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COLLABORATION AND CONNECTION

The Grid of Things (Part 4)

Electric Energy T&D MAGAZINE

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POWERPOINTS

Busting the Biodiesel Myth and a Heartfelt Thank You

In the July/August 2017 issue of EET&D, I wrote that I am looking into buying a new car. After my initial research into energy-efficient options, I explained that I am leaning towards purchasing a hybrid.

The day the digital issue of the magazine was posted, I received an email from Cody Graham with the National Biodiesel Board. In his email, Graham let me know he had concerns with my perceptions of biodiesel fuel and offered to speak with and educate me about the fuel source. Fortunately, I took him up on that.

Prior to our conversation, Graham had looked at the websites I referenced in my column and understood how I had arrived at my conclusions. He then pointed me to the website for his organization (*www.biodiesel.org*), where there is great information, including a fact sheet that addresses certain myths the general public has about biodiesel fuel. Because I had a couple of EET&D readers tell me they, too, are looking into purchasing a car that runs on renewable energy, I am taking this opportunity to pass along more accurate information about biodiesel.

One of the greatest myths is that biodiesel smells like French fries or vegetable oil. That was my assumption as well. The truth is fuel-grade biodiesel must be produced to strict industry specifications to be considered a legal motor fuel, so if a car smells like fried food, it is likely running on "homemade biodiesel". Otherwise, the smell is similar to that of regular diesel.

In response to my concern that biodiesel could gel in cold weather, Graham pointed out that like regular diesel, biodiesel will gel in cold weather, but also like regular diesel cars, it can be treated for winter use. According to biodiesel.org, a person can use up to a 20 percent blend of biodiesel year-round, in any weather condition. B20 can be treated for winter use, similar to how Diesel #2 is treated. As is the case with all types of automobiles, those that run on biodiesel require proper care and maintenance as well as advance preparation in the event of cold weather.

In the two issues I have edited since joining the magazine, I have asked for comments or suggestions. I am sincere in this request and greatly appreciate Cody Graham for taking the time to contact me and to educate me on myth versus reality when it comes to biodiesel fuels .

We are putting this issue to bed, just as another hurricane has hit, this one decimating Puerto Rico and parts of the Caribbean. With hurricane season lasting until early November, this nightmare could continue for several weeks. In my landlocked state of Colorado, the most problematic weather conditions we face are hailstorms and blizzards. Both can wipe out power and topple trees, but we do not face the devastation that threatens those who live in the path of hurricanes. In a blizzard-caused power outage, it can be a cold and uncomfortable wait for power to be restored, but we have no reason to doubt that the power will be restored.

Those affected by hurricanes experience much more than the inconvenience of their power going out for a few days. By the time the storms have subsided and those affected by them are putting their lives back together with what little they have left, getting the power back can mean the difference between life and death. The staff of Jaguar Expo and the EET&D team want to acknowledge all of those first responders who kept the loss of life to a minimum. As members of the global electric energy community, we also express our heartfelt gratitude to those line workers who have already begun the cleanup and may be working for months to get people back online.

On its website OSHA lists the hazards line workers face on a daily basis, such as electrocution, falling, being struck or crushed by falling limbs, polls, cranes, etc. (not to mention dehydration or exhaustion). Throw in the instability of a site post-hurricane, and the potential for accidents is even greater. Line workers are aware of the dangers they face even in the best of circumstances. (For years, the occupation of line worker has received the dubious recognition by Forbes, CNN, CNBC and other major media outlets of being one of the 10 most dangerous.) The reality is, these men and women are committed to helping people return to some sense of normalcy.

Thousands of line workers from throughout the United States and Canada have rallied to help those who were hit by hurricanes Harvey and Irma. As Hurricane Maria continues to ravage whatever is in her path, it is uncertain how long it will take to get Puerto Rico back online. Based on the incredible amount of damage, it will require thousands of more utility workers and could take years to restore Puerto Rico's power.

Line workers are not recognized as heroes, but the work they do is most definitely heroic. To acknowledge the brave work of those who helped the Tampa, Florida area, one community held a thank you dinner. Marilyn Meyers, a Girl Scout troop leader and mother, felt it was important to show appreciation for the line workers. With the assistance of three other mothers, Seminole High School and the Seminole Booster Club, Meyers organized a dinner/festival. She then shared information about it on her Facebook page.

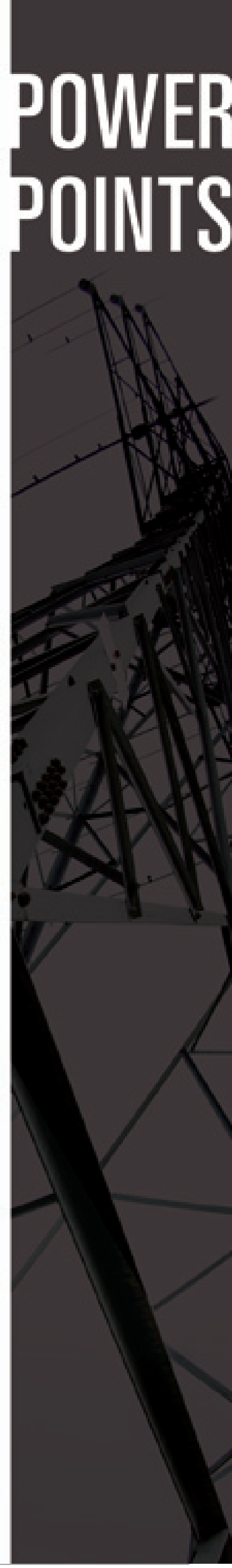
The post went viral and more than 300 volunteers showed up to assist with the dinner. They served about 400 linemen and women, most of whom were from outside of Florida.

Beckwith Electric, a Tampa Bay-based manufacturer for the power industry also participated in the event. When asked what motivated Beckwith to get involved, Wayne Hartmann, VP of message and media explained, "When a disaster strikes, like Hurricane Irma, linemen often deal with two misfortunes: the utility customers with outages and their own home and family situations. Bravely, they restore the system without complaint, working in dangerous situations often under extreme conditions." Hartmann also pointed out how these workers had to disrupt their lives and leave their families to assist with post-hurricane efforts, which means after a long and strenuous day in the field they return to a hotel without power, experiencing the same outages and conditions as those they are serving.

When the 2017 hurricane season has ended, new practices may be implemented to prepare for the next big hurricane. People will continue to rebuild their lives. Federal and local governments will work with the business community to repair and rebuild infrastructure. The line workers, who came from other locations to help out, will return to their daily routines. There will be no ticker tape parade for the individuals or organizations that dropped everything to respond to those in need of assistance. Few will experience the type of recognition those in the Tampa Bay area received, but those of us receiving that assistance or merely watching from the sidelines see the selflessness, compassion and dedication line workers put into their effort. It can be thankless work, so if I may be so bold, on behalf of the rest of the power industry, thank you, to all of the line workers, for going to such great lengths to ensure the rest of us are safe and comfortable.

