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Cover photo: Battery storage units at Avista

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Editor-in-Chief

TERRY WILDMAN

GO BIG! – They weren't kidding

I'm back from the IEEE PES T&D tradeshow and conference held in Dallas, Texas a few weeks ago. The theme was GO BIG and they weren't kidding. The show was huge with over 900 exhibitors. Before I get into that, though, I would like to bring you up to speed on a few of the latest 'buzz' technologies that I mentioned in my last editorial about DistribuTECH 2016.

Asset Health and Management today

Utilities struggle under the repair-and-replace needs of aging transmission & distribution (T&D) assets. The situation is made more difficult by:

- Financial pressures that limit operations and maintenance resources
- Loss of valuable knowledge as long-time employees leave or retire
- An environment of increasing regulation

Together, these factors put utilities under intense pressure to reduce inefficiencies and eliminate unknowns. Meanwhile, improved asset monitoring and communications capabilities hold tremendous promise to optimize T&D operations. But they are delivering such an overwhelming flow of data that few companies are able to put it to meaningful use.

The idea of Asset Health Management is to utilize all that data to achieve real-time performance analysis of T&D assets from one end of the enterprise to the other. It would enable utilities to make thoughtful, strategic and fiscally sound decisions about which assets should be replaced, and when the rest ought to be scheduled for maintenance and repair.

So far, this vision is unrealized. Typical engineered solutions lack the embedded industry intelligence needed to turn data into the kind of actionable knowledge that allows complex integrated systems to be optimized. Analysis of data is often done manually, a slow process that strengthens functional silos and leaves departments vulnerable when key engineers retire or leave the company.

Until utilities address the issue of asset health management systemically – with an end-to-end solution offering the right combination of integration, embedded intelligence and automation – they will struggle under the demands of aging resources, stringent regulatory environments, and increasing financial pressure.

The high cost of doing nothing

Most asset health management today is conducted through a patchwork of routines, assembled over time in the absence of a comprehensive solution. As a means to manage a vast network of assets, even those who built these systems often acknowledge their shortcomings:

Incomplete analysis: Fewer than half of all transformer failures originate with the insulation system. Home-grown asset management systems typically look only at results from oil sampling. Maintenance records, loading history and tests of tap changers and bushings may be overlooked because they are hard to bring together. Critical repair-and-replace decisions are based on information that is most convenient – not necessarily most meaningful.

Unrealized ROI: Smart grid investments have created a flow of Big Data that internal systems don't have capacity to consider – meaning the full value is being extracted from technology that's already in use.

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Reliance on instinct: The simple spreadsheet is still the most common tool for making maintenance and lifecycle decisions that can cost millions of dollars and directly impact reliability. Such manual processes fail to exploit current technology like a leading edge Asset Health Center – which automates and optimizes asset health decision-making.

Inability to adapt: Home built systems struggle to evolve as technology and other factors affect processes and best practices. The results can be costly: from unplanned outages to shortened asset lifecycles to punitive penalties for lapses in regulatory compliance.

Poor visibility: From the field force to facilities management to engineering to IT to the executive suite, each part of the organization needs the right information presented the right way to do its job, and most systems struggle to meet this need.

Cumulatively, these deficiencies defeat the impact of what today is often referred to as asset health management.[1]

Advanced Distribution Management Systems

Advanced distribution management systems (ADMSs) have emerged over the past few years as a major smart grid technology innovation with the potential to unify utility distribution IT systems into a single, more efficiently managed platform. As such, the market for ADMSs has exploded with investment in marketing and R&D on behalf of many smart grid IT and combined IT/operational technology (OT) vendors. Although this technology is still in the midst of a steep learning curve, its direct and indirect benefits to utilities are becoming widely recognizable.

Utilities are becoming increasingly strategic in smart grid IT/OT deployments, and ADMSs are no exception. With ADMSs, however, utilities have recognized that in order to maximize its potential, they have to approach the technology with an all-hands-on-deck attitude. In the past, they had developed IT in a reactive and operationally isolated manner, doing what worked to solve the problem. Today, the utility business is going through fundamental change at the hands of efficiency and renewables targets, growing customer demands, reliability pressure, and grid-edge instability. Utilities have thus been forced to adopt a holistic approach to developing smart grid roadmaps where multiple aspects of the system enhance traditionally separate systems. According to Navigant Research, global ADMS revenue is expected to grow from $681.1 million in 2015 to $3.3 billion in 2024.

Companies analyze the global market opportunities for ADMSs. Studies provide an assessment of current operational benefits for utilities, market drivers and barriers, regional trends, and technologies, in addition to business recommendations for both vendors and utilities. Global forecasts for software purchases and upgrades, integration services, maintenance, analytics, and software as a service (SaaS) for ADMSs, segmented by region and category, extend through 2024. Reports also profile key industry players and examine several utilities that have implemented ADMS technology to align with more ambitious smart grid initiatives and aggressive regulatory policies.

Key Questions Addressed:

- What are the regional market drivers/inhibitors for advanced distribution management systems (ADMSs)?
- What are the different revenue opportunities for ADMSs?
- How do ADMSs benefit previous smart grid deployments?
- How do ADMSs support a more efficient distribution grid?
- How can ADMSs improve the operating efficiency of the utility and lower operating costs?
- What ADMS substitutes are available within the market?
- How does the convergence of information and operations technology (IT/OT) affect the ADMS market?[2]

Back to the tradeshow. Included in what seemed several kilometres of walking, I learned a bunch of stuff. Although one conversation that I was very familiar with centred on how much of a family-type fraternity the transmission and distribution sector is. The show floor as you can imagine was enormous. Luckily I only had to have my shoes resoled once. I wish I could say the same for my feet. The following is a small collection of tidbits that I found during my IEEE T&D travels.

Transforming reliability

A European-based firm was celebrating its 80th year in business. It started out life taking data readings from the upper atmosphere and translating those data into weather forecasting. Today, they do much the same thing albeit with much more sophisticated equipment and far greater accuracy. Now, in addition, their core business is reading and detecting power transformer faults with online monitoring tools. Their latest device provides real-time trouble-free monitoring with no false alarms or maintenance. It measures Hydrogen, Carbon Monoxide, Methane, Carbon Dioxide, Ethane, Ethylene, Acetylene, and moisture.

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The company's products are in use in 150 countries in industries where failure would present big problems including airports, pharmaceuticals, and the power industry.

Finding fault

Another firm scours the streets of cities across North America detecting stray and contact voltage underground coming from aging and/or deteriorating cables. From the cabs of their field service trucks, crews use highly sensitive equipment to find the problem and then use hand held devices to pinpoint the problem on the street. Most of the time, the local utility crews follow closely behind so any repairs can be done immediately. I became familiar with the problem a few years ago when I heard that a dog in my city had stepped on a 'live' manhole cover and was electrocuted. Last year the company located and saw more than 12,000 stray voltage incidents taken care of.

Going forward, they are looking at the next item in their toolkit – the use of drone technology to find problem cabling. Apparently, in the not too distant future, the FAA will be loosening the reins on height restrictions and over city flying. This opens the door for the company to explore the value in using a military-style UAV. One never knows, as the sensing technology evolves and becomes even more accurate drones may find a place in the civilian world.

Pushing paper

A very well-known company is in the testing phase of an inorganic-based insulation to enable smaller, higher-temperature, liquid-filled transformers (LFT). The new LFT product boasts excellent thermal stability up to Thermal Class 155 degrees Celsius, has very low moisture absorption, high thermal conductivity, and is sustainable (RoHS & REACH Compliant)

The new 'wrapping paper' has been tested to the industry standard for mineral oil quality and compatibility (per ASTM D3455). The same method has been also used for ester oil, which also meets these requirements.

Extending cable life and mitigating hole events

A west-coast U.S. company is restoring and extending the life of aging cable. Using Sustained Pressure Rejuvenation (SPR), they are brought up to like-new standards and performance. It's done by injecting a healing and upgrading fluid into the strands of medium voltage power cable. The rejuvenation fluid migrates into the conductor shield and insulation modifying the chemistry of the insulation. The dielectric strength of the cable increases immediately. Full strength is achieved within seven to ten days.

As utility infrastructure ages and recognizing that over 2000 manhole events occur in North America, the same firm has developed a new standard in manhole covers. Problems include smoke, fire, and explosions that often trigger the wrath of politicians and the media. It's an event suppression solution that actively vents and removes reduces combustible gases; limits exposure to water, salt, and debris; reduces risk of secondary cable failure; utilizes a cloud-based data logging system with sensors that predict events before they occur and transmits real-time alerts.

These accounts, of course, barely scratch the surface of the myriad of technological advancements that seem to come to fruition daily in the world-class world of transmission and distribution. I never failed to be impressed and very glad to be a part of it.

[1] *http://library.e.abb.com/publicbd0874a998f1126b85257b12007123f8/abb_asset_services_brochure_1.31.pdf*
[2] *www.navigantresearch.coméresearch/advanced-distribution-management-systems*

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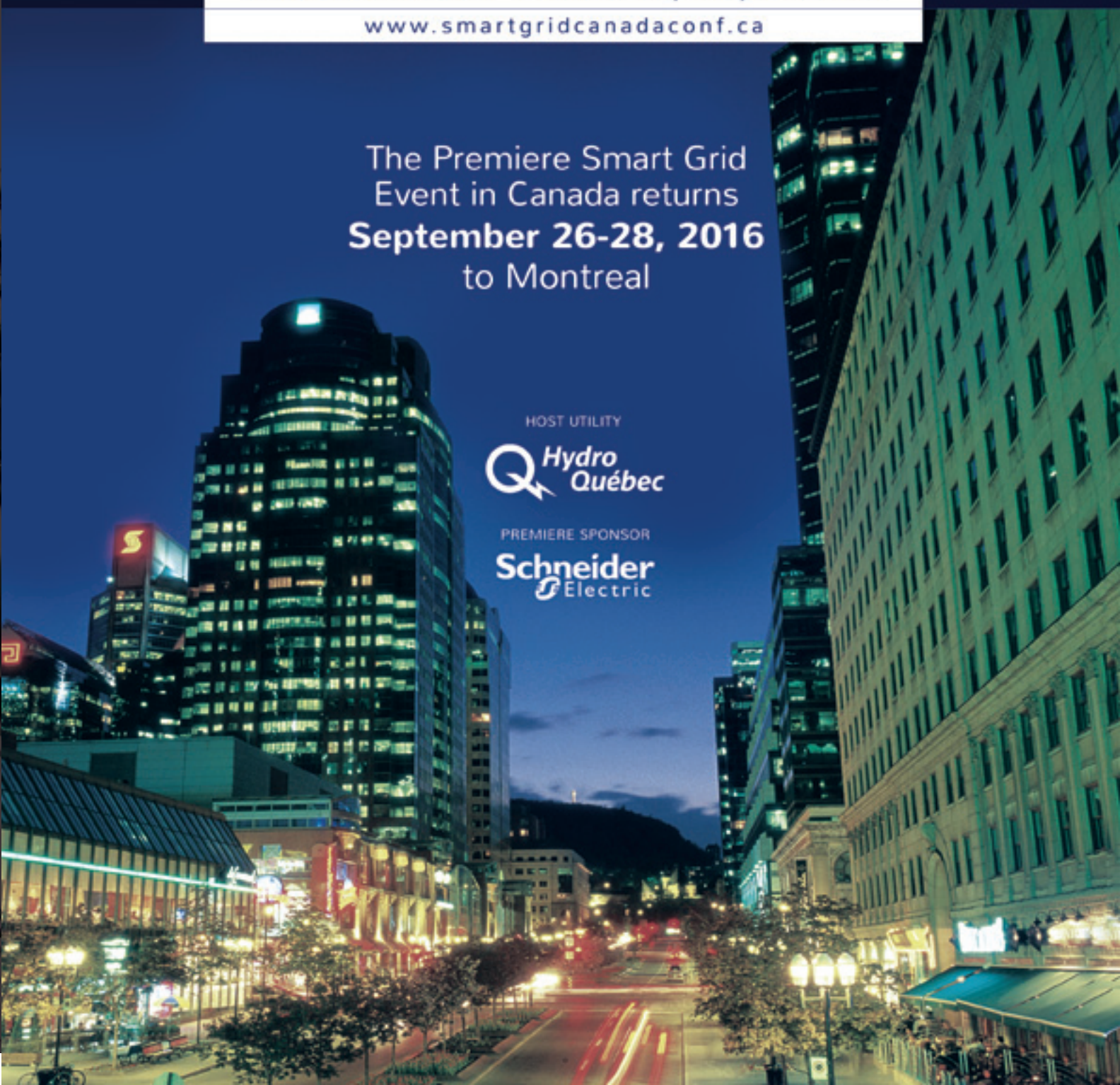

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Metropolitan Nashville Airport Authority Airport Authority Completes Installation of Largest Geothermal Lake Plate Cooling System in North America

May, 2016

Marking an innovative use of a former rock quarry, the Metropolitan Nashville Airport Authority (MNAA) ceremonially "turned the valve" on the largest geothermal lake plate cooling system in North America during a project completion ceremony.

MNAA switched to its new geothermal lake plate system in February 2016, and officially completed the transition and project in May 2016. Prior to February 2016, Nashville International Airport (BNA) chilled water equipment's energy consumption was 1.056 kilowatts annually on average. From February - May 12, 2016, energy consumption has reduced to 0.525 kilowatts annually on average, a 50 percent reduction.

"This is a remarkable project for its scope, ingenuity and efficiency," said Rob Wigington, president and CEO of MNAA. "The Airport Authority is committed to making sustainability an integral part of our business model. Not because sustainability is easy rather, it is often a complex process but because the benefits to our airports, the region and our environment are overwhelmingly positive. This historic project will significantly reduce our electricity usage and potable water consumption, which will result in substantial annual utility savings. This is the very essence of sustainability."

The project recently accorded industry-wide recognition by a leading Airport trade association. MNAA received the 2016 Environmental Achievement Award in the Special/ Innovative Projects Award category from the Airports Council International-North America (ACI-NA) for the geothermal lake plate project. The Environmental Achievement Awards are presented to airports that strive to protect and preserve the environment through their programs, initiatives, and projects. MNAA was also awarded the 2015 Governor's Environmental Stewardship Award in the Sustainable Performance category by the Tennessee Department of Environment and Conservation.

Located east of Donelson Pike and Nashville International Airport Runway 2R/20L is the former 43-acre Hoover rock quarry, with an average depth of 150 feet, containing approximately 1.5 billion gallons of water. At a depth of 50 feet, the water is 50 degrees Fahrenheit year round.

The project takes advantage of that cool temperature by circulating water through closed looping and geothermal heat exchangers submerged in the quarry to the airport terminal's central plant, providing cooling for the entire terminal. In addition to the geothermal system, the project also allows for the use of the quarry water for landscape irrigation.

The project is expected to reduce electricity usage by 6,000 kilowatts of peak demand and result in annual savings of 1.3 million kilowatt-hours and 30 million gallons of potable water. The utility savings to MNAA are expected to exceed $430,000 per year.

The project was developed and engineered by Energy Systems Group, Garver, and Smith Seckman Ried. The fast-track project was delivered by Blakley Construction Services utilizing a design-build contracting method with design and construction support services provided by Energy Systems Group, Garver Engineers, and Smith Seckman Ried.

FirstEnergy Corp. JCP&L Proposes Monmouth County Reliability Project

May, 2016

Jersey Central Power and Light (JCP&L), a subsidiary of FirstEnergy Corp. (NYSE: FE), is proposing the Monmouth County Reliability Project (MCRP) to enhance service and modernize the electric system. The project will include a new, nearly 10-mile, 230-kilovolt transmission line and substation enhancements that will benefit approximately 214,000 customers. The plan requires approval by the New Jersey Board of Public Utilities (BPU) and New Jersey Department of Environmental Protection.

"We know customers are expecting more from their electric utility, and it's our responsibility to deliver the power they need when they need it. The Monmouth County Reliability Project will help us provide the consistent, reliable electricity our customers depend on in their daily lives," said Tony Hurley, vice president of Operations at JCP&L. "We look forward to working with the community to ensure the project results in minimal impacts and maintains the unique beauty of our area."

