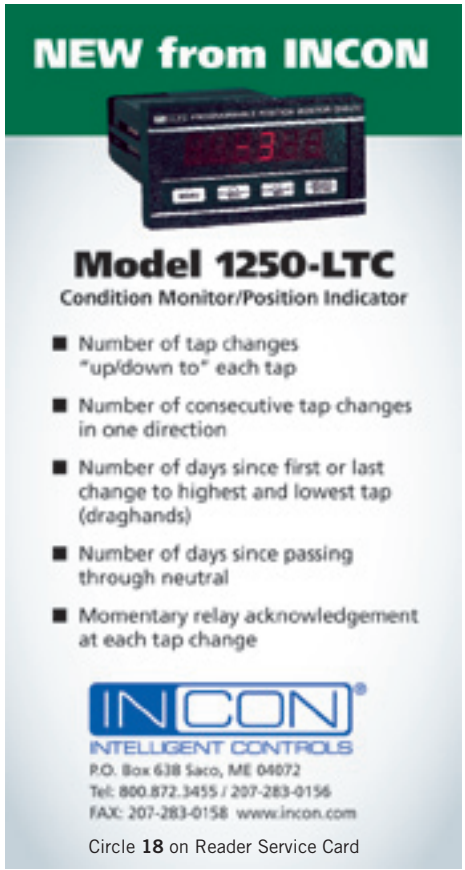

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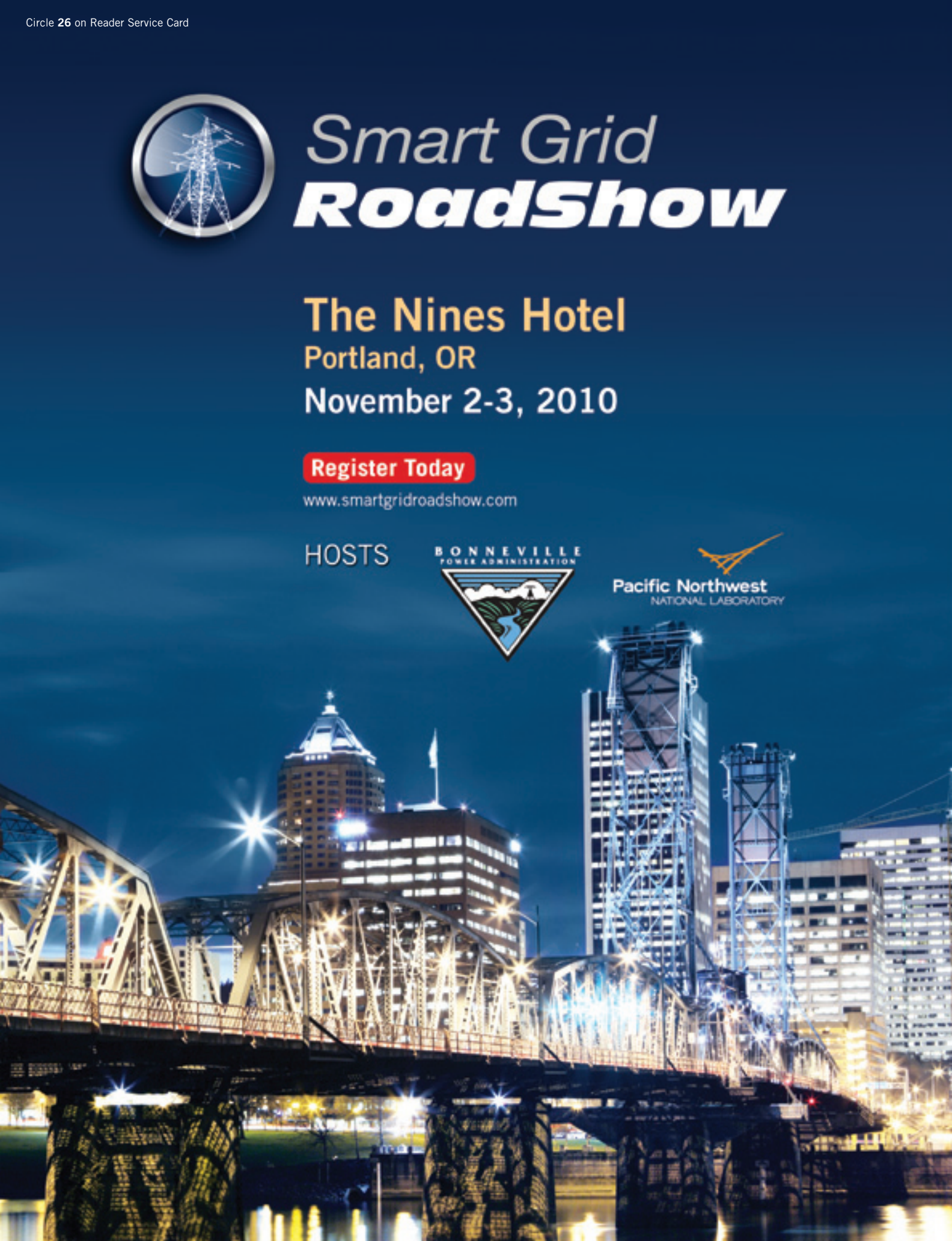