If you would like to contribute an article or if you have an idea about interesting technology, solutions, or suggestions, please email me at *Elisabeth@ElectricEnergyOnline.com.*

Elisabeth



DEWA & Dubai Airports sign MoU to promote Smart Dubai

September, 2017

Dubai Electricity and Water Authority (DEWA) signed a Memorandum of Understanding (MoU) with Dubai Airports, as part of the efforts to expand cooperation and joint efforts to promote Smart Dubai, launched by HH Sheikh Mohammed bin Rashid Al Maktoum, Vice President and Prime Minister of the UAE and Ruler of Dubai, to make Dubai the smartest and happiest city in the world, and to achieve the Dubai Plan 2021, which aims to make Dubai a smart, integrated, and connected city. The agreement aims at unifying the energies and resources, exchanging knowledge, innovation, ideas and effective communication to implement DEWA's three smart initiatives at Dubai Airports, to meet the needs of the community and to achieve the overall interests of the Emirate of Dubai.

DEWA's smart initiatives include: Shams Dubai, to encourage home and building owners to install photovoltaic (PV) solar panels on rooftops to produce energy and connect it to DEWA's grid; and Smart Applications through Smart Meters and Grids, designed to speed up service delivery and response, to ensure the reconnection in case of service unplanned interruption, while rationalising smart energy consumption by monitoring consumption details simultaneously and at any time, using smart meters. The third initiative is the 'Green Charger' to establish the infrastructure for electric vehicle charging stations. This works to achieve society's happiness, and to support the sustainability of resources.

"As part of DEWA's efforts to achieve the sustainable development, and support the Smart Dubai initiative, launched by HH Sheikh Mohammed bin Rashid Al Maktoum, Vice President and Prime Minister of the UAE and Ruler of Dubai, to make Dubai the smartest and happiest city in the world, we are pleased to sign the MoU with Dubai Airports. We are committed to strengthening our cooperation and working together to integrate Dubai's government institutions for the public good by implementing the three smart initiatives we launched, in 2014, to drive Dubai's smart transformation, at Dubai Airports' specified locations. This ensures the management of Dubai's services and facilities through connected and smart systems. DEWA's smart initiatives include the Shams Dubai leading initiative to increase reliance on solar energy through the installation of PV solar panels on rooftops. We have already installed photovoltaic panels on 439 buildings with a total capacity of 17.6 megawatts (MW). This will increase in the future to eventually cover all buildings in the Emirate by 2030. The customers' solar photovoltaic systems connected to DEWA's grid so far include, among others, the rooftop of the employees' building at Dubai World Central (DWC), which was the first Shams Dubai project with a capacity of 30 kilowatts at peak load (kWp), as well as the solar energy panels at Dubai International Airport's Concourse D building," said HE Saeed Mohammed Al Tayer, MD & CEO of DEWA.

"The second initiative is Smart Applications through Smart Meters and Grids, which provide many smart features for customers, including automatic and detailed reading, enabling them to monitor actual consumption and contribute to solutions to rationalise the consumption of electricity and water. DEWA has successfully installed 200,000 smart meters by January 2016, and plans to complete the installation of 1,200,000 smart meters by 2020. Smart meters will replace the mechanical and electromechanical counters, all over Dubai. The third initiative is the Green Charger for the construction of infrastructure and electric vehicle charging stations to encourage the public to acquire environmentally friendly vehicles. 100 electric vehicle charging stations were installed successfully, in different locations in Dubai, by the end of 2015, in coordination with the institutions responsible. This cooperation comes within the framework of DEWA's plan to double this number to 200 in 2018," added Al Tayer.

"The three smart initiatives are part of DEWA's efforts in the field of smart transformation, in accordance with a clear strategy that is in line with the latest technology and latest developments. DEWA has succeeded in transforming all its services into smart services, within one year of the launch of the Smart Dubai initiative, providing smart and timely services that enable customers to complete their transactions anywhere and at any time, without visiting DEWA's customer happiness centres. This saves their time and effort, and promotes DEWA's vision to become a sustainable innovative world-class utility," concluded Al Tayer.

"In line with the long-term goals of aviation industry, Dubai Airports' vision is to ultimately attain carbon-neutral growth, and this cooperation represents an important step towards achieving that goal," said Paul Griffiths, CEO of Dubai Airports.

"Dubai Airports is constantly seeking innovative ideas and new technologies designed to limit our environmental impact through an integrated environmental strategy, while supporting the UAE Vision 2021, Dubai Plan, and the Dubai Supreme Council of Energy's goal of achieving 20% reduction in utilities bill for all government buildings by 2020," added Griffiths.

Fingrid among the best energy brands in the world

September, 2017

An international brand competition for the energy industry is taking place for the second time this autumn. Again Fingrid has progressed to the finalists in the transmission brand category.

As the energy industry is getting more and more visible in the world, also the energy brands are receiving more attention. CHARGE competition which measures the attractiveness of the energy brands is now taking place for the second time.

Companies participating in the CHARGE competition are assessed based on criteria such as segmentation, standing out and business models. The competition is built on five categories this year: Best Established Brand, Best Green Brand, Best Transmission Brand, Best Distribution Brand and Best Product Brand.

Fingrid is one of the three finalists in the Best Transmission Brand category.

"It is an honour to be nominated again. We can thank for this acknowledgement our personnel and our customers, that is to say we can thank them for a good work and open discussions we have done together. A brand is always more than a statement, it is about who we are and how we operate," says **Jukka Ruusunen** from Fingrid.

The winners of the competition will be announced in Reykjavik on Tuesday, 10 October.

INDUSTRY NEWS INDUSTRY NEWS INDUSTRY NEWS

Debra L. Reed Ranked Among Fortune's 'Most Powerful Women in Business' For 2017

September, 2017

For the seventh consecutive year, Fortune magazine has named Debra L. Reed, chairman, president and CEO of Sempra Energy (NYSE: SRE), to the magazine's "Most Powerful Women in Business" list.

Reed is ranked No. 20 in 2017, up from No. 22 in 2016.

Fortune's "Most Powerful Women in Business" was launched in 1998 to recognize the most successful women in the nation.

In compiling the list, Fortune editors consider four criteria: the size and importance of the woman's business in the global economy; the health and direction of the business; the arc of the woman's career; and social and cultural influence.

Fortune's "Most Powerful Women in Business" list is now available online.

Reed, 61, has served as Sempra Energy's CEO since 2011, as the company's chairman since 2012, and president since March 2017. She has spent her entire 38-year career with the Sempra Energy companies. Previously, Reed was executive vice president of Sempra Energy. From 2006 to 2010, she served as president and CEO of San Diego Gas & Electric (SDG&E) and Southern California Gas Co. (SoCalGas), Sempra Energy's two California utilities. Reed first joined SoCalGas in 1978 and became the company's first female officer 10 years later. She holds a bachelor's degree in civil engineering from the University of Southern California.

Sempra Energy includes SDG&E, SoCalGas, Sempra South American Utilities, Sempra Mexico, Sempra Renewables and Sempra LNG & Midstream.

Sempra Energy, based in San Diego, is a Fortune 500 energy services holding company with 2016 revenues of more than $10 billion. The Sempra Energy companies' more than 16,000 employees serve approximately 32 million consumers worldwide.