The proposed upgrades will allow JCP&L to better monitor and more quickly react to power needs with modern technology that delivers real-time information about system conditions. Sleek monopoles will be used for the proposed transmission line, rather than the bulky lattice-style towers that were used in the past. The line will be built on an existing public use right-of-way already containing electrical equipment servicing New Jersey Transit's North Jersey Coast rail line. The MCRP will provide approximately 245 temporary jobs during construction. JCP&L will host a series of face-to-face open house events in neighborhoods near the proposed project to share more information and gather feedback from interested parties. Additional details also are available online at www.monmouthreliability.com.

The project is part of JCP&L's multi-year, $250 million "Energizing the Future" transmission system reliability enhancement program. PJM Interconnection, the organization that oversees the electrical grid across 13 states and the District of Columbia, has identified the MCRP as necessary, and it should be built to reduce the length and frequency of service disruptions in Monmouth County. If approved, construction is expected to begin in June 2017, with a planned in-service date of June 2019.

AltaLink's Proposal to Save Albertans $520 Million by 2019 Approved

May, 2016

AltaLink's proposal to save Albertans millions of dollars was approved by the Alberta Utilities Commission (AUC) on Monday, May 9, 2016. The savings, which will total approximately $520 million over a four-year period, apply to all Albertans:

- Residential customers: $92.7 million in savings
- Farm customers: $17.6 million in savings
- Commercial customers: $141.9 million in savings
- Industrial customers: $267.7 million in savings

"We know our customers and all Albertans are hurting during these economic times," said Scott Thon, president and chief executive officer of AltaLink. "Our proposal keeps money in the hands of Albertans to invest in their homes, farms and businesses."

AltaLink is Alberta's largest electric transmission company, and provides transmission service to approximately 85 per cent of the province's population. Albertans pay for AltaLink's services through a portion of the transmission delivery charge on their electric bills. In addition to the approximately $360 million in approved savings for 2015 and 2016, AltaLink has applied for an additional $160 million more in 2017 and 2018, which would be transferred to customers.

Supported by its owner, Berkshire Hathaway Energy, AltaLink's rate relief proposal for customers was approved as part of its 2015-16 General Tariff Application (GTA). The GTA outlines AltaLink's capital and operating expense requirements to safely and reliably run and finance its transmission system on behalf of its customers.

U.S. Department of Energy New Study Examines Progress toward SunShot Initiative Goals, Identifies Emerging Solar Energy R&D Opportunities for 2020 and Beyond

May, 2016

Today (5/18), the Energy Department released the On the Path to SunShot reports, a series of eight research papers examining the state of the U.S. solar energy industry and the progress made to date toward the SunShot Initiative's goal to make solar energy cost-competitive with other forms of electricity by 2020.

The solar industry is currently about 70 percent of the way towards achieving the Initiative's 2020 goals, but as solar has become more affordable, helping the industry grow by an astonishing 23-fold since the beginning of the Obama Administration, new challenges and opportunities have emerged.

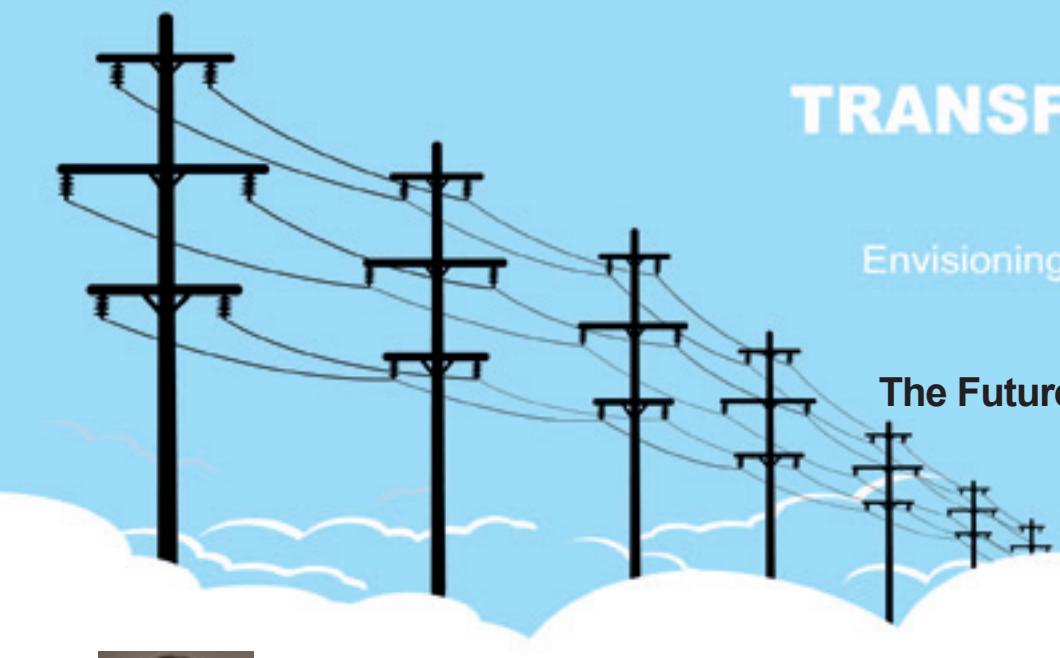
The reports released today (5/18) explore the lessons learned in the first five years of the ten-year Initiative and identify key research, development, and market opportunities that can help to ensure that solar energy technologies are widely affordable and available to power millions more American homes and businesses.

"Solar energy is an integral part of our nation's ongoing energy revolution," said U.S. Secretary of Energy, Dr. Ernest Moniz. "The U.S. has over 10 times more solar installed today compared to 2011 when the SunShot Initiative was first launched, and the overall costs of solar have dropped by 65 percent. The Administration's continued efforts through the SunShot Initiative will help to further reduce costs to make solar energy more accessible and affordable for American families and businesses."

Launched in 2011, the SunShot Initiative was created with the goal to reduce the cost of solar energy technologies by 75 percent within a decade across the residential, commercial, and utility-scale sectors. Since then, solar technologies, solar markets, and the solar industry have changed dramatically. The On the Path to SunShot series serves as a follow-up to the 2012 SunShot Vision Study, which analyzed the economic and environmental benefits that would result from achieving SunShot's ambitious 2020 goal. This new study series explores the areas of focus that could help the United States to achieve cost-competitive solar energy.

Among the conclusions from the study series, a recurring theme emerges that sustained innovation across all levels of the industry from cell efficiency improvements, to faster and cheaper installation methods will help to achieve the Energy Department's SunShot goals.

The On the Path to SunShot series was developed in collaboration with leading researchers from the National Renewable Energy Laboratory, Lawrence Berkeley National Laboratory, Sandia National Laboratories, and Argonne National Laboratory.



THE GRID TRANSFORMATION FORUM

Envisioning the 21st Century Grid

The Future of Electrical Energy Storage and Delivery

We are in discussion with Heather Rosentrater, Avista Vice President of Energy Delivery looking at the future of electrical energy storage and delivery of that power.

EET&D: What does the landscape look like going forward from your perspective in the area of energy services?

Rosentrater: Technology is rapidly changing the energy landscape in ways we may not even be able to imagine today. It's a time of tremendous change. For example, Distributed Energy Resources are continuing to impact the energy industry. Those utilities that ignore these influences run the risk of becoming irrelevant, while utilities that embrace change and explore new technologies will be in a better position to build a trusted relationship with customers in the energy future.

At Avista, innovation has been in our DNA for 127 years. Energy providers can actually cultivate an innovative culture if they're intentional and build the capacity into their skill set. Employees must be encouraged to identify opportunities and problems and look into new technologies and how to access more data to find solutions.

It's important to always look ahead and identify leading edge technologies. At Avista, that includes installing the largest operating vanadium flow battery in North America and Europe with an Energy Storage Project. It's allowing us to address one of the biggest challenges facing our industry as we learn how to integrate intermittent renewable energy into the electrical grid.

EET&D: How does a culture of innovation help position providers for the utility of the future?

Rosentrater: This is an exciting time in the energy industry. Technology is transforming the way energy is generated, transmitted and consumed. Rapid disruptions in technology are creating viable pathways to integrate more renewable energy, creating more choice to consumers and dramatically changing how electricity is delivered.

Through a culture of innovation, energy providers can actually help shape how the utility of the future will deliver value and services to the next-generation customers. This can be accomplished by focusing on 3 areas:

- Bringing value to customers: We must have the ability to offer different services based on customer preferences. Some customers simply want to pay their bill. Others want to actually participate in the grid. Providers need to meet the customer where they are.
- Improving grid operations through technology pilots: Another area of focus is the more technical side of grid operations. For example, when Avista received three grants from the U.S. Department of Energy's American Recovery and Reinvestment Act (ARRA) we built a foundation for the future by installing sensors, switches and software to automate many parts of the distribution system. We have applied what we learned to future upgrades to our distribution system. As a result, customers have experienced fewer and shorter outages and we've seen energy efficiencies on our system.
- Workforce development: Fostering a culture of innovation inspires employees to think differently and continually learn.

EET&D: Why should an energy provider explore battery storage?

Rosentrater: The industry and consumers see tremendous promise in energy storage as we move forward on the renewables front. The challenge is how to integrate intermittent renewable energy into the electrical grid.

Rosentrater: For example, Avista's Energy Storage Project is a 1MW, 3.2MWh battery storage system that went online in April 2015 and has now been in operation for more than one year. The three-year battery storage project carries a $7Million price tag, which is supported in part by a $3.2Million Clean Energy Fund grant and $3.8Million in Avista matching funds.

The pilot project is allowing Avista to invest in our Energy Storage Project to explore numerous value streams and to test for a number of use cases with the goal of increasing efficiency and building a more reliable system. Ultimately, what we learn about battery storage will help our electrical grid become more flexible, reliable and resilient.

EET&D: Given all the forces that are disrupting the energy industry, how do utilities remain relevant in the future?

Rosentrater: In order to remain relevant in the new energy future, it would be prudent for utilities to explore different business models.

At Avista, we're focusing on new business models – like 'Economies of Scope.'

We believe battery storage is a real game changer and the utility is uniquely positioned to leverage the stacked value of battery storage assets for multiple purposes – such as reliability and maintaining power quality.

As we look toward the future, we are building upon the utility industry's current business model focused on economies of scale – where growth occurred by adding customers – and leveraging a new business model focused on 'Economies of Scope,' which allows us to maximize assets for multiple uses, creating new revenue streams.

Through 'Economies of Scope' the utility can leverage energy storage every minute of every day.

EET&D: How do you continue to cultivate Avista's culture of innovation for the next generation of employees?

Rosentrater: We've intentionally created Grid Edge and Innovation Workgroup Teams that are constantly thinking ahead about how to meet the changing expectations and future needs of our customers.

We are also applying design thinking and a 'how might we' approach to emerging issues – like solar.

Unlike other parts of the country, we don't have high rooftop solar adoption or penetration. But we know that solar is viable and some of our customers want that technology. So we developed choices.

We have an online web tool that allows customers to determine if it's cost effective to install solar panels on their home. Avista has recently built the largest community solar installation in Washington state. Customers can participate by purchasing panels without getting pre-qualified or dealing with construction or maintenance.

It's a win-win situation. Customers can easily participate in solar and Avista can learn about integrating solar into our electrical grid.

EET&D: What else can utilities do to prepare for the energy future?

Rosentrater: We know that new technologies will continue to change the energy landscape. And many utilities are embracing this change.

We don't know what will happen in the future, so we are focused on piloting technology, partnering with others, and pushing to understand so we can continue to learn and innovate.

We're well positioned to take action when opportunities arise.

This approach also allows Avista to actually lead during times of change.

EET&D: We can't thank you enough for taking the time to walk us through the future of energy storage. It's a complex and at the same time exciting time in the world of transmission and distribution with a lot of new technologies at play.

GREEN OVATIONS

Innovations in Green Technologies

Technology harnesses the power of Lake Ontario to help boost electricity to the city

By Cameron Lewis

In November 2015, a world first for energy storage was unveiled in downtown Toronto

Jurisdictions around the world are turning towards renewable forms of energy – such as solar and wind – to lower emissions and protect the environment. The expected benefits offered by renewable energy are numerous but only available when the sun shines or the wind blows. So, how can these intermittent resources provide firm power needs? Solving this and other dilemmas is where energy storage plays a key role in unlocking the modern grid.

Presently, electricity is the most widely used and least stored commodity in the world. We store grain, oil and water, yet electricity is generated upon demand, which means it misses the efficiency opportunities that storage brings. Without storage, renewable energy can only provide a fraction of peak demand (typically only around 30%). On a hot summer's day, peak load is satisfied by dispatching expensive peaking generation resources. In contrast, periods of low demand often result in selling off surplus power below cost simply because some base load generation resources don't maneuver easily. Operating this way has worked in the past, but this inefficiency represents real costs in the power markets and higher environmental emissions.

Imagine being able to store low-cost excess power during off-peak periods and drawing upon this during subsequent high cost on-peak periods in place of expensive peaking resources. Imagine better utilizing transmission lines during off-peak periods to reduce transmission loading following on-peak periods and deferring the need for expensive transmission upgrades. Imagine converting intermittent renewable energy to a firm dispatchable resource. Imagine storing electricity underwater in the form of compressed air. Now stop imagining as a company called Hydrostor has now developed this technology.

Hydrostor

Based in Toronto, Hydrostor is a Canadian start-up that has brought Underwater Compressed Air Energy Storage (UCAES) from a dream to a reality. This past November, the company started up the world's first UCAES located on Toronto Island and connected to the city's distribution system with support from the utility host Toronto Hydro. Hydrostor currently has contracts to build additional facilities within the province and in the Caribbean.

How it works

At first glance, Hydrostor seems like a wild idea; however, the actual physics behind it are quite simple. Hydrostor takes electricity from the grid and uses it to run a compressor, thus transforming the energy in the electricity to pressurized air. This air is pressurized to the same hydrostatic pressure found at the depth where the system's accumulators are located. The air travels from the compressor to the accumulators where it can be held indefinitely. When power is required by the grid, the flow is reversed and the weight of the water pushes the air back to surface at the same pressure where it's used to drive a generator, converting the stored energy back into electricity for the grid and completing the storage cycle.

The system is mechanical in nature using no toxic chemicals, which makes it an environmentally friendly method of storage. The system's charge rate, discharge rate and duration are all decoupled so unlike batteries, this system can be tailored to meet specific needs. In other words, you can easily design the system to soak up large amounts of electricity in a short amount of time and return it over a long period of time, say in the case of storing excess solar or wind production.

Prototypes and challenges

Designing Hydrostor was only half the battle; building a working demonstration plant was another. With financial support from both the private and public sectors, Hydrostor embarked on a journey involving complex marine engineering and construction, drilling below a lake, welding 80 tons of steel into a single connection pipeline and integrating components from Canada and around the globe to finally pump in and expel air into the working UCAES. Working in a marine environment has unique challenges. During construction, Hydrostor encountered an unexpected rogue wave causing damage to the accumulators and piping. Many other lessons were learned on all aspects of the plant, including heat recovery systems, air-water separation and underwater methods. This is what makes a demonstration so valuable: learn the lessons and incorporate improvements to strengthen future projects.

Finding a partner to test this idea

As a Toronto start-up, Hydrostor wanted to test this idea locally. Fortunately, Toronto is located on a large lake (Lake Ontario) and Toronto Hydro saw potential in the technology.

Toronto Hydro is in the midst of a massive capital program to renew and upgrade its electricity system. It's actively exploring energy storage as a way to manage peak demand, relieve system congestion and extend the life of some of its equipment and is looking towards innovation as a way to do that. This is where Hydrostor fits into the strategy by offering Toronto Hydro a real-world application of energy storage to assess system benefits. Toronto Hydro provided Hydrostor direct access to its electricity grid and in kind project support with engineering, interconnection, host project site and operational support to test the system. Together, Toronto Hydro and Hydrostor are moving UCAES forward.

Why it's needed

Utilities all over the world are facing challenges to provide reliable, cost-effective and environmentally friendly power. Ever-growing demand is placing higher loads on aging assets and infrastructure. Modern distributed renewable generation resources, such as solar, are introducing two-way energy flows, and electrical grids must be managed differently. Storage is an enabler for all these changes. It allows for assets to be better utilized while extending their life, addresses the inherent power fluctuations of renewable energy and gives grid operators the flexibility to accommodate new technology and demands.