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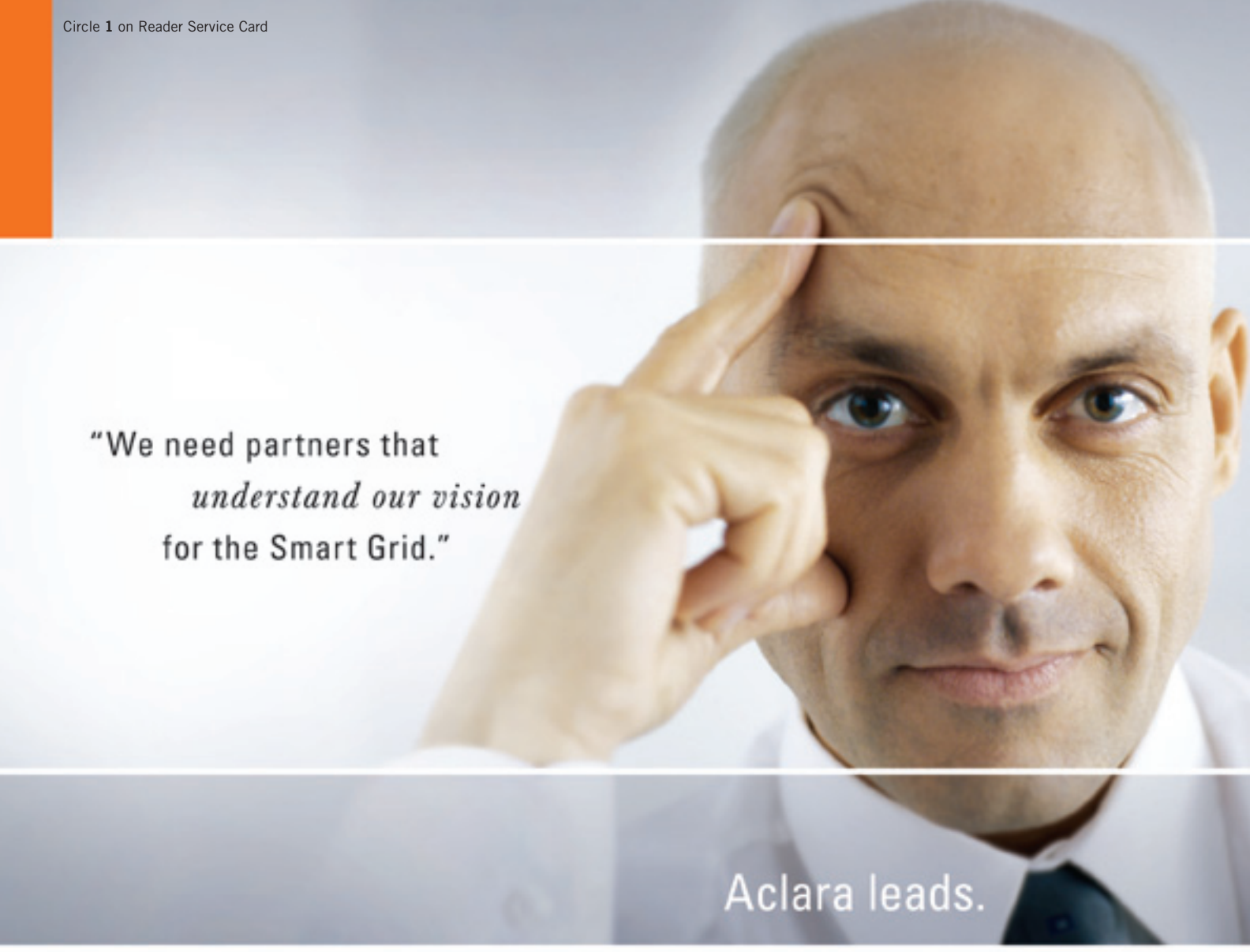

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