Continued Investment in the Grid is Boosting Reliability for Eversource Customers

Energy company reports reduction in power interruptions

September, 2017

The number of Eversource customers who experienced power interruptions in New Hampshire decreased by more than 25 percent this spring and summer compared to the same period in 2016. The improvement is credited in large part to the energy company's enhanced tree trimming and the company's investment in new equipment that has strengthened the state's power delivery system.

Historically, the leading cause of power outages in New Hampshire is damage to equipment resulting from trees and limbs falling onto power lines. That's why Eversource continues to implement robust vegetation management programs, investing $41 million in tree trimming throughout the state in 2017 to remove hazards to the energy system. Since the start of 2017, Eversource tree crews have completed trimming along more than 1,550 miles of overhead power lines in New Hampshire, and the company plans to complete about 2,800 additional miles of trimming before the end of the year.

Eversource implements a rigorous four-year trimming cycle and hazardous tree removal program along our energy system in New Hampshire, which helps minimize the number of tree-related outages our customers experience," said New Hampshire Vice President of Electrical Operations Joe Purington. "This work is having a significant positive impact on our efforts to keep the power on for customers."

In addition to tree trimming, Eversource continues to invest in modernizing and hardening the energy grid. This year, Eversource is investing more than $250 million on upgrades that make New Hampshire's transmission and distribution system smarter and more resilient when severe weather strikes, including:

- Installing stronger, more durable poles and covered wires to make the system more resilient to severe weather
- Automating equipment at substations, which allows system operators to identify issues as soon as they occur and reroute power to customers
- Installing more than 200 smart switches, which are used to isolate trouble spots and reroute power to customers, reducing the duration of an outage and the number of customers impacted
- Reconfiguring and rebuilding power lines to create redundancy on the energy grid, enhancing systems operators' ability to reroute power to customers during an outage

"We have made significant progress over the past year, and we will continue to work throughout the state building smarter energy infrastructure to deliver reliable power to New Hampshire residents and businesses," said Purington.

THE GRID TRANSFORMATION FORUM

Envisioning the 21st Century Grid

The Internet of Things Starts with the Grid of Things - Part 4 - The Role of Collaboration

How can we, the industry, become interoperable? It's a question on the minds of most utility executives and service providers. And while the answer is a simple word, collaboration, how we, the industry, achieve this vision is a little more elusive. In this installment of The Internet of Things Starts with the Grid of Things, grid leaders from across the world have chimed in with their thoughts on where we are today and where we are headed.

The Internet of Things Starts with the Grid of Things Part 4

"I want my toaster to talk to my Utility."
– Zac Canders

The Internet of Things Starts with the Grid of Things is a six-part tell-all editorial series that's been documenting the journey of interoperability and the role next generation software plays in the utility industry. For those of you that missed it, Part 1 announced the Grid of Things. It was complemented by Part 2, a step-by-step manual on how to embrace interoperability. Part 3 laid forth the definitions of the individuals responsible; the software developers, product managers, and technical experts, and Part 3.5 was the how to guide for translating the global value of data.

In Part 4, "The Role of Collaboration," the series dives deep on how the industry is changing from collaboration, and what better way than to meet directly with those driving the collaborative journey in the utility industry.

Esri - Bill Meehan, Director, Utility Solutions

The word Interoperability has eight syllables. Our friends at Microsoft gave the sentence, "What is meant by Interoperability?" a Flesch-Kincaid readability grade level of 14.5, which means someone has to be a junior in college to even understand the sentence. I like the two-syllable word connect better. Modern IT platforms are based on the simple principle of connecting people. Connecting for the purpose of giving and getting information or stuff. I connect with Amazon. I tell them what I want. They know what I like. I connect with my credit card. I get my stuff. Platforms are all about connection. The word interoperability conjures up standards, extraction, transfer and load data. I can picture the dearly departed comic, George Carlin saying the word "interoperability" with a deep, exaggerated frown and low intimidating voice. Then he smiles with a huge exaggerated smile and says, "Connect" with a happy voice.

If we think about how we connect with parts of our business, the value is enormous. Think about how we all hate it when we are not able to adequately connect with businesses that have not adopted a platform of connection. No one returns my text, emails, phone calls. Think about when we have to struggle with an IVR with all kinds of information about our birthday, our address and our favorite Taylor Swift song, only to have to repeat the information to a real person after a long wait listening to music.

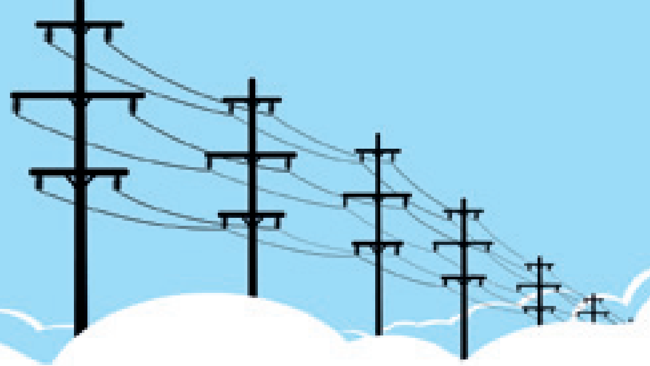
The single value of connection is to make interactions with different parts of society easy. In a power company, it means having a way to connect field crews to the office to the call center freely, immediately and without hassle. It could mean providing data from the city to the utility company immediately; it saves time, money and guess what? It makes people work better. Gets things done.

Between the Poles - Geoff Zeiss, Principal at Between The Poles

It is estimated that the lack of reliable information about the location of underground utility infrastructure costs the U.S. economy $1.5 trillion dollars annually in direct costs and several times this in indirect costs. One of the factors contributing to the deplorable state of information about underground infrastructure is poor interoperability.

THE GRID TRANSFORMATION FORUM

Envisioning the 21st Century Grid



The exchange of underground utility information between infrastructure organizations within the same jurisdiction or in adjacent jurisdictions has been greatly hampered by incompatible and incomplete data. Recently the Open Geospatial Consortium (OGC) has initiated a multi-year project to develop interoperability standards for underground infrastructure.

About four million excavations are carried out on the UK road network each year to install or repair buried utility pipes and cables. Not knowing the location of buried assets causes practical problems that increase costs and delay projects, but more importantly, it increases the risk of injury for utility owners, contractors, and road users. The problems associated with an inaccurate location of buried pipes and cables are serious and are rapidly worsening due to the increasing density of underground infrastructure in major urban areas. In the U.S., it is estimated that an underground utility is hit about every minute. Underground utility conflicts and relocations are the number one cause for project delays during road construction.

Nicole Metje of the University of Birmingham has researched the direct costs of utility strikes in the U.K.