Island nations are a prime example of rapidly changing grids. Currently, these nations are utilizing expensive diesel generation resources, which produce relatively high emissions and many island nations are seeking cheaper, cleaner wind and solar generation resources for their electrical needs. Without storage, most are limited to the amount of generation infrastructure they can install, leaving entire economies vulnerable to the price of oil. With a Hydrostor system, these island nations are able to break the fossil fuel habit, reducing their electricity costs and environmental footprint. Cities – such as Toronto – that face rapid population growth are another good application. As a city grows and sprawls outward, energy demand grows and transmission lines fill during the day, but have capacity at night. With a storage system able to directly support congested load centres, such as the financial core, the need for costly transmission line expansions can be deferred.

Why there's so much buzz

Hydrostor is clearly unique in the storage marketplace. Batteries are often utilized for electricity storage but are best suited for applications under four-hour duration because of high cost and capacity degradation over the long-term. UCAES offers a scalable system for bulk energy storage beyond four-hour duration with many benefits: low capital cost, low operational costs, 30-plus years of life, minimal standby-efficiency losses and operational flexibility.

The electricity system must adapt and evolve. Hydrostor's energy storage is part of that evolution.

About the Author

With nearly 15 years of manufacturing experience of oil-field production equipment in Alberta, Mr. Lewis has worked directly with all types of process equipment meeting all types of needs both domestic and abroad. He has prior experience with a number of start-ups including Delaney Energy Manufacturing, Chadco Canada, Armadillo Card Company, and most recently Environmental Electric Company, developing wind farms in Ontario.

From Research to Action

A Matter of Time

By Christine Hertzog and Glen Chason

Utilities are aware that their growing reliance on wired and wireless sensor networks to support advanced grid operations has a downside – an increased attack surface. But many utilities have yet to realize that there's another risk in the significant deployments of machine to machine (M2M) networks that's relatively undefined but has potential impacts that could cost utilities dearly. That's the issue of vulnerabilities to timing accuracy incorporated into sensors and intelligent devices deployed in today's grids.

These components and devices integrate to perform highly synchronized operations and provide timestamps for data used by equipment widely deployed in utility networks to monitor and manage grid operations. If timing is vulnerable to physical or cyber tampering, their precision can be altered, leading to incorrect operations and inaccurate timestamps. What does that mean for the data created or transmitted by these devices? That data becomes inaccurate too.

There are three main timing transfer methods used in today's telecommunications networks:

1. Global Positioning System (GPS)
2. Network Time Protocol (NTP)
3. Precision Time Protocol (PTP)

While GPS is widely known, the latter two protocols are increasingly found within telecommunications operations that support carrier networks as well as privately managed networks such as those deployed by utilities and other business sectors with significant telecommunications infrastructure.

Is precision timing really important for utilities? Absolutely! Advanced grid operations require accurate synchronization to ensure that one true time for data exists across their systems. For instance, the addition of Distributed Energy Resources (DER) assets harnessed for balancing volt/VAR levels will require precise and accurate timing coordination. EPRI's technical resources have worked with utilities to confirm that inaccurate timing data regarding fault locations sent utility work crews miles in the wrong directions and in other cases was the causative factor to tripped breakers on high voltages lines. Those situations have top-line and bottom-line impacts to utilities.

Utilities, labs, and academic institutions have confirmed some vulnerabilities in precision timing that may pose risks to grid applications, mission-critical and otherwise, that rely upon highly accurate timing. However, the potential risks associated with exploitation of these vulnerabilities is unknown.

In addition to the absence of clarity regarding potential risks created by precision timing vulnerabilities, there is also an absence of field-tested and proven mitigations for the most critical vulnerabilities. Existing research on vulnerability mitigations has been mostly confined to theoretical situations, not the practical knowledge needed to address the unique requirements of utility operations.

The Electric Power Research Institute (EPRI) Timing Security Assessment and Solutions research project will examine three essential questions about precision timing:

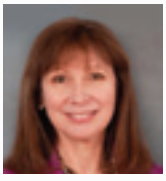
1. Is equipment relied on for precision timing vulnerable to attacks that could impact synchronized grid operations?
2. For equipment vulnerabilities identified, what is the potential level of risk to power delivery systems?
3. Can mitigations be identified and implemented to reduce the potential for exploitation of vulnerabilities in power systems?

If your utility hasn't asked, or can't answer these questions, now is the time to start building awareness and take action. For more information about EPRI's Timing Security Assessment and Solutions research, please get in touch with us.

References

For a detailed discussion about time-aware applications and the need for timing accuracy, the authors refer readers to the Time-Aware Applications, Computers, and Communication Systems (TAACCS) Technical Note 1867 published by the National Institute of Standards and Technology in February 2015.

About the authors



Christine Hertzog is a Technical Advisor for ICT and Cyber Security R&D programs at EPRI. She was previously the founder of a consulting firm focused on innovative grid solutions and has an extensive telecommunications hardware, software, and services background. She authored the Smart Grid Dictionary and co-authored Data Privacy for the Smart Grid. She has also served in an advisory capacity to startups, industry associations, and publications. She has an MS in Telecommunications from the University of Colorado at Boulder.

Glen Chason is a Principal Technical Leader of Cyber Security & Privacy in the Power Delivery and Utilization group at EPRI. He is also the manager for EPRI's Cyber Security and Research Lab located in Knoxville, TN. In this role at EPRI, Glen leads numerous projects in the areas of Penetration Testing, Threat Assessment, and the analysis of security for embedded systems. He is also providing technical leadership for a number of other projects including the Policy-Based Configuration Framework (PBCONF) project, Incident Management, and the Security Architecture. He also participates in numerous working groups and technical committees on cyber security for the electric sector. Glen has a Bachelor's degree in Computer Science from the University of Texas at Dallas and Master's degrees in Telecommunications and Security Engineering from Southern Methodist University.

Power System Transient Studies using EMTP-RV

By Thomas Grebe, P.E.

Power system transients that are caused by utility switching operations or lightning strikes to electric facilities have significant potential to damage equipment or disrupt operation. High frequency transients have been recognized for quite some time as a threat to electronic loads. Low and medium frequency oscillatory transients, such as utility capacitor bank switching, are usually of modest magnitudes but contain substantial energy, so their effects can be felt quite far electrically from the point of origin. Low frequency transients have been strongly correlated with nuisance tripping of customer power-electronic equipment, such as some types of adjustable-speed drives.

Transient voltages and currents are caused by sudden changes within the electric power system. Opening or closing of a switch or circuit breaker causes a change in circuit configuration and the associated voltages and currents. A finite amount of time is required before a new stable operating point is reached. Lightning strokes to exposed transmission or distribution circuits inject a large amount of energy into the power system in a very short time, causing deviations in voltages and currents which persist until the excess energy is absorbed. Both of these events cause a temporary departure of system voltage and current from their normal steady-state sinusoidal waveforms. All transients are caused by either connection or disconnection of elements within the electric circuit or injection of energy due to a direct or indirect lightning stroke or static discharge.

Transient Simulation Tools

Power system transient studies are completed using electromagnetic transients programs, such as EMTP-RV, PSCAD/EMTDC, and ATP. Computer simulations provide a convenient means to characterize transient events, determine resulting problems, and evaluate mitigation alternatives. Occasionally, the simulations are performed in conjunction with system monitoring for model validation and identification of important customer power quality problems. The complexity of the computer simulation models generally depend on the system characteristics and the transient phenomena under investigation.

EMTP-RV is a sophisticated program for the simulation of electromagnetic, electromechanical and control system transients in multiphase power systems. The program has a wide variety of modeling capabilities encompassing electromagnetic and electromechanical oscillations ranging in duration from microseconds to seconds. EMTP-RV is also used to study harmonic interactions in the frequency domain, including impedance frequency scans, harmonic distortion, and IEEE Std. 519 compliance analysis.

Types of Transient Studies

EMTP-RV is used to study potential problems associated with utility and customer equipment interactions. These studies include analysis of the methods for controlling transients based on economic, control, and technical considerations. Mitigation equipment specifications are determined for the required switching devices, current-limiting reactors, surge arresters, and customer surge control devices. Power system transient studies are needed to investigate utility transmission system expansion concerns including insulation withstand levels, switchgear capabilities, protective device energy duties, and system harmonic considerations. These issues should be extended to include utility distribution systems and customer facilities. Representative transient studies that can be completed using EMTP-RV include:

- Switching Surge Analysis
- Capacitor Bank Switching (Energizing and Switch Restrikes)
- Shunt Reactor Switching
- Transmission Line and Distribution Feeder Energizing
- Lightning Surges (Backlash)
- Transient Recovery Voltage (TRV) Analysis
- Arrester Duties and Insulation Coordination
- Wind Plant Temporary Overvoltages (TOVs) during Single-Phase Faults
- Transformer Switching and Dynamic Overvoltages
- Ferroresonance / Parallel Linear Resonance
- Motor Starting
- Voltage Notching
- Customer Adjustable-Speed Drive (ASD) Motor Transients
- Vacuum Circuit Breaker Switching (Current Chopping and Pre-Strikes)
- Power-Electronic Device Switching (Power Supply Inrush Currents)
- Outrush Reactor Transient Recovery Voltage Analysis

Capacitor bank switching studies often receive special consideration because the capacitor bank energizing transient is one of the most frequent utility switching operations and it can produce high phase-to-phase transformer overvoltages, excite circuit resonances, or cause problems with sensitive customer equipment. The frequent switching of utility capacitor banks coupled with sensitive customer end-use equipment has led to a heightened awareness of several important power quality concerns which include magnification of capacitor bank switching transients and nuisance tripping of power electronic-based customer loads.

Utility Capacitor Bank Switching Studies

Recent and upcoming power plant retirements are resulting in a need to reinforce our transmission systems. One measure being adopted is to install additional reactive power in the form of capacitor banks that often require detailed harmonic or transient simulation studies to assure a successful design.

The analysis of utility transmission capacitor banks often includes measurements and computer simulations for studying application considerations that include capacitor bank configurations, insulation withstand levels, switchgear capabilities, grounding, overcurrent protection, overvoltage protection, energy duties of protective devices, and unbalance detection.

The most common methods for controlling utility capacitor switching transients include switching control (e.g., synchronous closing, pre-insertion inductors/resistors), fixed series inductances, and MOV surge arresters. The application of transmission and distribution system capacitor banks has long been accepted as a necessary step in the design and operation of electric power systems. Design considerations often include traditional factors such as voltage support, power factor, and released capacity. However, as customer systems evolve through the use of power electronics, future capacitor bank designs should also consider power quality.

The utility capacitor bank switching study should include a transient analysis of overvoltages and overcurrents during capacitor bank energizing and capacitor bank switch restrike events. The primary issues evaluated during the study include:

- Evaluation of transient overvoltage magnitudes for normal capacitor bank energizing operations, including the effects of other capacitor banks and system loads.
- Evaluation of the effectiveness (control of energizing transients) of various transient control methods (e.g., pre-insertion inductors/ resistors, synchronous closing control, etc.).
- Evaluation of arrester duties during capacitor bank switch restrike conditions.
- Evaluation of inrush currents for normal and back-to-back switching operations.
- Evaluation of outrush currents for nearby fault conditions.
- Evaluation of capacitor switching transients on lower voltage systems.
- Magnified transients at lower voltage distribution buses and within customer facilities.
- Nuisance tripping of adjustable-speed drives.
- Evaluation of system frequency response characteristics (resonances).

A utility capacitor bank study is needed to determine recommended equipment ratings and requirements for protecting against excessive transients for the power system and to also present guidelines for applying transmission capacitor banks with respect to overvoltage mitigation. The study includes the following equipment recommendations:

- Options for current limiting reactors for controlling inrush and outrush currents.
- Requirements for capacitor switching devices, including the effectiveness of transient overvoltage mitigation techniques (i.e., synchronous closing control, pre-insertion resistors/inductors).
- Arrester requirements associated with a capacitor bank switch restrike event.
- Requirements to protect against excessive transients at lower voltage capacitor banks, including capacitor switching controls, surge arresters, reactors, or capacitor size limitations.
- Requirements to protect against excessive transients at low voltage adjustable-speed drives, including capacitor switching controls, and reactors.
- Guidelines for developing a standard capacitor bank design with respect to overvoltage mitigation, reactor requirements, and surge arrester applications.

Case Study - Utility Capacitor Bank Switch Failure Investigation

Power system apparatus, such as switchgear, capacitor banks, and surge arresters may be exposed to various types of transients. Transients from restrikes during vacuum switch opening may cause problems for electrical equipment because they can cause local overstressing of the insulation system and exceed surge arrester energy ratings. Capacitor bank switch restrikes often produce high transient voltage surges that result in severe energy duties for adjacent arresters or damage unprotected equipment.

A transient investigation was completed for a utility in Kansas. The primary purpose of the study was to investigate a capacitor bank vacuum switch failure that occurred during a multiple restrike event on an ungrounded 7,800 kVAr, 34.5kV capacitor bank that was protected with a 27kV MOV arrester. A large number of customer power quality complaints recorded during the capacitor bank switch failure included adjustable-speed drives and HVAC equipment tripping due to the resulting secondary transient overvoltages.

The principal objectives of the study were to determine transient overvoltages and evaluate mitigation alternatives for vacuum switch restrike transients (refer to Figure 1) that were believed to have caused the capacitor bank switch failure.

A capacitor bank switching device de-energizes a capacitor bank at a current zero. Since the current is capacitive, the voltage at the time of current interruption is at a system peak. Successful interruption depends on whether the switch can develop sufficient dielectric strength to withstand the rate-of-rise and the peak recovery voltage. For grounded-wye capacitor banks, two times (2.0 per-unit) the system peak voltage will appear across the switch contacts one-half cycle after interruption. If the switch cannot withstand this recovery voltage, the switch will restrike.

During normal grounded-wye capacitor bank de-energization, the capacitor bank current is interrupted at the peak system voltage thus leaving a 1.0 per-unit trapped charge on the capacitor bank. This trapped charge results in an offset in the transient recovery voltage that reaches a magnitude of 2.0 per-unit one-half cycle after opening. Significant transient voltages can occur if the switch restrikes during clearing. The worst restrike transient occurs when twice the system peak voltage appears across the switch contacts. Theoretically, in this case, the magnitude of the transient voltage approaches 3.0 per-unit.

The transient voltages on a capacitor bank and the recovery voltages across the switch can be reduced by installing arresters on the capacitor bank side of the switching device. If the switch is rated for the recovery voltages involved, then the arresters can be located on either the capacitor bank side or source side of the switch. Connecting arresters line-to-ground on an ungrounded-wye capacitor bank does not necessarily limit the voltages trapped on the capacitor units to the arrester's protective level.

Since a restriking capacitor bank switching device can result in transient voltages that may result in severe arrester energy duty or equipment damage, it is desirable to choose a switching device that will minimize the possibility of restrike. Since all switching devices have some probability of restrike, the effects of restrike events should be investigated in the transient study.

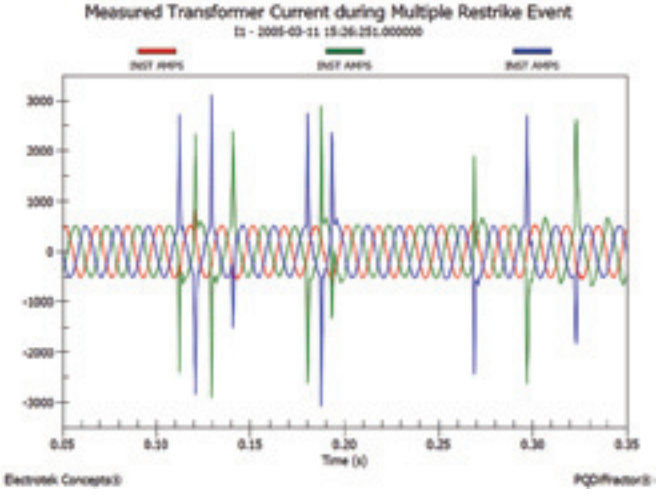


Figure 1 – Measured Transformer Secondary Current during Capacitor Bank Vacuum Switch Failure

Case Study - Hospital Transformer Failure Transient Investigation

High-frequency transients and very steep overvoltages may cause problems for electrical equipment because they can cause local overstressing of the insulation system. Vacuum circuit breaker (VCB) opening-and-closing operations are a significant source of these high rate-of-rise (dv/dt) transients. In addition, dry-type transformers and motors are often more vulnerable to these transients due to their lower insulation level (BIL) ratings.

A high-frequency transient investigation was completed for a medical center in California. The purpose of the study was to investigate a transformer failure that occurred during commissioning of the facility. The principal objectives of the study were to determine transient overvoltages and evaluate mitigation alternatives for vacuum circuit breaker current chopping and pre-strike transients that were believed to have caused the transformer failure.