- Electricity £ 970
- Gas £ 485
- Telecom £ 400
- Fibre-optic £ 2,800
- Water £ 300-980

Direct costs include the costs of sending a crew to assess and repair the damaged pipe or cable. Indirect costs include the impact of traffic disruption as a result of the strike, any injuries and other impacts on the health of the workers directly involved or people in the immediate neighborhood, and the lost custom that businesses would have experienced as a result of the traffic disruption. Dr. Metje has found that the true costs associated with utility strikes are much higher than the direct costs. Her estimate is that the true cost is about 30 times the direct cost. A number of return on investment (ROI) studies have identified the significant benefits of knowing where underground utilities are located. A USDOT-sponsored survey conducted by Purdue University in 1999 quantified a total of US$4.62 in avoided costs for every US dollar spent on accurately location underground utilities. Although qualitative savings (for example, avoided impacts on nearby homes and businesses) were not directly measurable, the researchers believed those savings were significant, and arguably many times more valuable than the quantifiable savings.

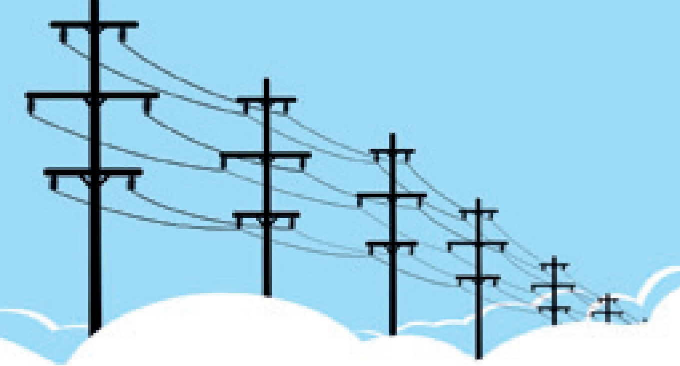
Currently, the exchange of underground utility information between infrastructure organizations within the same jurisdiction or in adjacent jurisdictions has been greatly hampered by incompatible and incomplete data. The Open Geospatial Consortium (OGC) intends to make a significant contribution towards facilitating improved information management, sharing and collaboration which should make infrastructure planning, operations and maintenance, and emergency response less costly and time-consuming, and more effective. The OGC has initiated a three-phase project to develop interoperability standards for underground infrastructure. The Underground Infrastructure CDS project is supported by the Fund for the City of New York and its sister organization, the National Center for Civic Innovation, the Ordnance Survey, and other organizations. The underground infrastructure data interoperability project will take two and a half years to complete and is intended to involve the collaboration of many cities, utilities, and engineering and technology companies.

Teradata - David Socha, Practice Partner, Industrial IoT

Given we're talking specifically about interoperability, most thoughts so far have had an operational leaning. Which is fair, of course. More efficient/effectively integrated operations are what interoperability is primarily for. But I'd like to highlight what might be considered a consequential benefit of a focus on interoperability: rich, massive data sets ripe for analytics. This is a perspective you'd expect from a big data and analytics company - but then that's the point of asking for lots of different perspectives, right?

Analytics deliver value at many points in the IoT value chain—from real-time (or near-real-time) decisions and actions in the field based on analytics at "the edge," all the way to strategic analytics that take place back at the enterprise and inform long-term investment planning—and all points in between. There are many challenges in delivering an Analytics of Things architecture. One of them is having comparable data sets for analysis. Whether that's understanding idiosyncrasies across sensor data sets, the vagaries of differing semantics across ERP or CRM systems, or even just getting to a baseline definition of an asset that IT, the asset management department … and then, also, a third-party business can agree on. Sound familiar? They should. Because as well as challenges for an analytics infrastructure, these are key challenges for interoperability.

Sad to say, I'm likely not as much of a genius or as insightful as I like to think I am. It all came down to collaboration. This group of gents grew up together in the utility, played golf together, lived in the same neighborhoods, but simply couldn't and wouldn't play nicely with each other.



The first stop in the interoperability journey comes with collaboration. Simply stated, this industry lacks collaboration. Internally within the utility, between utilities, let alone within the vendor community.

Utilities are notorious for fiefdoms. Collaboration is fun, so long as your particular feudal lord wins. When utilities get together to collaborate, they often promote their own agenda. When the standards wonks get together, their focus is on satisfying their own needs or generating revenue, e.g. how can I make some money at this, or maybe if I get my message as a standard it will reduce my cost downstream.

My standards committee experiences have been amongst the most dissatisfying of my life—long conference calls that accomplish nothing, meetings in locations that I can't justify to my shareholders, and acronyms and terminology that no one understands—exclusionary behavior all around. Let's look at the cycle time of standards ratification in our industry. It's longer than the technology evolution cycle at this point in time. So, how do we expect the industry to evolve? Maybe a lack of evolution is the way people like it? It's comfortable. Complacency? This isn't a technology problem; this is a collaboration issue. The industry needs to set aside agendas and creating standards that move us forward.

Patrick Engineering - Mike Goggin, Director – Geospatial Services Team

Sitting at my drafting desk in 1993 applying as-built changes to a paper map, I got my first look at analytics. An engineer approached my desk and asked me to find how many miles of 1/0 OVHD wire we had in the City of Libertyville. I thought to myself, "Next they will have me hunting snipes." The engineer then pulled out this extremely small measuring wheel and said he needed the information by the end of the week. After the shock wore off I went to work looking up what maps I needed, pulling them from the drawer(s), then going through each one finding the wire size and using the measuring wheel to record the miles. It took me three days. This was collaboration circa 1993.

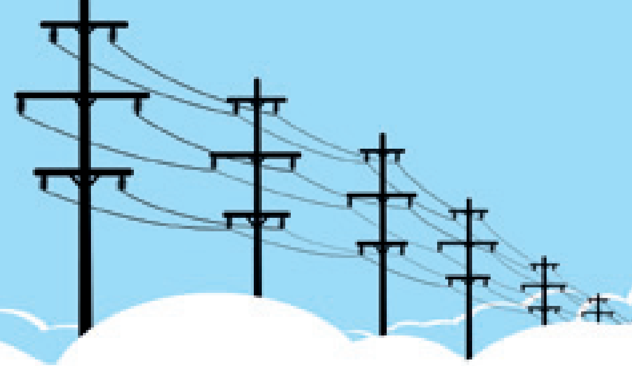
After years of labor, tens of thousands of dollars, and the evolution of geospatial technology, this task now can be achieved by the engineers themselves and takes about five minutes—a definite step forward in collaboration. Oh, and that wheel is now a fixture next to the ink well and pens! But let's be honest, the vision of the utility wasn't to improve the process of calculating material in a particular geography; it was to increase the collaboration associated with outage management.

Interoperability is not just critical for the levels of integration and collaboration operational systems need in the changing world of 21st Century utilities. It's also a foundation for the analytics-based decisions and actions that will enhance those operational systems, improve performance, and ultimately, inform the strategic direction of the future business.

Boreas Group - Robert Sarfi, Managing Partner Boreas Group

According to the Oxford English Dictionary:
Collaboration [mass noun] is

1 **The action of working with someone to produce something.**
   "He wrote a book in collaboration with his son."
2 **Traitorous cooperation with an enemy.**
   "He faces charges of collaboration."



In the context of interoperability for utility technology, I like definition two! Today I was talking about technology and data governance with a large, highly respected IOU. I described why I thought "Things" were broken, I quickly bonded with the executives because they said I could read their minds and understood them.

The existing outage management process relied on a dispatcher to review customer calls, then use a paper map to manually group them, and finally, to send a trouble crew to where they felt the trouble was located. This process was incrementally successful but took time and meant longer outages, loss of revenue, increased cost, and negative customer satisfaction. The new Outage Management Systems leveraged a connected model (electrical network) and analyzed customer calls based on how they were connected then more accurately predicted to a device. The automation of this process sped up the time it took to get a confident location to send the trouble crew. The result was a positive impact on reliability indices, financials, and customer satisfaction. This was a major step forward in increased collaboration.

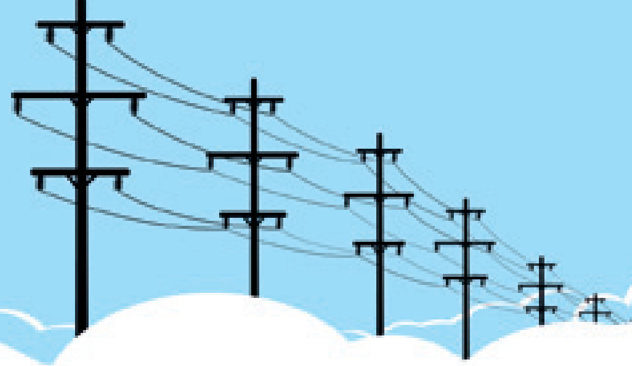
Fast forward to today and now we are talking about IoT and the Grid of Things. The evolution of people, process, and technology is taking the utility to the next paradigm of collaboration. The goal is to move from reactive to predictive and then to prescriptive through the collaboration of sensors and analytics powered by location. We are seeing technology advancements coming in the form of devices like AMI meters and distribution SCADA as well as systems like Advanced Distribution Management and the reality of self-healing networks. The grid is getting smarter because of the collaboration between people, process, and technology.

It's an exciting time in the utility space and having an advantage point to see how far we have come over the years and to help determine the future is right where I want to be.

WebMapSolutions - Matt Sheehan, Founder & Principal

We are in the midst of a technology revolution. The cloud and mobile have created amazing opportunities to bring technology into homes and the workplace. To solve problems that were once impossible.

But technology is complex. Hiding that complexity is key. Interoperability and IoT are meaningless. Mention the word "connected," and you have my interest. So we now have the ability to pull together information in one place about "objects" located anywhere and to visualize and ask questions of these "objects" in real time. That information began life as data: raw, unorganized facts: the national weather service shows dangerous thunderstorms approaching a wind farm. A generator within a wind turbine has just shared it is over a threshold temperature.



We can gather all this data together and connect it into one operational view. Making it easy to send crews out with specific information about the "where" and the "what for" repair.

But let's not pretend we have arrived at this nirvana quite yet. There is plenty more to be done. The journey has just begun. Connect then simplify. That needs to be the mantra. We need to bridge the gap between established workflows: "This is how we have always worked" and the new "Technology is my friendly time saver." Bring the old and young together in a shared use of technology.

Today, it's less about the tech and far more about the steps to put in place a solution. That's where those who know how to connect technology become important. Often we are talking integration. Pulling data from multiple sources and connecting within a mapping interface for example. And that's far more than a simple software purchase.

Connect, visualize, analyze. Then take action. Fast. That's our exciting future.

EPRI - John Simmins, Technical Executive - Information and Communication Technology

The Internet of things (IoT) is a network that connects people to people, things to people and things to things. It's not a new technology but an amalgamation of existing and emerging technologies that creates a new ecosystem for information. The people and things that make up this network more often than not have a relationship to each other whose principle attribute is spatial in nature. Adding in another attribute, time and the spatial component becomes a relative position in the past, now, and into the future. A geospatial information system (GIS) is the natural repository for spatial relationships and for the analysis of those relationships.

No other industry has as many "things" as the utility industry. The utility things form a network where there are relationships. GIS is good at dealing with the spatial, time phased, and attributive data of IoT.

Adding to the complexity of analysis that the time constants for communication to the things vary over a truly enormous range. Devices may only get inspected or replaced on the order of years or decades (i.e. 10^9 seconds). The condition of these devices may impact the operation of devices on the network that are measured 10-6 seconds – 15 orders of magnitude. Thus, any kind of spatial asset health analysis needs to look at data that could span decades.

Let's say that a utility has noticed that there are sub-cycle voltage fluctuations on feeders where there are splices located in vaults. These fluctuations seem to start out as sporadic but they become more frequent and when they reach a threshold, the splice fails. These vaults are subject to a variety of temporary conditions. Some vaults are flooded periodically with high-salt runoff from melting road ice and snow. Some vaults are in the bottom land where long, fresh water floods are common. Trying to correlate the condition of the splice over time to the periodicity of the disturbance, the type of disturbance, the type of splice, who did the splice, etc. is the realm of the GIS.

DataCapable - Zac Canders, CEO and Cofounder

We're now entering the era that power systems engineers have dreamt of for over a century, intelligently connecting all of these grid devices with each other. Gone are the days when utilities can withhold access to grid data. It threatens the safety and reliability of the grid. It also threatens the progress we all want to see. If innovation defined the last 100 years of the grid, the next 100 must be defined by collaboration.

In 2017, the use of social media by businesses and customers and data mined from this usage is at an all time high. This is a new, exciting, and valuable data set to be shared with grid operators and service providers. By thinking holistically about the value of data, utilities can be notified faster, trucks can roll sooner, and customers can get their lights on quicker. Here's the great news, if the utility operators don't want to think, return vendor phone calls, or innovate, they don't have to. Someone else will gladly do it for them.

Gone are the days when a utility could just talk about embracing the value of the customer. If the utility doesn't want to capture value, other firms from across the world will gladly do it (and take it) for them. That being said, together, the industry and those that support it might need to reflect on the above. These are real statements that shouldn't be ignored. We, the industry, are just beginning to discover how a services-oriented utility can drive deeper relationships and new efficiencies in the meter-to-cash business process. Collaboration makes the journey a lot more fun and valuable for everyone; the customer, the utility, the safety of field workers, and product and service providers.

Collaboration

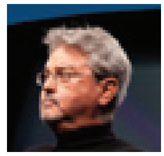
The thoughts and opinions expressed in this article represent a global view on how interoperability and collaboration are changing the grid. The Grid of Things is a new area of opportunity for electrical utilities to maximize their investments, explore new value propositions, and embrace try-before-you-buy scenarios – all while passing the value back to their customers via the intelligent devices they own.

Collaboration is the most important aspect to advancing technology. Without collaboration, every business would be wasting time rebuilding the same functionality over and over. These are exciting times for the utility industry and the message within this article should be loud and clear. Together we can build the grid of the future.

Together we can build an interoperable grid. A grid that is ready for the sharing of data and a grid that embraces the value of interoperability.