The study included analysis of MOV surge arresters and other mitigation alternatives (e.g., R-C snubbers). Based on the analysis completed during the study, the hospital installed R-C snubbers (refer to Figure 2) at the switchgear terminals of the distribution circuits where the transformers were being switched. Properly-designed R-C snubbers reduce the initial rate-of-rise of the transient voltages, which is beneficial because severe dv/dt transient voltages can damage the first few turns of insulation of dry-type transformers and motors or excite internal transformer resonances producing severe overvoltages.

Vacuum circuit breakers are understood to be capable of initiating a phenomena described as current chopping. The physics of the vacuum circuit breaker allow for a smaller space to be utilized in the interruption of current in a vacuum. It is well-known that these devices can interrupt (chop) current. This is a different behavior than typical air circuit breakers, which normally allow current arcing following contact separation until a natural zero crossing occurs.

The current chopping phenomenon is generally not troublesome, however, there are specific circuit configurations that can cause problems. The most common configuration involves using vacuum interrupters to de-energize unloaded transformers or other highly inductive circuits. In this case, the inductive current to the transformer is interrupted, possibly causing high transient overvoltages. The current chopping analysis showed that severe transient overvoltages will occur if the vacuum circuit breakers chop current during opening.

Pre-strikes are a breakdown of the vacuum dielectric during closing of a vacuum circuit breaker. A pre-strike occurs when an arc current flows for a short period-of-time before mechanical contact closure. The pre-strike phenomenon is very complex and difficult to predict. The transient currents and voltages are dependent on many factors, such as circuit breaker characteristics, dielectric properties, surge impedance of the circuit components, and high-frequency current interrupting capability.

Transient voltages during pre-strikes are a result of the interaction (resonance) between a transformer inductance and a capacitive network. The susceptibility to the resonant frequency phenomena depends on cable lengths and other capacitive parameters and on the transformer inductance. The pre-strike analysis completed during the study showed the potential for high rate-of-rise transient voltages if the vacuum circuit breaker pre-strikes during closing.

Figure 2 – R-C Snubber Installed at Customer Facility

About the author

Thomas Grebe, P.E. is a Principal Consultant at EnerNex. His areas of expertise include power system and power quality analysis, transient analysis, harmonic monitoring and analysis, and utility capacitor bank application studies. His experiences include completing numerous utility power system studies and research projects for organizations including CEATI, EPRI, NRECA, and TVPPA. Tom has over twenty-five years of application experience using the Electromagnetic Transient Program (EMTP-RV) and PSCAD transient simulation programs.

Tom served as Conference Secretary and Local Organizing Committee Chairman for the 1997 International Conference on Power System Transients (IPST) Conference that was hosted by the University of Washington. The IPST Conference was created with the goal of promoting the study of power systems transients by offering a platform of scientific and technical excellence for its presentation. Tom is currently an IPST Steering Committee member.

Tom is a Senior Member of the Institute of Electrical and Electronics Engineers (IEEE) Power and Energy Society (PES), Chairman of the IEEE Working Group on Capacitor Technical Papers, and is Past Chairman of the IEEE PES T&D Committee and IEEE Capacitor Subcommittee. Tom is registered as a Professional Engineer in the State of Virginia.

Utilities and the Internet of Things: Leveraging the Data

By Bradley Williams

We have heard a lot about the Internet of Things (IoT) in our daily lives in recent years, from smart thermostats, smartphones, wearables and other connected devices to the myriad of apps that run them. Behind the IoT hype – and, indeed, the phrase itself – what we're really talking about here is the proliferation of 'things' or devices with intelligent sensors, networked connectivity of those things, and the ability to leverage the data being gathered by them.

The utility industry is no stranger to the Internet of Things. The smart grid, after all, is essentially the application of IoT technology (smart sensors, two-way communications, and analytics) to our electric grid infrastructure to enable better efficiency, improved reliability, the integration of more renewables and distributed energy resources, reduced emissions, and more engaged and empowered customers.

In coming years, this industry is expected to drive exponential growth of new IoT applications to communicate machine-to-machine to new field devices and consumer energy technology devices at the edge of the grid. But even more important than this ubiquitous communication is the sensor data being gathered by these machines, and how that data can be operationalized for more efficient and proactive efforts on the part of the utility.

Utilities are already leveraging IoT

Leveraging technology is nothing new to electric utilities. As Deloitte Consulting's Rob Young, John McCue and Christian Grant wrote in The power is on: *How IoT technology is driving energy innovation:* "The electric utility industry's use of IoT applications has closely followed the arc of technology availability. While seldom on the bleeding edge, utilities have always leveraged available technology to optimize and control assets, increase safety, control the grid, and keep the lights on."[1]

Young and his colleagues go on to point out that supervisory control and data acquisition (SCADA) sensors and actuators already communicate with and are controlled by a central master unit, providing a user interface 'through a human-machine interface.' As well, they say, advanced metering infrastructure (AMI) provides for a two-way communication system of smart devices 'on both the utility and customer sides of the meter,' consisting of home area networks, in-home displays, energy management systems, smart meters, communication networks, and data management systems.[2]

By applying analytics to all of this near-real-time sensor and device data, utilities are now able to leverage existing technologies with even more prowess, unlocking actionable insights improving asset performance management and grid reliability as well as customer satisfaction.

There are also a number of other ways in which utilities are already leveraging, or planning to leverage, IoT technologies to enable the vision of the future distribution utility. These include asset performance management and grid and energy optimization (including distributed energy resources and consumer energy technologies). And ultimately, it will be IoT technologies that will help to facilitate a consumer-driven (or crowd-sourced) energy market.

Let's look at each of these areas in more detail.

Leveraging sensors for asset performance management

With operating costs skyrocketing, utilities are being pressed to reduce expenses while finding new ways to decrease their environmental impact and deliver more customer-centric service. Asset performance management is a key part of that equation. Low-cost, smart field sensors are providing real-time eyes in the field, enabling utilities to proactively determine whether it is necessary to replace or repair an asset before it breaks down. This determination requires an understanding of that asset's condition and importance to the organization, and is best gained by aggregating all asset data, including work history and condition rating, into a single system, balancing the importance of one factor versus another, and updating any condition changes as they occur. Armed with this data in real time, the utility has a more reliable view of asset health and can make more meaningful investment and work decisions on how to best balance compliance, reliability, safety and risk.

In the past, business insight was based upon intuition and subjective or observed assessment. In an increasingly digitized utility environment, this type of assessment is being replaced by objective data analysis that is by its very nature more accurate, providing utilities with far more actionable insight than before. This analysis, when automated as a core business process, has demonstrated significant capacity to affect margin by lowering operating costs while increasing revenue.

How, specifically, does this occur? Proactive work has been shown to reduce asset failure rates and drive down the cost to operate each asset. For example, by scheduling proactive work during normal business hours instead of having to react to a failure with an after-hours call-out, costs are reduced and reliability is greatly improved. If you add automation to this equation, made possible by smart sensor and control devices – many of which are IP-addressable and wireless connected – along the utility's infrastructure, you can also add real-time asset analysis to the asset management toolset. Advanced asset risk analytics than then correlate the appropriate data from across the enterprise (for example, correlating specific sensor data with advanced metering data for a certain area) to provide immediate prescriptive maintenance work requests, thereby alleviating a problem while it is still minor.

Leveraging new resources for grid optimization

The modern grid is changing as many consumers are choosing to become prosumers. Empowered by technology innovation and sustained by changing regulatory policies, consumers are adopting distributed energy resources (DER) such as rooftop solar and on-site energy storage in record numbers, far more quickly than anticipated. By managing their energy consumption behavior with little or no input from their utilities, these consumers are driving change in how the modern distribution grid will work in the near future. These DER, too, are pushing massive amounts of real-time data back onto the distribution grid, providing utilities with the means to change the way they manage this evolving distribution grid.

Made possible by IoT technologies, modern distribution management requires utilities to take a data-centric approach to monitoring, control and optimization of both traditional distribution and new edge-of-grid needs. Optimizing the grid and leveraging these distributed energy resources and consumer energy technologies begins with the ability to model the generation output profile of each of these DER, accounting for location, condition of use, and other attributes unique to each asset. (If the DER is a rooftop solar resource, for example, it is important to account for clear or cloudy skies, latitude, time of day, day of year, and the direction and pitch of panels.)

Each DER asset type is different, as are their impacts on the distribution grid. But by being able to more accurately model their generation output profiles, utilities can better forecast where and how DER growth will impact their distribution grid and use that information to improve their long-term resource planning to support this growth. Further benefits include reducing the capacity for intermittency to cause disruption and safety issues; eliminating the need to bring additional, costly generation resources online; and minimizing customer interruption minutes by way of improved generation output profiling.

Facilitating a consumer-driven energy market

As defined by the GridWise Architectural Council in its initial framework document, the term 'transactive energy' (or TE) 'refers to techniques for managing the generation, consumption or flow of electric power within an electric power system through the use of economic or market-based constructs while considering grid reliability constraints. The term 'transactive' comes from considering that decisions are made based on a value. These decisions may be analogous to or literally economic transactions.'[3]

With consumer-owned DER continuing to proliferate, a consumer-driven, transactive energy market is expected to take shape in the future. Utilities have a choice: they can view this challenge as a threat to their business, or they can turn it into a business opportunity to manage the evolving energy distribution platform, improving their investment performance and lowering operating costs along the way. The TE construct provides for this future by including utility customers' and other third-party distributed energy resources in the new market exchange equation, a dynamic balance of energy supply and demand. IoT technologies will provide the means for utilities to model and manage the granularity and scale of DER and other consumer energy technologies involved in this dynamic market.

Going forward

End-to-end visibility, and the ability to model, manage, analyze and control these new grid-edge resources, will be key to the advanced distribution management required of utilities, both now and in the future. IoT is the vital link connecting this end-to-end utility IT/OT technology platform both to the consumer and to the edge of the grid. Are you ready to make this shift?

[1] Deloitte, The power is on: How IoT technology is driving energy innovation by Rob Young, John McCue and Christian Grant, Jan 21, 2016
[2] Ibid
[3] The GridWise Architectural Council, "GridWise Transactive Energy Framework Version 1.0," January 2015. http://www.gridwiseac.org/pdfs/te_framework_report_pnnl-22946.pdf

The "Era I" Enterprise Needs to Be Ready for Anything

By Bradley Williams

The digital age has brought with it a new type of consumer, one who increasingly expects, and even demands, to have it his or her way whether transacting, communicating, working or simply enjoying leisure time. We have entered "Era I" – the Age of the Individual.

But while consumers have new, individual expectations of the enterprises with whom they interact and do business, what does this mean for today's enterprises? Organizations and businesses need to be ready and able to respond very quickly to consumer – and employee – expectations and deliver content, experiences, services and technology to individuals however and wherever those individuals desire. But, while businesses understand the need to change, it can be quite difficult to quickly put that goal into action. How prepared, really, are organizations to make this shift?

Earlier this year, Oracle conducted telephone and online interviews with 300 North American C-level executives across 10 industries: Communications, Education and Research, Engineering and Construction, Financial Services, Healthcare, Hospitality, Life Sciences, Public Sector, Retail, and Utilities. The goal: To answer that question.

Most organizations are unprepared for Era I

The resultant report, *The Era I Enterprise: "Ready for Anything"*, was published in April of this year. Across industries, the study revealed that organizations, by and large, are unprepared to manage the need for personalization brought about in Era I. Key takeaways included:

- 84 percent of those surveyed say their organization has experienced a trend toward customers wanting a more individualized experience, and 70 percent have experienced this trend from employees.
- Nearly two-thirds of managers say the shift is a growing challenge in their ability to compete more effectively.
- Less than one in five C-level executives gave their organization an "A" in its ability to offer highly individualized customer or employee experiences.
- Their biggest weaknesses are their abilities to: turn on a dime in response to change or opportunity, offer highly individualized products/services, and respond effectively to changing market conditions.

There were, of course, some fluctuations in percentages from one industry to another. For example, 100 percent of communications and hospitality executives have noticed this customer trend toward wanting a more individualized experience, as compared with other industries, and utility executives were the most likely to respond that Era I expectations are impacting their ability to compete.

Individualization is a growing challenge for utilities

Utilities executives' responses regarding the trend itself mirrored those of other industries, with 87 percent reporting customers wanting a more individualized experience, and 73 percent experiencing the same trend with employees. However, a full 82 percent – the highest of any of the 10 industries surveyed by a full nine percent – say the shift is a growing challenge in their ability to compete effectively. Further, only 20 percent of utility respondents rated their organization's ability to offer highly individualized customer or employee experiences an 'A.'

A deeper dive into the Era I utilities industry survey results turned up the following:

- There are many missed opportunities for utility customer individualization. Many utility respondents indicated that their organizations did not currently offer on-demand order fulfillment (83 percent), self-service options from the device of choice (73 percent), individualized content (63 percent) and intuitive online experiences (63 percent).
- The utility employee individualization numbers are comparable, with organizations not currently offering to employees self-service options from the device of choice (83 percent), data analytics (70 percent), a flexible work environment (67 percent) and industry-specific applications (67 percent).

There weren't many surprises in the areas chosen by utility executives as offering the greatest opportunities for their organizations to take advantage of more individualized content, products, and services for their customers and/or their employees. These included:

- Use mobile technologies for individual field employee productivity (53 percent)
- Simplify doing business with the utility process through enhanced self-service options (43 percent)
- Enable customers by offering customized solutions to optimize cost and convenience (37 percent)
- Deliver employee development programs to empower our diverse (i.e., aging) workforce (37 percent)
- Use social media channels to actively engage with customers, per their preference (17 percent)

A few years ago, using social media to more fully engage their customers was still in early adoption stages at many utilities. Today, however, many utilities have harnessed the value of Twitter, Facebook, YouTube, LinkedIn and other social media channels not only for customer engagement, but also for outage communications as well as for customer acquisition and retention (for competitive energy retailers). Some are even beginning to use social media channels to improve internal utility business processes. The low percentage response in the Era I study to using social media as a customer engagement tool may well reflect the fact that it is already entrenched in many utilities' business and communication processes now.

Using the cloud to deliver individualized experiences

The Era I report's utilities snapshot also revealed a strong correlation between the cloud and a utility's capability to act more fully upon customer and employee individualization efforts. In fact, 97 percent of utility respondents said they believed that there is an important link between cloud-based IT solutions and their organization's ability to deliver individualized employee and customer experiences.

Oracle Utilities saw similar results in its recent study, *On Cloud Now: Cloud Technologies are Here for Utilities*. Conducted by Zpryme on our behalf, the cloud study surveyed 100 electric, gas and water utility executives and directors about their cloud objectives, and found that 45 percent of utilities surveyed were already using cloud technologies in some areas of their organization, and a further 52 percent are making plans to do so, for a total of 97 percent looking seriously at cloud-based IT technologies.

Of the cloud survey group, 53 percent cited a need for rapid innovation as the top characteristic of different utility business areas that would make them strong candidates for the cloud.

There are still obstacles to be tackled

There are definite challenges to 'turning on a dime' for utilities who want to offer more individualized experiences for customers and for employees. For one, the utilities industry is highly regulated, and there are many restrictions to what types of services can and cannot be offered by utilities to their customers. As well, utilities are facing mounting demands upon them: demands of the changing customer relationship, demands around big data, environmental and financial demands, demands around the types of generation to be used to create electricity in the future, and demands caused by customer-owned resources at the grid's edge. Through all of this, they continue to look for opportunities to provide new value in the ways in which they interact with their customers and strategically operate their infrastructures.

Utility responses to the Era I survey reflect these challenges. When asked what the biggest obstacles the utilities industry faces in delivering more individualized content, products and/or services, they responded this way:

- Regulatory constraints (67 percent)
- Budget/cost constraints (40 percent)
- Security concerns (40 percent)
- Developing customer value within a commoditized industry, where price drives customer behavior (27 percent)
- Addressing typical reputation challenges (20 percent)
- Building customer relationships in a low-engagement sector (20 percent)

Looking forward

It is clear across the board, in every industry surveyed, that "business as usual" will no longer cut it in The Age of the Individual. Increasing digitization of all industries—backed by strong analytics applications providing actionable information quickly and by cloud technologies providing the ability to increase an organization's flexibility and innovate more quickly—is paving the way for a real step-change in enterprises' ability to provide more individualized customer and employee experiences and engagement.