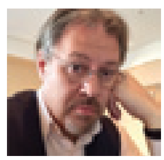
In the final edition of the series, Part 5 will conclude in an industry first (and extremely exciting) technology demonstration that's going to require your help. By embracing the lessons learned from this series we're going to prove how collaboration and interoperability can make Toaster-to-Utility communications a reality. Stay tuned for Part 5 in the coming edition of Electric Energy T&D Magazine.

About the authors



Bill Meehan, P.E. heads the worldwide utility practice for ESRI, the world's largest GIS software company. Author of *Empowering Electric and Gas Utilities with GIS, Power System Analysis by Digital Computer, Modeling Electric Distribution with GIS, and GIS for Enhanced Electric Utility Performance*, as well as numerous papers and articles. Meehan has lectured extensively and taught courses at Northeastern University and the University of Massachusetts. He holds a B.S. in electrical engineering from Northeastern University and an M.S. in electric power engineering from Rensselaer Polytechnic Institute.

Geoff Zeiss has more than 20 years experience in the geospatial software industry and 15 years experience developing enterprise geospatial solutions for the utilities, communications, and public works industries. His particular interests include the convergence of BIM; CAD; geospatial; and 3D; open source geospatial; and facilitating the adoption of geospatial data and technology in vertical industries such as construction and utilities.



David Socha is an engineering, business and IT professional and Fellow of the British Computer Society.
With an early career as an electrical distribution engineer, Socha's credibility with asset and engineering customers is assured. He honed his strategic skills creating and managing a major utility's energy networks and corporate IT strategies, and while pursuing his M.S., he focused on change management through mobile technologies.

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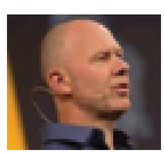
Mike Goggin is a geo-centric professional with 24 years experience expanding and applying GIS to the electric; gas; cable; industrial and government industries.



Matt Sheehan has been working with GIS for over 20 years. He is a Principal at WebMapSolutions, which specializes in providing mobile GIS solutions.

Dr. John J. Simmins is a technical executive at the Electric Power Research Institute (EPRI), where he manages the information and communication technology for distribution project set. His current responsibilities focus on bringing thought leadership in the area of integrating diverse applications. Simmins also leads the EPRI efforts in the use of augmented reality, social media, data analytics, and visualization to improve outage restoration efforts and improve grid resilience.

Zac Canders leads the worldwide delivery of the UtiliSocial platform. His experience includes leading design; development; configuration; implementation and support of smart grid solutions and services. His experience encompasses onsite smart grid project management at utilities across the U.S.

GREEN OVATIONS

Innovations in Green Technologies

A Broad Overview of Renewable Energy Storage

By Brandon Bartling, Tim Hebrink, Michael Yandrasits and Krzysztof Lewinski

Introduction

Exponential growth in solar and wind renewable energy generation has the potential to create grid instability. Both solar- and wind-generated energy are intermittent sources that fluctuate in energy delivered to the grid. Without substantial increases in grid-scale energy storage, it will be difficult for solar and wind-generated energy to become greater than 30-40 percent of our total energy generation. Fortunately, technology advances in large-scale batteries, fuel cells, and electrolyzers have been made recently.

This article describes a broad overview of some shorter term, mid-term, and longer-term options for energy storage that takes into account variable factors.

Reduced solar energy production output is experienced at night, during high cloud cover and inclement weather. New technologies, which store photovoltaic energy for generation shortfall periods will enable renewable energy to account for a higher percentage of total electricity production and reduce the base load requirements of fossil fuel-generated electricity production. Figure 1 shows the daily electricity demand in California (2013 CAISO report). Daily solar energy production peaks at noon and tapers off at 3 to 4 p.m. creating shortfalls from 5 to 9 p.m. and from 6 to 8 a.m.

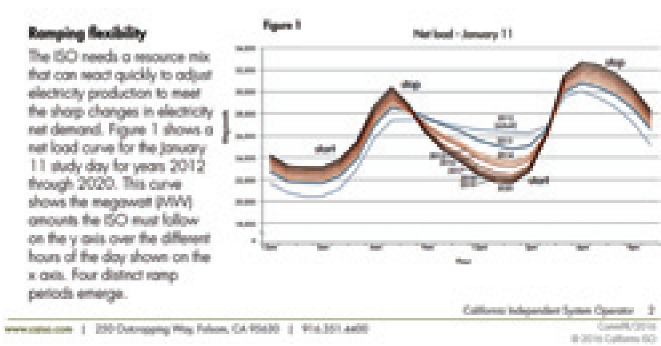


Figure 1

Lithium-ion Batteries-Shorter Term

Increased investment in Lithium-ion battery storage can bridge the hourly/daily shortfalls between solar energy production and net electricity demand. Over the past five years, lithium-ion batteries [1] have dominated electrochemical grid storage. This dominance is due to the effort over the last two decades in research and manufacturing for energy storage in portable electronic devices. This effort, combined with the growing installed cell manufacturing capacity, has resulted in storage costs going from $1500/kWh in 2006 to $300/kWh in 2014 [2]. A number of companies are offering lithium-ion battery energy storage systems that are cost competitive with diesel generators and lead acid batteries in grid storage applications [3, 4]. Typical ideal applications require less than four hours of operation or have rapid charge/discharge cycles, frequency regulation.

Lithium-ion battery describes the combination of different anode and cathode materials. The most commonly utilized anode material – graphite – was first commercially paired with a lithium cobalt oxide cathode to power early-generation camcorders and laptops [5]. A shift to higher-energy density and greater safety needs for large-scale operation led to the adoption of new chemistries. A partial replacement of graphite with silicon, such as silicon alloy [6], and replacement of the lithium cobalt oxide with lithium nickel manganese cobalt oxide have resulted in cells with more energy while improving safety.

Battery system architecture should be designed to allow sufficient, uniform, temperature regulation. Failure to address either of these can result in premature capacity loss, system failure and cell thermal runaway. Interest in this area has become great enough that industry-sponsored committees are developing standards around this topic [7] [8].

The future of lithium-ion batteries in grid-scale energy storage is exciting. As companies continue to scale up manufacturing capabilities, and raw material suppliers improve their yields, the market will see costs come down. Researchers will improve the energy density, life and safety through material advancements. Two areas of particular interest: development of solid electrolyte systems to replace flammable electrolytes [9] and high-voltage stable electrode materials to enable longer operational life [10].

Flow Batteries-Medium Term

Medium term renewable energy-generated electricity shortfalls include days of low wind speed, cloud cover, and nighttime electricity demand lasting more than four hours. One energy storage system experiencing rapid growth to meet the challenge is a redox flow battery (RFB). Under development for over three decades, it is touted for specifying system power independent from operational run time [11]. A long-running commercial demonstration is being conducted by Sumitomo Electric Industries with a calendar lifetime of over a decade [12]. Newcomers such as Vionx, Rongke Power and ViZn have recently entered the market [13] [14] [15].