About the author

Bradley Williams is vice president of industry strategy, Oracle Utilities. Williams is responsible for Oracle's smart grid strategy as well as utility solutions for outage management, advanced distribution management, mobile workforce management, work and asset management, and OT analytics. Williams has spent the last 30 years driving innovation in the utility industry in roles, including T&D power system engineering, technology development, asset management, and industry analyst.

Shining the light on poverty

By Armand Pineda, Western Europe & Africa Region General Manager, GE Grid Solutions

Energy and poverty – two elements with a direct relationship, as studies show that access to electricity has a positive effect on poverty (International Energy Agency). It has the potential to increase efficiency, improve health, promote economic growth and boost competitiveness. The poor are least likely to have access to electricity, and the more they are disconnected or not connected to the grid, the more likely they will remain poor. It is a never ending cycle of overlooking the vital role connection to the electricity grid plays in enhancing people's lives.

Extending days with access to lighting allows communities to have more time to study, work and play, advancing a country's capabilities, productivity and effectiveness. Heating, refrigeration and modern cooking facilities are all enabled by electricity. Having access to electricity could mean saving time and energy to focus on productivity. Agriculture could receive a boost with modern farming technologies that save time, increase harvest and yield. Access to electricity also means an improved and reliable healthcare system for the wellbeing of the citizenry.

In 2013, it was estimated that approximately 17 percent of the world population (International Energy Agency) did not have access to electricity. Most people without access to electricity live in rural areas of the developing world, mainly in South Asia and sub-Saharan Africa. In sub-Saharan Africa, electrification rate in urban areas is approximately 60 percent, whereas rural areas are only at 14 percent.

According to the World Bank data, Malawi – the landlocked country located in southern central Africa – provides less than 10 percent (The World Bank) of its population with access to electricity. With more than 70 percent of Malawians (United Nations) living below the income poverty lines of less than US$1.25 per day, the government through the Malawi Growth and Development Strategy II is investing in key strategic areas to stimulate the country's economy. Recognizing the importance of energy in economic development of the country, Government has put energy as one of the key priority areas.

In this respect, the Government of Malawi is working towards increasing generation capacity by rehabilitating the oldest power station, Nkula A, as well as expanding, upgrading and rehabilitating the country's backbone transmission network and the transmission and distribution network for an efficient power system. The Government is also reforming the electricity supply industry in the country to create an enabling environment for private sector investment in generation and later in transmission and distribution.

One of the key strategic partners in improving Malawi's Energy sector is the Unites States funded Millennium Challenge Corporation (MCC) which gave the Malawi Government a US$350.7 million grant for the Power Sector Revitalisation Program, managed and supervised by Millennium Challenge Account – Malawi (MCA-Malawi).

As a result, the Malawi Government through the MCA-Malawi engaged GE Grid Solutions business to design, supply and install the Supervisory Control and Data Acquisition (SCADA) to assist engineers in real time remote monitoring, planning & optimization of ESCOM's transmission systems spread over the country. This is will help to help create a modern and efficient power grid.

Malawi, the "warm heart of Africa"

Lying to the east of Zambia, west of Mozambique and south of Tanzania, Malawi is divided into three regions, Southern, Central and Northern, and has the third largest lake in Africa, Lake Malawi. Agriculture contributes more than a third of the country's Gross Domestic Product (GDP) and generates more than 90 percent (South African Development Community) of total export earnings. Often referred to as the 'warm heart of Africa', Malawi's population of approximately 16 million is well known for their warmth and hospitality. With 90 percent (Africa Guide) of its people living in rural areas, about the same percentage lives with under US$2 per day. The United Nations ranked Malawi's social and economic development at 173 out of 188 countries in its 2015 Human Development Index (United Nations), and according to the World Bank last year (Muheya, 2015), Malawi is the poorest country in the world. A country battling against the odds to develop with integrity, overcome the impact of HIV-Aids claiming tens of thousands of lives year after year, Malawi is trying to rise above the economic crisis of 2012 (Peter Mwanakatwe) while fighting the forces of nature, such as unexpected floods that have damaged the country's infrastructure and crops – its main export earnings.

Most of the power generation plants in Malawi (Electricity Supply Corporation of Malawi Limited) are hydro-powered and located in the south along the Shire River – where close to 50 percent (Rural Poverty Portal) of the population reside, making it the most densely populated region – and approximately 40 percent live in the more fertile, lush lands in the central region near the capital city of Lilongwe. Yet today, more than 90 percent of Malawi's population still do not have access to the electrical grid.

Recognizing this uphill battle, the Government of Malawi has launched several campaigns and programs to help Malawi embark on the journey out of poverty and into economic development. One of the organizations working to improve the country's economic growth is the MCA-Malawi

MCA-Malawi

MCA-Malawi, a Government entity, was established in 2011 to implement, manage and supervise the US$350.7 Million Millennium Challenge Corporation (MCC) Compact for investment in the energy sector. MCA-Malawi's purpose was to implement activities that will revitalize the power sector. This includes investments in three key areas: Infrastructure Development, Power Sector Reform and Environmental and Natural Resources Management.

Each project, with different roles to play, has underlying objective – to stimulate economic growth and play a part in reducing poverty in Malawi.

Infrastructure Development project (IDP)
This project aims to rehabilitate, upgrade and modernize priority Generation, Transmission and Distribution assets in Electricity Supply Corporation of Malawi Limited (ESCOM) system. The project is thus investing in rehabilitate, upgrade and modernize Malawi's generation, transmission and distribution assets that are in most need of repair. This is done to maintain the existing generation and enhance the capability of Malawi's transmission system while improving the efficiency and sustainability of hydropower generation.

Power Sector Reform project (PSRP)
Complementing the Infrastructure Development project, this project is supporting government, improving the financial and operational performance of ESCOM and strengthening the regulatory environment to support policy reform and investment. It looks into two activities – the turnaround of the Electricity Supply Corporation of Malawi Limited (ESCOM) and Regulatory Strengthening. This sets the stage for the expansion of the power sector in the near future.

Environmental and Natural Resource Management project (ENRM)
This project focuses specifically on the Shire River Basin Catchment areas. The objective is to address the immediate problems of siltation and weed infestation limiting power generation by ESCOM through mechanical and biological means. It addresses the issues affecting the river, such as aquatic weed infestation and excessive sediments that could cause disruptions to the hydropower plant downstream. Through the ENRM project, the government seeks to improve land use and watershed management practices in the river by addressing underlying environmental and social issues.

Optimizing the grid

Improving the availability, reliability and quality of power supply is essential to ensuring the stability and efficiency of the grid. To do this, MCA-Malawi engaged GE to install and commission an Energy Management System (EMS) and telecommunication system at ESCOM.

The installation of the SCADA/EMS e-terra platform will allow ESCOM to monitor, plan and optimize its transmission systems nationwide in real time. With this system, ESCOM will be able to optimize Malawi's power system and increase its efficiency in delivering much needed electrical power to Malawians. GE will also install remote terminal units at existing and new transmission substations in the central and southern region of Malawi, as well as upgrade ESCOM's existing telecommunication system. GE's team of experts will also provide the technical training to ensure that ESCOM is able to garner the best out of the installed system.

As the electricity market evolves, energy management plays a key role to ensure sufficient energy supply to meet energy demand. Today, operators have to take Distributed Energy Resources, Renewable Energy integration and Smart Grid transformations into consideration, while maintaining the current grid and preparing it for the future. Grid stabilization and modernization in Malawi is an important element to ensure more people gain access electricity – a key step to the eradication of poverty. The stability of the grid is also essential for future developments, such as grid interconnections, that could further cement the much needed availability of electricity.

Malawi's electrical future – sharing the load

In preparing for Malawi's future electricity grid, MCA-Malawi will construct a 173km 400kV overhead line (OVHL) from Phombeya in Balaka to Nkhoma, Lilongwe, and 129km 132kV OVHL Chinteche in Nkhata Bay to Bwengu, Mzimba. The substations at Phombeya, Nkhoma and Bwengu will be designed to accommodate the government's future plans to interconnect Malawi's grid to its three neighbouring countries, Mozambique, Tanzania and Zambia. Sharing the load would mean that Malawi will be able to both receive power when they need it and provide power when it has excess.

Grid interconnections can have a positive impact on electricity availability and could also lower the cost of electricity supply. In Europe for example, grid interconnections is a step towards sustainable energy by allowing countries to share clean energy, generated at potentially lower costs, with utilities potentially passing these savings to its customers.

Malawi's energy sector is evolving. Plans have been laid out for bigger and better grid connections, coupling it with the right equipment to support the effective, efficient distribution and higher availability of electricity. Although access to electricity is not the only solution to poverty, the link between them is evident – especially in developing countries. Better electricity supply could be a catalyst to the eradication of poverty in Malawi, one kilowatt at a time.

About the author

Armand Pineda is the Western Europe & Africa Region General Manager at Grid Solutions a GE and Alstom joint venture, in GE's Energy Connections business. Armand has an international career with more than 20 years of experience in the business development and execution of projects of the Power Industry in Asia, Northern Africa and Europe.

Prior to his role with GE, Armand was the Region Vice-President of Western Europe and Africa for Alstom Grid. He joined Alstom Grid in April 2012 as the Vice-President in charge of the Engineering and Projects Excellence including the Large Projects Organization.

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Applying New Intelligence to Integrating Distributed Energy Resources

By Matthew Spaur

How do you move, consciously and deliberately, from the past to the future?

More specifically, how do you make the most of your existing distribution infrastructure while planning for and taking advantage of new technology?

Today's electricity distribution system is caught between the aging, one-way power flow infrastructure of the past and the rapidly arriving future of decentralized generation and storage coupled with demand response, big data and analytics.

Many utilities like yours are currently experiencing stagnant load growth on an annual basis, but more volatile demand levels on any given day.

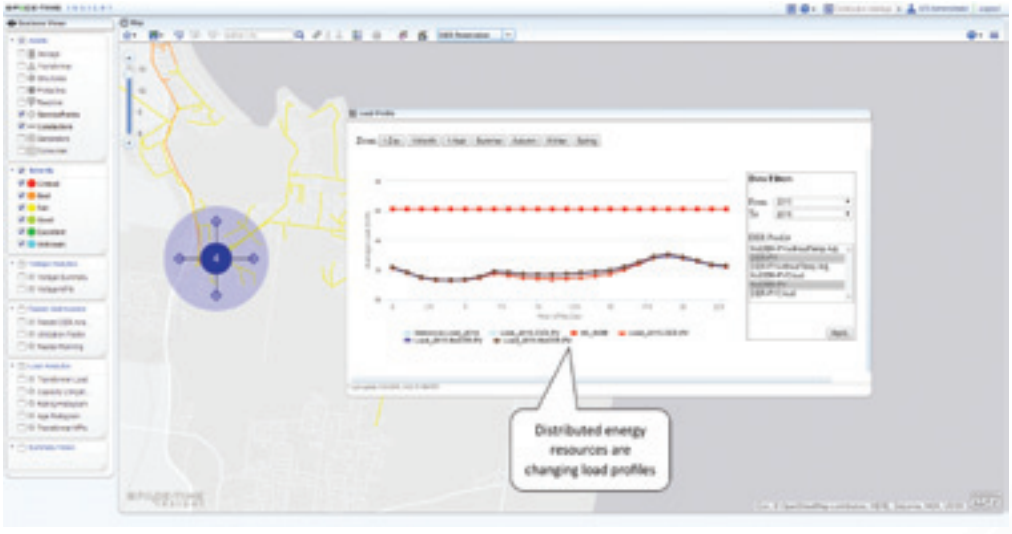
In the past, you would have upgraded the neighborhood distribution circuit to handle the higher daily peaks. Today, you have the opportunity to employ emerging technology to make your existing infrastructure last longer and provide a bridge to the future.

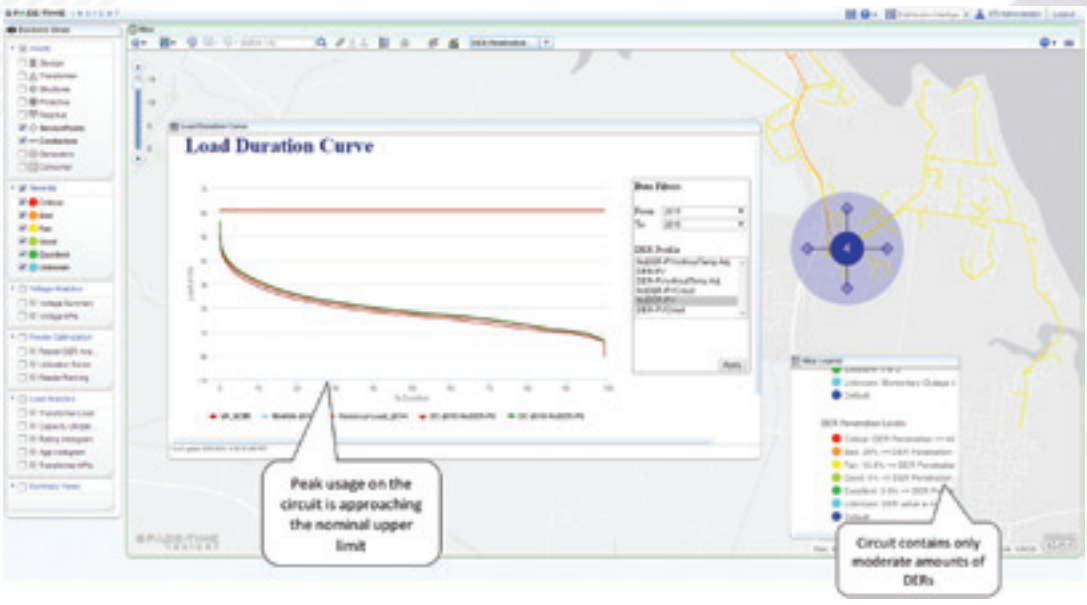
Making the Most of What We Have

Load profiles show us the peaks and troughs of projected daily power use. Distributed energy resources (DERs) are driving changes in traditional load profiles. Across the neighborhoods you serve, rooftop solar generates large amounts of power during the day, then drops off precipitously when evening arrives. Electric vehicles take large amounts of energy off the distribution grid at night, previously a period of low consumption. These changes run counter to the historic power usage patterns of daytime peaks and nighttime lows. You can create a more complete picture of load by predicting the impact on the service point of rooftop solar, energy storage, demand response and energy efficiency. Matching these new distributed energy resources to the volatility in local usage allows you to meet demand without upgrading the local circuit.

This new approach gives you two main benefits:

- One, it can happen much faster than a substation and/or circuit upgrade. That means you can satisfy customers and regulators more quickly.
- Two, it postpones the capital outlay needed for the upgrade. The ability to postpone for 5-7 years the $5-10 million costs to upgrade a substation gives you real, measurable benefit. Aggregate that benefit across multiple substations and circuits, and combine it with other benefits such as better power quality and reliability, higher customer satisfaction and fewer, shorter power outages, and you have a solid bridge to the future.





Relying on new, distributed energy technologies to meet demand isn't free, but it is less expensive. Your circuits may even eventually need an upgrade. However, the twin results of faster response and delayed investment make integrating DERs into the distribution grid an attractive alternative.

Applying Distribution Intelligence

The problem of what distributed energy resource is needed where and when to balance out a circuit is a perfect use case for situational intelligence applications.

Situational intelligence applications analyze simultaneously the spatial, temporal and network aspects of a problem to provide the what, where, when, why and how for any asset or event. The results of that analysis are then visualized for rapid comprehension and decision making.

For example, this screen shot shows a situational intelligence application for integrating distributed energy resources such as rooftop solar into your distribution network.

You can see that the highlighted portion of the distribution network has been experiencing periods of high peak usage, and yet contains only moderate amounts of distributed energy resources. This portion of the network could be a prime candidate for adding more rooftop solar to help offset the high peak usage.

(Of course, this assumes that the periods of peak usage coincide with period of high solar energy production. Such might be the case on hot, sunny days when residential air conditioners are running. If the peak periods of energy demand and solar production don't coincide, for example with a neighborhood full of electric vehicle owners, you might need to install local energy storage along with the rooftop solar. That way, excess energy generated by solar systems could be stored and then later released to offset peak demand.)

By factoring in existing and potential distributed energy resources into the distribution network, you decrease the peak load without the need for a capital project to increase the capacity of the circuit.

Summary

The future of energy is here, today, in your service area: rooftop solar power, home-scale batteries, electric cars, high-efficiency appliances, smart thermostats, demand response programs.

However, the future doesn't come with a clean slate. You must accommodate what came before, including the assets and infrastructure that you already have in place. The future is evolutionary, and evolution requires time. By taking advantage of emerging technology, you can buy more time for your aging infrastructure while the new energy future continues to evolve.

About the author

Matthew Spaur is Senior Marketing Manager at Space-Time Insight. He's an energy and technology veteran with previous roles at Microsoft and Itron.

Web Services Extend Network Data, Improving Operations and Customer Service

By Bob Galvin

Customer satisfaction is the name of the game. As consumers, we expect to flip a switch and have the lights turn on. But this simple action requires a chain-reaction of complicated processes. A utility's administrative, engineering and operational personnel must have access to the right information at key intervals to make sure service is uninterrupted. Whether planning, designing or operating the network – or engaging in any number of key business tasks -- the network model is the foundation and source for spatially-enabled information.

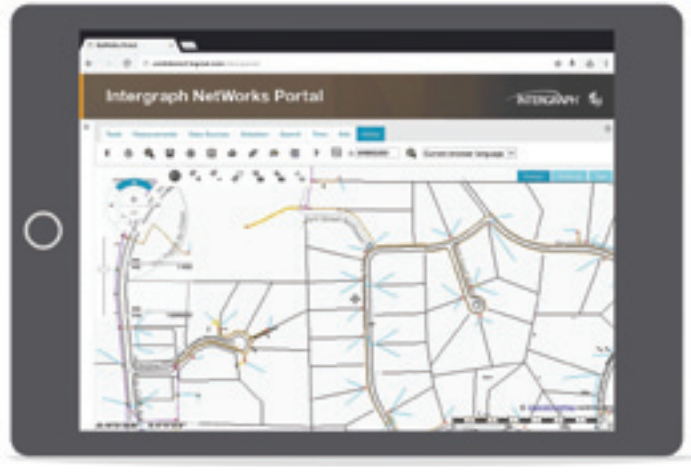
Unfortunately, access to this crucial data is often limited. A current, growing challenge for utilities is to provide secure, real-time access among multiple users to location-based engineering and operational data across the utility enterprise. The challenge is not surprising. Data, systems and processes often are managed independently, without regard for future needs or integration. Such disconnects prevent a wide range of network users from seeing what is occurring with utility operations and assets. They also create inefficiencies, redundant processes and even raise questions regarding the accuracy of data. Fragmentation of the information needed for effective decision making in the field or in the office can weaken the utility's ability to deliver quality service, especially when crises occur within power service areas.

Wider Access to Real-Time Data Needed

To counter these complexities, utilities are realizing the need to implement processes that can provide necessary data to employees and other key users anytime, anywhere, and in multiple ways – for example, by leveraging consumer mobile devices and platforms. In short, the utility must be in control of every aspect of its network data so that decisions can be made in an all-inclusive manner. After all, effective data management involves collecting, storing, organizing, analyzing and sharing information comprehensively. Furthermore, this means utility users must be empowered to do the work they need to do, as easily as possible – with task-specific applications, as opposed to general mobile GIS or mapping applications.

The most effective way to enable information to reach those utility users who need it most is through a web service-enabled network model. Based on standard, open protocols, a web service is a means of sharing data to applications via the Internet or corporate intranet. Such a solution pushes feature-rich data out in real time so that the utility can manage any number of incidents or day-to-day tasks more expediently. Any client application, from any vendor, can utilize these web services for a variety of workflows.

The right software should permit GIS administrators to easily and rapidly set up a web service featuring the network data and symbology managed in their enterprise utility GIS. Using portal and mobile applications, users should be able to browse, visualize, analyze, update and add network feature information from the web and consumer mobile devices.



Networks portal screen shot

Merge, Combine Data From Other Systems

Not only can users share network data, they also can merge and combine it with information from other systems and applications necessary for the task at hand. Let's say a storm has rolled into an area and unleashed considerable damage – a typical scenario routinely confronting a utility. The utility's field personnel can easily assess the damage with mobile devices by taking photos and making edits and notes about aspects of the damage they've seen in the field. Using a web services-based solution extended to portals and mobile apps, the source network information is available to crews and information from the field is immediately accessible by all necessary personnel, which yields smoother workflows, cost savings and efficiency.

"Every utility has someone who does the map request," according to Michael Baker, product manager for Hexagon Safety & Infrastructure's utility GIS products, Intergraph G/Technology and Intergraph NetWorks. "The isolation of data isn't intentional; it's just that in this day and age, everyone uses the tools that he or she is familiar with. The person handling the data requests usually is converting data from one format into another. With an open-data web service, it's independent of any client, which means that now this person who was handling data requests is freed up for other tasks."

Plus, those outside of the GIS department get the information they need how and when they need it. So, for instance, if a switch has been closed or is open, Baker added, this will be reflected in the data from the network. Keep in mind that with an enterprise data network, information is not going to be pushed out to everyone in its entirety. Instead, accessibility will be permission-based so that the utility can provide only information it wants to share with its many users.

Growing Consumer Demand

The move toward web-provided data to all stakeholders is not new, but it has gained momentum and become more refined (that is, to serve very specific purposes) due to growing demand by the utility's customers. These customers already have come to expect more information in their daily lives, and quickly, from all kinds of devices, including phones, tablets and websites. Naturally, with a craving for everything mobile and cloud-based, consumers have now pushed on utilities to provide more information and to make it easier to retrieve. "It's almost kind of like the perfect storm where everything is available to utilities to bring all of their data together and push it out to everyone who needs it – but in the very specific way they need it, which is different for customers versus field crews," Baker said. "With the evolution of the enterprise data network, now this is the way to share data."

Utilities Pushed To Lower Costs

In addition to the consumer push for more information, there also is pressure on utilities to lower their costs. Web services-enabled network information can dramatically help meet this demand. A web portal being fed from the network model makes it easy and less expensive to access and manipulate data. All the client needs is a browser, and that browser can be on any smart device. The portal is the only software the user needs. "So, suddenly the cost of installing a client on everybody's machine to view data goes down," Baker noted. This can apply to a utility crew working in the field, a contractor, or a temporary worker. "Instead of needing an application installed on their machine, they can just access the data through the browser," Baker added. "This reduction of software costs and of the need for having installs will be significant."

One Public Utility Sees Big Gains with Real-Time Data Network

Benjamin Beberness, Chief Information Officer for Snohomish County Public Utility District (PUD), north of Seattle, would agree with the benefits offered by creating real-time operations in its transmission and distribution systems, and on the PUD's business side, too. Snohomish County PUD supplies electricity to 337,000 customers and water to nearly 20,000 customers in a major part of northwestern Washington State. In addition to upgrading its electric grid with a 'smart' grid system, automating substations and distribution systems, it has consolidated its IT resources onto a single real-time enterprise platform. "We had three ERP (enterprise resource planning) systems when we were considering a platform solution," Beberness said. "They were all disconnected, and we had to enter the same information in multiple systems."

Engineer with mobile tablet

Now, with the real-time enterprise data network in place, which leverages SAP integrated with Hexagon Safety & Infrastructure's utility GIS, Snohomish PUD is more efficient, saving time and money, and giving key users the information they need regardless of time or location. "Let's say I'm an assessor in the field responding to damage caused by a storm," Beberness offered in describing the network's value. "I've just walked up and down this line of damaged area. As I'm updating that and feeding the information via tablets back to our outage management system, customer service system and work management system, our office is scheduling crews and determining which crews have the right equipment and skills to be able to fix the damage," Beberness continued. "Crews are all connected and can respond in real time. They can indicate they've just finished one job and can ask what needs to be done next and what crews are available and when."

The network data is helpful not just for storm assessment, but also for normal maintenance work that utilities must perform.

Spatial Component Also Valuable

A truly robust enterprise solution should not just let you view data and edit it, but should also have a spatial component. Think about a tornado that touches down and runs for a mile and a half. Using the network data, the user can send a polygon with all the features contained in the polygon, such as poles, conductors or anything else. This means they can send information to the server and request not just attributes but also spatially where they are. Not only would the network offer a map of the data, and allow the user to edit attributes of the data, but that user could also request an area of interest and extract this from the network. This might be the foundational step for a crew to conclude that it needs, for example, 50 poles because there are this many poles within the polygon that are damaged.

Since the data network is web-driven, "It's easy to combine it or integrate it with other data, such as data that might be coming back from SCADA (supervisory control and data acquisition) or DMS (distribution management system)," noted Baker, citing automated meters or the operating temperature of a transformer as examples. "What's nice about this web service is that you can combine it with those other systems to get a visual of what's going on. It's a really great way to give a visual representation of what's occurring on the network," Baker said.

Compelling Advantages

Deploying a web services-based network solution for a utility enterprise offers several distinct advantages, including:

- Replacement of fragmented, siloed information and systems with an integrated, reusable connection that distributes data throughout the enterprise.
- More accurate data for enterprise users and customers. The currency of data improves because users access a definitive source to which they can, in turn, provide data more quickly and easily and view others' updates.
- Vastly improved operations for employees. The GIS manager will spend less time processing data requests, and see better data quality. Customer service representatives will deliver improved customer satisfaction because they're able to view real, up-to-date data. The IT manager will have lower costs of dealing with information, and have better agility and improved control over data.
- Lowered duration of customer power outages as a result of improved response time, reducing labor and overtime costs.

As web services-driven applications come online, they will reflect data from everything users have stored inside their database. Consequently, this will increase the value of a utility's data by extending its visibility and reducing costs because the data already has been configured.

Potential for More Innovation

These advancements underscore the power of extending the network model via web services to task-specific applications across a utility enterprise. What's more, they show how such a comprehensive capability will enable users to be more innovative with the services they provide. How? Beberness, the Snohomish County PUD Chief Information Officer, cites a dramatic example. According to Beberness, one utility on the East Coast can predict exactly where their power outages will be before they actually happen because the utility's operators can view weather patterns and combine this information with the network's database of information on prior outages. "If you have a big wind storm coming through and you know pretty well where you think the high gusts of those winds will be, the utility can look at what equipment is in that area," Beberness said. "So, you stage your crews based on the damage you assume is going to happen. I think utilities have to think along these lines and about how they can become more efficient and effective," Beberness added. "We can be better prepared and improve our outage numbers, which will lead to better customer service and reliability."

About the author

Bob Galvin is a freelance writer based in Oregon City, Oregon, who writes on issues and trends involving use of various business technologies. He can be reached at: rsgpr@msn.com.

Data Management and Digitization in the Energy Industry

By Brian Shannon

Organizations are continuously adapting to manage the ongoing stream of data, implementing strategic business plans to ensure that the company remains on top of current trends. But data volume management can be an arduous undertaking, specifically in highly regulated industries such as the energy industry. Without implementing some sort of data volume management strategy, organizations leave themselves vulnerable to risk from retaining data beyond corporate policies or penalties incurred from not responding properly to an audit request. Audit requests from tax authorities and regulatory organizations can be challenging, and data volume management needs to be a priority for finance and IT departments so that the organization can remain compliant with data retention policies and then quickly and simply extract data to respond to these requests. While some organizations implement an archiving strategy to retain data after the fact, an increasing number or organizations are digitizing business processes such as accounts payable and journal entry approvals to ensure that information is being stored properly from the beginning.

Digitizing Manual Processes

Digitization of processes enables organizations to take what were once labor intensive manual processes and turn them into efficient, effective means of gaining control and oversight into the organization. Outdated processes limit potential growth, and manual data entry is not only inefficient and time consuming, but prone to error. This can be remedied by digitizing processes, offering the organization more insight and visibility across the systems of record and opening the door for the exploration of new, key metrics. Collecting these metrics will allow the organization to benchmark process performance, providing valuable business insight and impacting corporate decision making. Digitization of processes also provides employees with time formerly spent on manual processes, which can now be used on tasks that offer the organization more business value.

The most important value realized by energy industry organizations that digitize processes directly relates to their newfound ability to comply with stringent data retention requirements, and to properly and quickly comply with audit requests. Digitization makes it possible for departments to automate manual invoice processes, which reduces the average invoice cycle time. This helps with compliance, and does so in a manner that provides immediate financial and process driven benefits. Some of the tangible returns on investment realized through digitizing processes include cashing in on early payment discounts, significantly reducing document storage fees, and improving the accuracy of data for tax reporting. These early payment discounts can add to the finance department's bottom line. Prior to digitizing processes, many organizations are not only failing to receive these discounts, but they are actually incurring penalties due to an inability to properly process invoices in a timely manner.

Accounts Payable

Accounts Payable Departments are typically in charge of invoices, and digitization can significantly help the department's overall efficiency. Prior to digitization, the process involves manually entering invoice details into a system of record, and the invoice is then sent through the necessary approval channels within the AP Department, often recording approvals manually on the original paper document. The process is labor intensive straining industry resources and stressing the need for automation within the organization. Digitization offers enhanced controls by automating processes such as approval routing and exception handling, which significantly increases the speed with which invoices can be processed and offers transparency into real-time invoice data. The increased speed in processing is a key factor in helping the organization capture early payment discounts.

Some of the other tangible benefits of automation include ensuring corporate compliance, reducing missed accruals, which helps grow the organization's bottom line, streamlining work centers and improving vendor relationships. Other savings due to increased automation come from reducing document storage fees and automating the processing of low-dollar, high-volume invoices.

Journal Entry Approvals

Another area that can benefit from undergoing digitization is an organization's journal entry process. Processing journal entries manually, prior to digitization, can lead an organization to experience many of the same problems as the Accounts Payable Department, starting with manual errors and delays in closing financial statements. Journal entry processing can be complex, especially for companies with multiple divisions and legal entities, extensive intercompany transactions or disparate accounting systems. Any journal entries generated outside of the system of record can be manual and prone to error. The process also lacks transparency as multiple stakeholders cannot review and approve the entries in a timely manner prior to posting, and complex spreadsheets must be shared by email.

In addition to poor transparency leading to untimely approvals, organizations with outdated manual processing of journal entries are at risk of ensuring that appropriate approvals or reviews are completed and that all required supporting documentation is available.

Organizations experiencing these issues can benefit from digitizing journal entry approvals. Digitization will help bring process implementation into the future, and provide tangible, near-term benefits by helping to lower costs, increase operational efficiency and significantly improve controls. The reduction of paper-based processing costs lowers the cost of funding, streamlining and automating processes enables the organization to scale, and improved controls help improve compliance due to the newly implemented digital approval tracking. Some of the immediate benefits an organization will experience are the ability to promptly and accurately comply with strict audit requirements, which is particularly important for regulated industries, and a significant reduction of financial close.

The correct digitization approach that matures over time will help the lifecycle of the journal entry process, starting with support for standard journal entry and eventually offering enterprise-wide control over global and cross-company journal entry processes. One issue faced by organizations operating globally is that they must deal with different accounting and regulatory requirements. This necessitates insight into each global location's requirements, and makes it crucial to facilitate local control. Digitization enables the requisite people to have visibility into each location's unique requirements, facilitating the review and approval process. Accountants responsible for manually approving journal entries are now less burdened with the approval processes, and financial executives responsible for fiscal reporting are put at ease when considering the accuracy of the results.

Conclusion

Controlling data is something that many organizations need to address, and an increasing number of them are looking towards digitization of important business processes, such as accounts payable and journal entry approvals, as the most effective solution. Undergoing a digitization effort removes many of the issues that manual, labor intensive processes present to an organization, including slower approval times, manual data entry and approval errors, and the inability to capture significant cash flow benefits provided by early payment discounts. Digitization allows for the excess volume of data to be easily stored, securely in compliance with industry regulations, and recalled at a moment's notice for use in tax and regulatory audits.

Furthermore, digitized processes provide full transparency into the audit trail, offering visibility into information as it moves throughout the organization. Auditors are increasingly making this a priority, and this also helps the finance department capture data points along the entire process lifecycle. This can be used by the organization to evaluate the processes in place, and to seek out other areas where process improvements may make the organization more efficient. On a large scale, digitizing processes gives important organizational decision makers two key things – control, and the ability to retain data – both of which are essential in highly regulated industries, and especially the energy industry.