The RFB is as much a chemical plant as it is a battery. Its design utilizes holding tanks containing active species dissolved in an electrolyte [11]. During charge and discharge, two mixtures--one cathode side and one anode side--are pumped through electrode plates called a stack. Within the stack is a repeating series of graphite-based bipolar plates and porous carbon electrodes separated by an ionically selective permeable membrane. As the mixtures pass through the porous electrodes, electrons are added or removed from the active redox species with the corresponding counter-ion passing through the membrane. The fluid is returned to the original holding tank, where it can be stored for future use or pumped through for further oxidation and reduction. Similar to a chemical reactor an important figure of merit is first-pass conversion efficiency.

To gain greater market adoption, manufacturers are improving the maturity and cost. The three biggest cost contributors to the system are the electrolyte, membrane and the porous carbon electrode. The electrolytes most widely used are aqueous based containing expensive metals like vanadium [16]. To reduce costs, efforts are being explored to use iron and zinc, or replace the metals with organic molecules [17] [18]. Due to the low chemical crossover requirements, expensive fluoropolymer membranes are often used [19]. To reduce costs and improve performance, designers are exploring thinner constructions or switching to hydrocarbon-based materials. Reducing system costs coupled with improved understanding of degradation mechanisms and operation life can accelerate adoption.

Electrolyzers-Longer Term

Longer-term renewable energy storage (>24 hours) will require that renewable energy be stored as a fuel in geographies not suitable for hydroelectric storage. Hydrogen can be generated using an electrolyzer and excess renewable energy. The process utilizes electricity to split water molecules into its chemical constituents, hydrogen and oxygen. Combining the fuel generation of an electrolyzer with energy production of a fuel cell creates a system where energy can be stored for extended periods. Such a system also provides independence of power and energy sizing with the use of aggressive chemicals.

PEM water electrolyzers operate at mild operating conditions with temperatures generally at or below 80°C and use perfluorosulfonic acid-based membrane as an ionic (protonic) conductor. Construction utilizes a membrane in direct contact with a Pt-based H2 generating catalyst on the cathode and Ir-based O2 generating anode for a catalyst coated membrane (CCM). The CCM is sandwiched between plates containing an arrangement of channels for evacuation of produced gases and ensuring a reliable water supply. When a voltage in excess of 1.23V is applied generation of H2 and O2 from water begins. The reaction rate depends on factors, including the key parameters of applied over potential, temperature, pressure, catalyst activity and active area, and membrane conductivity.

Progress in PEM electrolyzer development has grown in recently following decades of stagnation. Historical markets for generated hydrogen that are served by PEM electrolyzers include wafer cleaning, turbine cooling and lab grade instrumentation. These markets value the gas purity and reliability of supply offered by PEM electrolyzers. Cost (both operational and capital) was of relatively secondary importance -- there was no pressure to improve. The situation has changed in recent years with the substantial growth in renewable energy generation causing destabilization of power grids.

Fuel Cells-Generating Electricity from Hydrogen

Fuel cells are electrochemical devices that convert chemical energy into electrical energy. They differ from batteries in one key aspect: rather than having the chemical reactants sealed in a single container, they are open systems where fuel and oxidant can continuously feed into the device, and the byproduct of the reaction removed. This allows the cell to generate electricity as long as the reactants are supplied. While this may be possible for many electrochemical reactions, only those that produce benign byproducts such as water and carbon dioxide are of interest for venting into the atmosphere. Fuel cells that operate on hydrogen and ambient supplied oxygen are of interest since they can be highly efficient and produce water as the only byproduct.

There are several types of fuel cells that are emerging for commercial applications often classified by the type of electrolyte used in the cell. Proton exchange membrane fuel cells (PEMFCs) operate at much lower temperatures (<100°C) where the electrolyte is a polymer-based membrane. This system is suited for back-up power or transportation since it can quickly start-up, shut-down, and respond to electrical load demands.

One downside to converting electricity into hydrogen and back is the roundtrip efficiency of the process. Electrolyzers are about 80 percent efficient; fuel cells are about 60 percent efficient. This means a little less than half of the original electricity (48 percent) is returned at the cycle end.

Conclusion

The world of energy storage is not a one-size-fits-all. One must consider many factors including operational run time, system footprint and total system costs. For applications needing less than half a day operation, systems like lithium ion or flow batteries, may be the more cost effective choice. When longer storage times are needed, converting electricity to hydrogen allows the energy to be stored for periods of time that would be economically impractical for traditional batteries. A diversity of renewable energy storage technologies will enable the grid to use higher percentages of renewable energy, possibly even 100 percent renewable energy, as shown in Figure 2.

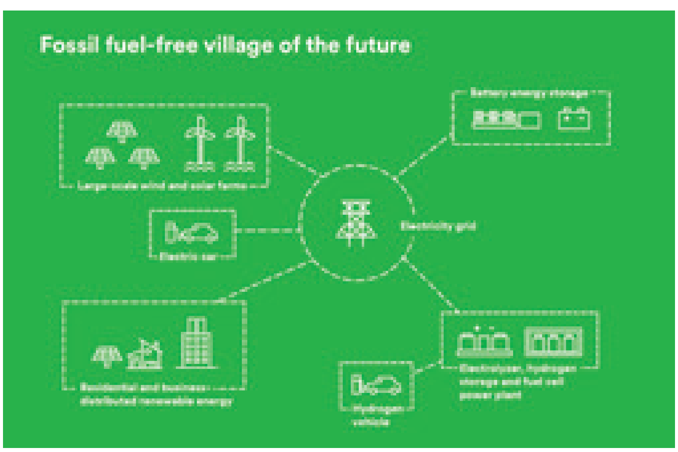
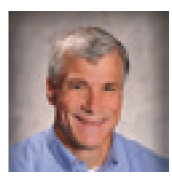


Figure 2

About the Authors

Brandon Bartling, advanced product development specialist in the 3M Energy & Electronics Business Group Lab, graduated from Case Western Reserve University with a Ph.D. in chemical engineering, and has 14 years of energy storage and electrochemistry experience. Bartling spent the beginning of his career working for Energizer Battery where he focused on research and engineering efforts in the areas of Zn-MnO2, Zinc-Air and Zinc-Silver Oxide cells. After finishing his Ph.D., Bartling worked at General Electric Global Research facility for four years developing a high temperature sodium-nickel battery chemistry. He now conducts research at 3M in the area of energy storage for a variety of chemistries including redox flow batteries, lithium-ion batteries and other energy storage systems

Tim Hebrink, staff scientist in 3M Corporate Research Lab, graduated from the University of Minnesota with a BS in chemical engineering, and has 32 years of polymer product development experience at 3M. His expertise and innovations in polymer properties and polymer processing has earned him 51 issued patents and 66 pending patent applications covering novel optical polymers, optical film designs, polymer films with improved properties, and novel applications of polymer films. Polymer films produced by his inventions have enabled significant 3M polymeric film sales resulting in 6 Golden Step Awards for individual products achieving sales greater than $15million/year and cumulative sales of greater than $5billion. He has held several positions ranging from polymer synthesis and polymer processing to environmental engineering and polymer film application development. He has also co-authored 14 research publications including a book chapter on Durable Polymer Films.