About the author

As Dolphin Enterprise Solutions Corporation's Chief Strategy Officer, Mr. Shannon is focused on business processes and financial solutions to maximize return on investment. He has more than 20 years of SAP experience and his background includes thought leadership, knowledge management, project management, training and SAP consulting with extensive experience in the automotive and manufacturing sectors as well as oil and gas, retail and utility verticals. Mr. Shannon's industry and finance experience includes positions as a National Credit Manager, International Finance Manager, Corporate Banking Credit Analyst and Financial Strategist. He earned a Bachelor of Arts degree in Political Science from the University of Manitoba, and an MBA in International Finance from the University of South Florida.

THE BIGGER PICTURE

BY CHUCK MOSELEY

Empowering Field Personnel with Satellite-Based Internet of Things Connectivity

Utilities around the world are embracing the Internet of Things (IoT) and all of the benefits that automating formerly manual processes has to offer. Utilities, which were one of the first industries to embrace point-to-point, machine-to-machine (M2M) communications and SCADA systems, are now utilizing the next generation of machine communications. IoT technologies are bringing exceptional operational efficiency to utilities, providing increased visibility and real-time data via automated processes and always-on connectivity, helping utilities "keep the lights on" and provide better overall service to their customers.

Smart Grid technologies are certainly getting their fair share of attention as a top IoT application for utilities, but another segment also deserves significant attention for its role in safety, compliance and business continuity of utility networks: field force automation. The IoT is changing the landscape for assets and employees out in the field, allowing them to use data analytics to make better decisions.

Field force automation and management – the practice of using technology to streamline the administrative role and logistics of field service personnel using the data received back from the site to make better decisions – allows field technicians and engineers to focus on problem solving at the job, instead of 'paper pushing' and the manual entry of data captured on site.

IoT is the enabler, providing a central hub that spans platforms, applications and devices out in the field. These devices can be used by humans (through PDAs, tablets, smartphones, etc.) or by machines (such as transformers or even heavy equipment such as bucket trucks or cranes, for example). IoT enables the sharing of information and provides a constant synchronization between field workers and people and machines at the home office.

Although IoT has automated many parts of the utility network, engineers and maintenance crews in the field are still play a critical role. In the same way that automated devices need two-way communications with headquarters to work effectively, so too do field technicians. These connections are used for many purposes, including transmitting work instructions and technical information, including large data files, to workers in the field, as well as to report back conditions on-site.

In many areas, cellular networks meet these connectivity needs. However, field workers are always on the move and cellular connections can be 'spotty' or 'patchy' in some of a utility's coverage area and aren't reliable – or frequently unavailable – in rural or other remote areas. The exchanging of large data files is often an issue as well because of cellular's limited bandwidth capabilities. As such, satellite connectivity is emerging as an efficient and reliable way to keep IoT solutions and field technicians productive, even in the harshest of weather conditions.

Out in the Field

IoT is playing a growing role in utilities around the globe. At the macro level, utilities are facing increased pressure from regulatory agencies to have communications infrastructures with an even greater of redundancy to ensure service continuity.

Events like the 2011 earthquake and tsunami in Japan and Hurricane Sandy in the U.S. in 2012 hammered home the need for not only more resilient utility networks, but more resilient communications networks to support them. In the United States, the Department of Homeland Security (DHS) Office of Infrastructure Protection (IP) collaborated with the utilities industry to identify guidelines, best practices and agreed-upon codes of practice to help with business continuity and disaster recovery. IoT is playing a big role in these proceedings, especially in the monitoring of lines, reclosers and transformers, helping not only to speed repair when the network is impacted, but in many cases preventing an outage in the first place.

But on a more micro level, IoT is having a huge impact on day-to-day operations of a utility company, including field force automation. Examples of some of the different benefits that IoT technologies are providing not only for the utilities, but for the workers in the field as well, include:

Satellite's Key Role

Despite the drive for greater innovation among utilities and to support field force automation because of IoT, none of these could be accomplished without reliable connectivity. Cellular has its role, but it's only as reliable as the strength of the signal from the nearest tower. In inclement weather, such as hurricanes and ice storms, service can be interrupted. In other areas where utilities may serve a very large area, there may not be any service available due to a lack of cellular infrastructure, or vehicles might go in and out of coverage several times depending on their route. In these areas, field personnel are 'flying blind,' unable to send or receive critical information to do their jobs.

Field workers need the ability to communicate with headquarters at any time, and vice versa, even in situations where a natural disaster has occurred. In these scenarios, utilities need the ability to manage and re-assign work crews in real time, consolidate operations with informed decisions based on real-time data, and issue work orders as soon as they are needed to repair outages, while maintaining communications during disaster recovery.

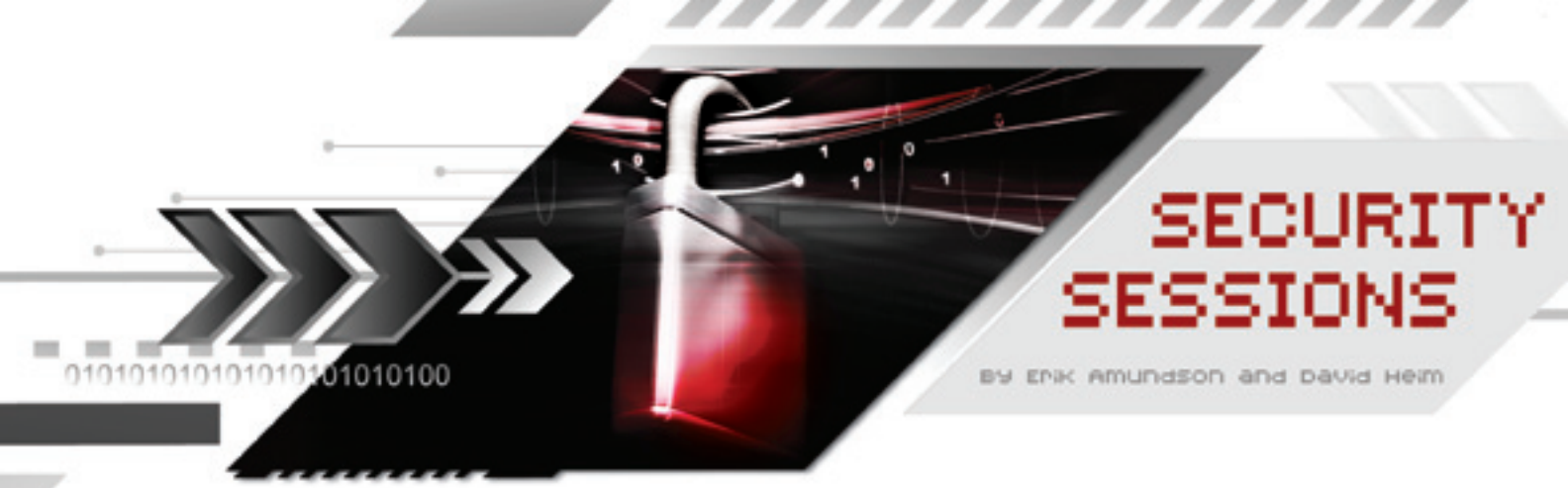
Cellular networks are often the first to be impacted in natural disasters because of their reliance on terrestrial infrastructure. Even some satellite solutions that operate in low earth (LEO) orbit are subject to disruptions from weather. However, satellite connectivity from a constellation in geosynchronous (GEO) orbit offers the best solution for utilities, free from weather disruptions and terrestrial constraints.

However, utilities do not need to rely solely on satellite for their IoT connectivity needs. Solutions that have both cellular and satellite connectivity capabilities are enabling utilities to achieve always-on communications with their field workers. The transition between cellular and satellite is automatic via least-cost routing; if the cellular signal is weak or drops, the device transfers automatically to its satellite connection, and back to cellular when signal strength is achieved. The driver or operator is free to just perform their tasks without needing to manage communications.

Today's utilities have come a long way from simple SCADA systems and IoT is playing a large role in making operations increasingly efficient. Field force automation is one of the key beneficiaries of IoT technologies, and by default, field personnel are also realizing key benefits as well.

ABOUT THE AUTHOR

Chuck Moseley joined Inmarsat in January 2003 with more than eighteen years' experience in communications. As Director, Internet of Everywhere, Chuck is responsible for Inmarsat's portfolio of M2M products and services worldwide. Prior to this role, he managed all North American SCADA communications customers and projects for Stratos (now part of Inmarsat). Mr. Moseley holds a Bachelor's degree in Marketing and a Master of Sciences in Telecommunications from Southern Methodist University.



Securing the Internet of (Grid) Things

At the edge of the distribution grid lies an inestimable number of devices (such as Solar PV and other renewable generation sources, electric vehicles, water heaters, and HVAC systems) that, if properly harnessed, could provide significant value to Smart Grid applications. While the value gained from communicating with these devices is enormous, a major roadblock to harnessing their power has been the lack of efficient, affordable, and secure communication paths.

To achieve the full promise of an interconnected power distribution system, utilities must be able to securely connect with and control end-use devices and other distribution grid assets. Doing so will give them the ability to optimize power supply portfolios, achieve grid visibility from end-use consumers to distribution substations, and use Demand Response (DR) and Distributed Energy Resources (DERs) to strategically manage system load and distribution grid operating conditions.

Implementing the kind of high-level security system needed to protect utilities and their customers from the increasing threat of cyber-attacks – while fully harnessing the reliability and economic value of end-use devices – will require utilities to invest in advanced networking and communications technologies.

Risks When Connecting Over the Public Internet

The U.S. energy sector is already one of the most targeted industries in the world, and cyber-attacks show no signs of slowing down. For example, in 2014, more than 30 percent of malware attacks reported to the Department of Homeland Security were reported by energy companies.

In the Smart Grid space, these security risks are major concerns, because communications from these devices are no longer confined to a boundary of a utility's controlled network. These devices will be exposed to many new threats, including foreign nations or terrorist organizations who mean to do us harm, as well as so-called 'script-kiddies' and 'hacktivists' that are trying to make political statements or want to see if they can play with the grid.

Unfortunately, many Smart Grid devices are not truly protected from these threats. Many send and receive messages using unsecured web services, often using proprietary networks for their communications and trusting in 'security through obscurity' rather than true protection. These networks rely on a level of implied security, simply because they are a little-known method of contacting end devices. Utilities engaging in these security practices wrongfully believe that because mainstream attackers don't use the technology, there is little risk of hacks. The truth is, for an attacker who is targeting the system specifically, getting access to the network method is not often technically difficult.

Once an attacker has access to the network method, the question becomes: are there any additional security barriers in their way, and can their presence and activity be detected? Unfortunately, all too frequently, the answer is no.

A Matter of Trust

Proper implementation of security technologies in the Smart Grid is the most important item to consider during manufacturing end-use devices, but it is often overlooked by businesses who are solely focused on functionality. Historically, some level of digital security has been established for communications with Smart Grid devices through the use of self-signed certificates and Private Key Infrastructure (PKI), but there is more work that needs to be done to make the Smart Grid truly secure.

There's a huge difference between the run-of-the-mill PKI and a PKI done right – with a Certificate Authority (CA) that's gone through vetting based on rigorous standards. Published standards developed by industry experts help ensure security controls exist to preserve the integrity of the root certificate and confidentiality of the private key. These standards include, for example, North American Energy Standards Board (NAESB) Wholesale Electric Quadrant-012 (WEQ), WebTrust for CAs, and Certificate Authority/Browser (CA/B) Forum.

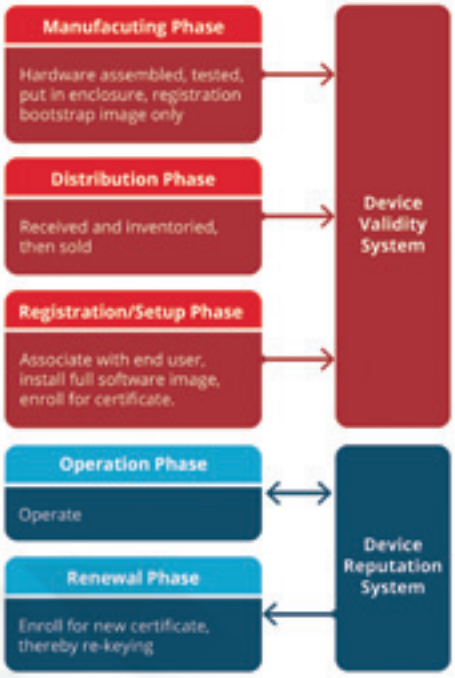
Regular auditing by a certified auditor on specific and detailed requirements related to business processes, controls, and cyber/physical security is one of the only ways to ensure a CA is up to par from an outside perspective. The audit reports and/or seals that are fruits of these audits communicate to those relying on a CA's services that they are, indeed, taking appropriate measures to maintain a secure root. Moreover, these standards ensure that the CA is not just run out of someone's basement and that the certificates are not merely self-signed.

There are many examples of how careless security practices can undermine the security of a CA, but two in particular that are worth mentioning in depth. Here's how self-signed certificates and sloppy PKI miss the mark:

- Self-signed certificates are static and cannot, by their very nature, be revoked. Since they never change, any attacker who has gained access to the system can indefinitely monitor the communications and even inject data into what is supposed to be a secure channel.
- Self-signed certificates only reside with the originating server and thus only provide one-way validation. In a secure system, both sides of the communication path would have certificates, proving their identities to one another and fully encrypting the data shared between each entity. In most Smart Grid systems to date, however, end-use devices have not been issued certificates.
- Worse yet, for many Smart Grid end-devices, PKI is generated on the server end and transmitted to a third party during manufacturing to be installed on a device. With this approach, it is impossible to have complete control of the devices' credentials. You don't know who they have gone to, or what the manufacturer has done with them. This violates the whole concept behind PKI, which should be generated by the end-user, and never be seen by anyone else.

How It Is Commonly Done

How It Should Be Done



Of course, PKI and Digital Certificates are only one part of a comprehensive security strategy that must also include layered physical and cyber security measures with no single point of failure. To fully safeguard their data, and their customers' privacy, data centers for utility operations must have robust physical security measures, such as fences, video monitors, motion sensors, and biometric scanners, as well as strong cyber security tools, including dedicated fiber channel links, firewalls, and encryption. Additionally, to store and access confidential and proprietary data with complete confidence, utilities must begin to think about building privacy protections into their operations, supply chain management, and more, to ensure security in their vendor management processes.

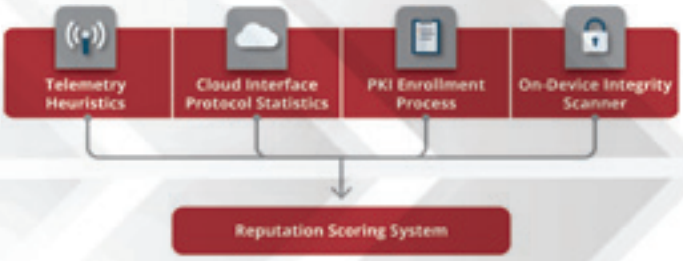
Better Grid Security with Super Devices

A successful Smart Grid will contain millions of connected end-points and millions of intelligent devices. The only way to securely connect to all of these unknown devices, while maintaining high-level security, is with what we at OATI refer to as a 'super device.' A super device is placed at each geographically distinct customer site and can generate its own credentials in the field at the point of installation.

A successful super device should have the following features:

- Communicate with the end-devices via multiple communication protocols, such as Wi-Fi, Zigbee, DNP 3.0, Modbus, or other standards
- Be resistant to physical tampering and have limited device-to-device interactions, where data that do not meet the specified formatting standard are simply discarded
- Be scalable for millions of different devices and technologies

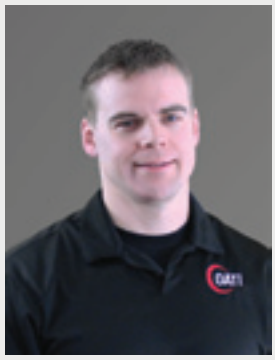
In addition to these functionalities, super devices should be included in a reputation scoring system that monitors data logs from all devices in the field to recognize when a problem is occurring. Devices that do this successfully receive a high reputation score, which tells others they can trust the security of that device.



Super devices can be connected to a wide area network through the customer site's existing public Internet, a private network connection, or, for hard to reach locations, by cellular network. Data traffic passing between the super device and the utility control systems is encrypted using PKI protocols, providing a secure and protected communication to and from the field assets.

As the Smart Grid space continues to grow, utilities will need to invest in the high-level security, advanced networking, and communication technologies needed to protect them, and their customers, from the increasing threat of cyber-attacks, in order to fully harness the reliability and economic value of end-use devices. Through the use of super devices, utilities will have an easy-to-deploy, cost-effective solution to confidently and securely connect with end-use devices and leverage their data to improve efficiency and realize additional savings.

ABOUT THE AUTHORS



Erik Amundson has more than 17 years of experience in virtually all areas of Information Technology. As Chief Technology Officer of Advanced Systems Design at OATI, Amundson works closely with product development teams and consults on system design and infrastructure. He has extensive experience in technologies and support of advanced data centers such as the OATI Active/Active Private Cloud, OATI GridControl, and OATI GridSafe, which connect the industry's most stringent cyber security measures, distributed processing, and plug-and-play operations to provide simple, secure, and cost-effective connectivity to grid assets and end-use devices. Amundson received EMC Clarion Training from the EMC Training Facility and is a Cisco Certified Networking Professional (CCNP) and Networking Associate (CCNA).

David Heim, J.D., has more than 15 years of experience in the energy industry. As OATI's Chief Strategy Officer, Heim is responsible for overseeing the Strategic Initiatives department, which includes development of new and emerging hardware and software technologies, development and construction of the new OATI South Campus and Data Center, oversight of OATI's existing Data Centers and infrastructure, and coordinating compliance with IT-related industry and regulatory standards. Heim began his career as an IT professional for a major international consulting firm. After obtaining his law degree, he joined OATI in the Office of General Counsel, and served as their Chief Information Officer. He received a B.A. degree in International Relations and Chinese from the University of Minnesota and, later, a J.D., Magna Cum Laude, from William Mitchell College of Law.

Guest Editorial 1

Progress on linchpins of microgrid uptake:
Focus is on controller technology, smart inverter policy and common information models

By Kay Stefferud

Enabled by increasing amounts of Distributed Energy Resources (DER), utilities and large facilities are turning to microgrids to support the resiliency of electric service in the aftermath of increasingly frequent, extreme weather events, as well as for grid support.

Yet microgrids' ability to 'island' and thus operate separately from the central grid – powered by DER especially solar photovoltaic (PV) arrays, fuel cells, generators and energy storage – depend on three factors that have inhibited uptake of this cost-effective and technically feasible solution.

First, utilities must implement new control methodologies – both direct and indirect – to enable microgrids that enable greater DER integration, regardless of who owns the DER, to support enhanced resiliency.

Second, states have been slow to enact policies that incentivize the use of "smart inverters" for solar PV arrays, energy storage, fuel cells and other DC-based DER devices. Smart inverter technology can perform commanded or automated grid-balancing functions at the point of DER to grid interconnections, thus avoiding grid imbalances.

And third, inverter vendors and utilities continue the work underway on common information models such as IEC 61850 and wire protocol standards such as DNP3 for inverter-grid communications to facilitate efficient, low-cost integration of DER assets into control systems.

Progress is occurring on all three fronts and stakeholders – virtually all of us – may appreciate an update on the issues and how they're being resolved, as microgrids represent a flexible means of addressing many utility challenges as well as benefitting civic and commercial entities seeking greater energy reliability and resiliency.

Utilities and controllers

Utilities are employing microgrids to manage reliability and resiliency issues relating to extreme weather, as well as instability on distribution circuits from high penetration of rooftop solar PV by residential customers and, in some cases, underserved feeders with high peak load. Utility sponsorship offers control of such projects and more leeway in configuring the microgrid for optimal integration, and more certain regulatory approval.

Utilities have also been asked to integrate non-utility microgrids sponsored by large customers such as corporate or educational campuses, hospitals or even municipalities, in which case the utility must manage a resource designed by others.

In the former case, a utility must implement advanced controllers that directly control – really, orchestrate – load, DER and other factors. In the latter case, the utility needs visibility into the microgrid in question and must apply indirect controls that manage the resource at the point of interconnection.

Due to the complexities involved, utilities often turn to third parties for microgrid and controller designs. The same is true for modeling that simulates microgrid operations and identifies microgrid power quality issues such as voltage, frequency and harmonics, in order to mitigate those issues. Utilities should ascertain that their consultant has deep experience in design, modeling and simulation, and in mitigation strategies – particularly with regard to DER-based, non-spinning generation. Managing the use of non-spinning DER, particularly when a microgrid is in island mode, can be particularly challenging and a third party should demonstrate experience and expertise in this area.

Suffice to say here, this is a highly complex technical challenge that is being met by ongoing innovation as utility-sponsored and non-utility sponsored microgrids are integrated with the macro-grid.

As to the innovations currently being explored, I'll simply quote the conclusion of a report, 'Grid Interactive Microgrid Controllers and the Management of Aggregated Distributed Energy Resources (DER)' released in November 2015 by the utility-sponsored Electric Power Research Institute (EPRI).

"For more advanced functionality, e.g., black start or anything with sequencing, [controller] messaging [capabilities remain immature]... In some situations, this gap can be managed through DMS [Distribution Management System]; however, in the future messages will need to be expanded. As standards evolve, future microgrid controller development should include an architecture, communications protocols and standard messages. Until these things are achieved, true interoperability will not be reached."

Smart inverter policy

As you may know, an inverter is a component of a DER system that converts DC power to AC power for on-site consumption or injection into the grid at the point of interconnection. A smart inverter is digital, programmable and enables two-way communications for monitoring and control. Smart inverters allow optimal management of microgrid- and DER-related resources on the distribution system.

California's ambitious renewable portfolio standard, revised recently to 50 percent by 2030, drove efforts to refine smart inverter policy and, thus, its technology, via the Smart Inverter Working Group (SIWG) sponsored by the California Public Utility Commission (CPUC) and the California Energy Commission (CEC). (The SIWG is comprised of state agencies, utilities, vendors, trade associations and advocacy groups, and was asked to identify technically feasible smart inverter functions and provide a road map.)

The SIWG's work on I-DER (inverter-based DER) led to revisions of California's Rule 21 and coordinated with parallel work on revisions to IEEE 1547.

Rule 21 contains CPUC-approved requirements, including technical and procedural criteria, for utility-I-DER interconnections. This rule, however, did not address small-scale DER and effectively increased costs to non-utility DER and microgrid sponsors. That led to the need for a revision to IEEE 1547 to recognize and support the benefits of smart inverters.

IEEE 1547 is a global standard for interconnecting DER with utility distribution systems; it needed revisions to account for key microgrid characteristics such as islanding. Briefly, IEEE 1547 was written to prevent unintentional islanding of grid-connected generation. Its ongoing revisions enable intentional islanding when a microgrid is designed to function in either grid-connected or islanded mode.

California has largely adopted a series of revisions that phase in implementation of various I-DER functionalities. IEEE 1547 continues to be revised to fine-tune needed changes to support the islanding/anti-islanding provisions that optimize grid-to-I-DER interconnections.

Though we've focused here on just one state's progress, Hawaii and Minnesota have also revised policies to support the role of smart inverters and other means to encourage microgrid adoption. Meanwhile, Arizona, Connecticut and New York, among other states, are studying the issue.

Common information models

The third area of heavy lifting in pursuit of microgrid enablement is the work that smart inverter vendors and utilities are pursuing on common information models such as IEC 61850 and wire protocol standards such as DNP3 for inverter-grid communications. The focus here is on facilitating the efficient, cost-effective integration of DER assets such as those within microgrids into utility control systems such as DMS, DERMS (Distributed Energy Resource Management Systems) and SCADA (Supervisory Control and Data Acquisition).

An array of stakeholders – including EPRI, the SIWG, the SunSpec Alliance (solar- and storage-related stakeholders) and MESA (Modular Energy Storage Architecture), among others – continue working on mutually agreeable protocols to incorporate IEC 61850's common information model, IEC DNP 3's wire protocol standards and smart inverter capabilities.

Led by EPRI, the above stakeholders are currently drafting a DNP3 Application Note for energy storage systems and solar photovoltaic systems that provides a single standard for key microgrid components. A joint EPRI-SunSpec Alliance project is developing a test framework for DNP3 communications with DERs using the Application Note.

Utilities are using third party assistance to design microgrids especially microgrid controllers, to model and simulate microgrid operation which identifies microgrid power quality issues in terms of voltage, frequency and harmonics, and to mitigate control system issues. When evaluating third-party assistance, utilities should look for experience with design, modeling and simulation of microgrid operation e.g. in order to identify issues with DER-based generation especially those dependent on non-spinning generation. Microgrid design issues which need to be considered through modeling include voltage collapse and stability, analyses of power flow, short circuit, protection, and relaying.

Looking ahead

Once these three main areas of current effort bear fruit, the technology, standards and policy will be in place to achieve more widespread, cost-effective microgrid implementations, for both utilities and third parties. It will be up to state-level regulators to recognize and endorse those technologies, standards and policies to realize the reliability and resiliency benefits that microgrids offer.

ABOUT THE AUTHOR

Kay Stefferud, director of implementation services at EnerNex, has overseen projects that require the design and testing of microgrids as well as assessing the impacts of distributed energy resources, including solar PV systems. Stefferud recently served as program manager for the California Energy Commission's Utility-Scale Renewable Energy Project (2011-2015).

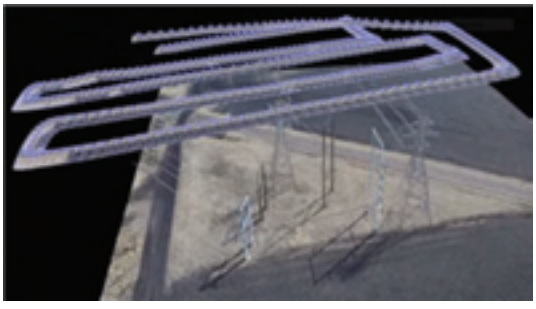
2000 Kilometres of Vegetation Encroachment Study for Manitoba Hydro's 500 kV HVDC Transmission Line Network

Guest Editorial 2

By Wesley Mueller

In the ever changing world of data acquisition, over the past year WIRE Services has been developing engineering and right of way management solutions for electric service utilities by utilizing high resolution imagery to create 3 dimensional data point clouds on transmission right of ways. Survey techniques are known by several names at the moment including 'Structure from Motion' or Photogrammetric Detection and Ranging (PhoDAR). The ability to utilize high resolution imagery to create point clouds on terrestrial objects and update information within PLS-CADD (power line design software) has started to surface as a potential new survey tool for the industry.

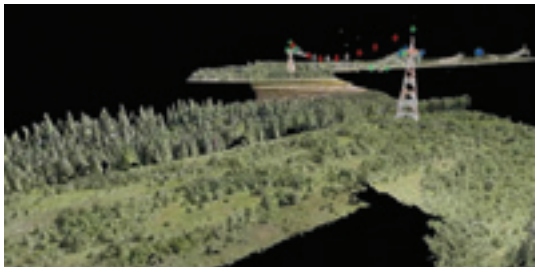
PhoDAR surveys have only recently become technically and commercially feasible by advances in digital imagery resolution and computing power on desktop computers. The technique transforms an array of high resolution images collected over a transmission right of way into a spatially correct dense point cloud on the natural terrain, vegetation, and man-made features.



PhoDAR image pattern flown by hobby grade UAV in proof of concept studies leading to commercial collection of imagery with fixed wing light aircraft.

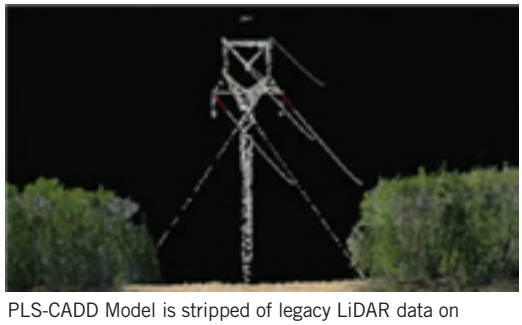
The key attractiveness of PhoDAR is its low cost compared to LiDAR. Collection and processing costs of PhoDAR are approximately 1/5th or less the cost of LiDAR which makes it an attractive option for transmission lines surveyed on a recurrent schedule for regulatory and operating compliance; and also for the transmission line designer tasked with maintaining and refreshing the data within a PLS-CADD model archive.

Initial testing of images and point cloud software confirmed the extensive calibration requirements for long narrow surveys like transmission corridors. Accuracy is maintained in the PhoDAR survey if accurate known UTM coordinates are available for the program to tie into. These points are readily available on a transmission line flown with LiDAR. Known points in the LiDAR model in every transmission span are correlated to the visible tie point locations made in each image. The dense colourized point cloud is generated from the accurate tie point layer and exported to a post processing filter and point classification method. Finally, the processed data is exported to PLS-CADD for end use.



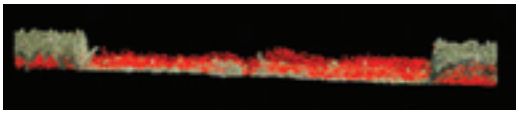
PhoDAR Point Cloud Rendering of Transmission Line Corridor with overlapping images collected by pod-mounted cameras mounted on commercial fixed wing aircraft. The red and white crosses depict the precise location of marker balls on the upper shield wire as determined by the image tie points made by the PhoDAR Analyst. The PhoDAR model is tied to visual tie points made on structures, hardware, and known objects points from LiDAR. With sufficient tie points from LiDAR and WIRE Services proprietary techniques, the final point cloud lies in sync to the LiDAR tie points.

Over the past 9 months WIRE Services has completed multiple projects for Manitoba Hydro to test out the various applications that may be possible. Several of those will be highlighted. For Transmission Line Maintenance, the significant project was the updating of vegetation information along the twin corridor 500kv HVDC transmission lines that bring power from Northern Manitoba to southern markets, running a total of 1000 linear kilometers.



PLS-CADD Model is stripped of legacy LiDAR data on vegetation and up to date studies on refreshed data completed.

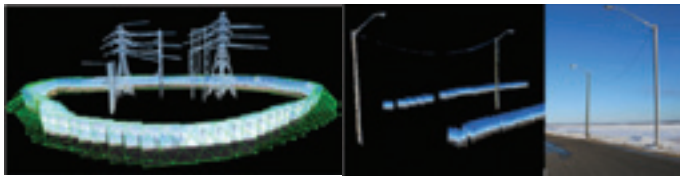
The project involved the collection of approximately 200,000 high quality 22 MP color images, processing into point clouds, re-insertion of point clouds back into the existing PLS-CADD model, and reporting on potential vegetation interactions based on the utilities analysis criteria. Processing was completed with several desktop computers, specially modified for the computing workload.



Cross section view of right of way containing fresh PhoDAR data and 5 year old LiDAR (in Red). The differences between the two surveys depict clearing done based on an original LiDAR report compiled on data five years old. PhoDAR can be used as a quick method to verify contractor contractual compliance to vegetation maintenance specifications on existing line corridors, and for Greenfield projects

Using ground collected PhoDAR to document a new parking lot and its lighting structures to ensure code clearances are maintained to the transmission line at all weather and operating conditions.

For the Transmission Line Designer responsible for coordinating design changes on older assets (i.e., thermal upgrades, right of way changes) it is desirable to have those changes reflected back within the PLS-CADD model.



Photographs of any object of interest may be collected from the ground to compose an accurate point cloud model.

Objects can be modeled with photography taken from air, or from the ground as long as specifications regarding image overlap, horizon positioning, and sunlight are adhered to. UTM tie points may be collected from the structure or other right of way objects. Post filtering of rendering artifacts from the bright sky background is necessary to sharpen the final point cloud.

Conclusion

The initial work completed by WIRE Services on behalf of Manitoba Hydro has provided proof of concept for multiple transmission line applications.

While this procedure has some limitations, it appears to provide another tool in the toolbox for Asset Managers, Transmission Line Designers, and Line Maintenance staff.

ABOUT THE AUTHOR

Wesley Mueller received his Civil Engineering Degree from the University of Manitoba, Canada, in 1991. He performed transmission line thermal rating studies, designed clearance solutions, and project managed the required construction activities for the utility Manitoba Hydro for 4 years from 1995-1999. He then progressed into the maintenance and asset management of the entire transmission line system in Manitoba, working in a technical role for 8 years, and then as the Department Manager for 6 years. His principle duties included developing and implementing diagnostic inspection programs, building a GIS system to improve data access and availability, and directing the asset investment strategies for the transmission line system. In 2014, Mr. Mueller undertook the role as Managing Director of WIRE Services and is responsible for all aspects of the business operations.

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