Michael Yandrasits is currently the Electrochemical Components Lab membrane research group leader in 3M's Corporate Materials Research Lab. He earned his bachelor's degree in chemistry from Illinois State University and Ph.D. in Polymer Science from the University of Akron. Yandrasits has worked in 3M's research labs for 35 years in, the last 17 years in fuel cell membrane development. He has more than 30 issued US patents primarily in the area of fuel cell technology. He has been the principle investigator for two Department of Energy-funded contracts in the proton exchange membrane field and most recently an Advanced Research Projects Agency- Energy (ARPA-E) grant to develop commercially viable anion exchange membranes.

Krzysztof Lewinski is a research specialist for the Electrochemical Components Lab in 3M's Corporate Materials Research Lab.

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From Research to Action

Utility Communications Networks for a DER Future

By Walt Johnson and Christine Hertzog

In order to facilitate integration of more distributed energy resources (DER) into distribution grids, U.S. utilities will have to apply standards that present opportunities and challenges as they create flexible, interoperable, and secure data and communication architectures.

Paving the Way

The Institute of Electrical and Electronics Engineers (IEEE) 1547 series of standards was developed to identify the fundamental technical aspects of connecting DERs—such as solar, charging stations, batteries, and demand response—to the electric grid. The standard is evolving to address the expansion of DER that interconnect with the distribution grid and the growing needs for remote monitoring and management of these assets. One of the changes to this series (1547.8) covers communications for microgrids and other groupings of DER assets to support interconnection to utility grids.

The IEEE 2030 standards family was designed to help foster interoperable communications solutions for DER asset integration to the grid. By March 1, 2018, California plans to adopt 2030.5 as the default protocol for smart inverter communications as part of Electric Rule 21, a set of regulations that describes the interconnection, operating, and metering requirements for generation facilities that interconnect to utilities regulated by the California Public Utilities Commission.

Title 24, the state's Building Energy Efficiency Standards, seeks to reduce energy use and encourage zero net energy goals for residential and commercial buildings. The updated draft version of the rules that take effect in January 2020 will stipulate that building loads must support Open Automated Demand Response (OpenADR) as the communications data model for sending and receiving demand response management signals. That means that California will mandate utility and building construction compliance with new procurement requirements. And when the sixth-largest economy in the world takes a stand on grid communications standards, there will likely be reverberations for the entire domestic electric sector.

The International Electrotechnical Commission (IEC) 61968-5 (Distributed Energy Optimization) standard specifies *internal utility system-to-utility system* and *utility-to-external entity* (e.g., aggregator) communications and should be ratified within a few months. A broad range of other standards exist—each with their own security and application strengths and weaknesses, such as the Open Field Message Bus (OpenFMB), IEC 61968, Distributed Network Protocol (DNP) 3, and Modbus standards.

The many standards available for DER communications adds complexity to questions already confronting utilities, including:

- What are the communications architectures that will securely transport the data required to maintain situational grid awareness and control of DER assets?
- Will traditional, centralized-control architectures be sufficient for dealing with the numerous devices that will be connecting at the grid edge?
- What interoperable communications architectures must be in place to support new business models that may include transactive energy scenarios and flexible groupings of DER assets?
- What are the differences between normal and abnormal operating conditions, and how will different scenarios impact communications?
- How will the constraints of existing technologies and practices affect internet security?
- Will lightweight security (to avoid overhead in computing cycles and data traffic) be sufficient?
- How will security be defined, and where will it be located to manage the expanding attack surface created by DER expansion?

A Path Forward

There are more questions than answers when it comes to the standards governing DER communications. Nevertheless, utilities must manage the increasing number of DER assets interconnecting to their grids. The starting point is to deploy secure architectures that enable the right assets to be added to the grid at the right time and at the right level of investment.

Grid modernization initiatives must be coordinated with legacy infrastructure in ways that enhance grid security while aligning cost-effectively with consumer and policy needs. The ideal grid architecture must be able to evolve in parallel with innovative technology.

The Electric Power Research Institute (EPRI) has created a special research project to help utilities create their communications networks for the DER-interconnected future. The research will help answer critical questions and offer guidance to utilities as they plan their future communications infrastructures with data models, communication protocols, and secure network architectures.

For more information about how to participate in this research, please contact Christine Hertzog (*chertzog@epri.com*) or Chris Kotting (*Ckotting@epri.com*).

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Walt Johnson is a technical executive at the Electric Power Research Institute (EPRI), where he specializes in smart grid strategies, technologies, standards, applications, and IT Enterprise Architecture. He managed EPRI's Automated Demand Response (OpenADR) Project and supports EPRI's information and communication technologies for Distributed Energy Resources project set. As an IT systems specialist with over thirty years of national and international experience, Dr. Johnson has held leadership positions at NASA, Gartner, Raychem, and the California ISO, and headed a CIGRÉ task force on architectural standards for real-time grid control systems. Prior to joining EPRI, he worked for DNV KEMA as a business process subject matter expert supporting execution of smart grid and energy IT consulting projects involving ISOs, RTOs, and global industry consortia. He holds a B.A. (*cum laude*) in chemistry from Claremont McKenna College and a Ph.D. in inorganic chemistry from Indiana University. He is a member of IEEE and of Sigma Xi, the Scientific Research Society.

Christine Hertzog is a technical advisor for information and communications technologies (ICT) and cyber security at the Electric Power Research Institute (EPRI). She works with utilities to resolve the unique and complex challenges of grid modernization initiatives by leveraging tools and deliverables from EPRI's collaborative R&D programs in ICT and Cyber Security. Hertzog also helps shape ICT and cyber security R&D directions. Prior to this role, Hertzog was the founder and managing director of SGL Partners and the Smart Grid Library, consulting and information services firms focused on smart grid and smart infrastructure ecosystems.

Hertzog is the author of the *Smart Grid Dictionary*, co-authored *Data Privacy for the Smart Grid*, and has written numerous articles about grid modernization. She is a recognized thought leader and regular speaker at industry conferences, and has also served in an advisory capacity to innovators, industry associations, and publications. She has an MS in Telecommunications from the University of Colorado, Boulder.

Analytics: The Journey, Not the Destination

By Mike Smith

Regulations, corporate drivers, leadership and market influences have combined to produce a patchwork of uneven progress on critical utility industry initiatives such as distributed generation, customer choice, asset optimization and the industrial Internet of Things. These initiatives rely on analytics to gain the most return on investment.

To better understand organizational readiness for analytics and key areas of analytic priority in this diverse business landscape, SAS conducted an industry survey. The survey explored the issues and trends that are shaping how utilities are deploying data and analytics to achieve their business goals.

The survey tallied responses from 136 utilities from 24 countries. More than half of the responses were from the US, with Australia, Canada, New Zealand and Denmark rounding out the top five. The survey responses show that the industry has come a long way in a relatively short period of time.

It was not too long ago that utility leaders were on a steep learning curve as their smart grids were fully implemented leaving new masses of data on their collective doorstep. Today, the use cases are becoming solidified and the lessons learned applied.

This is as true in the "soft" issues (people and process) as it is for the "hard" issues (technology and data). For example, today more than half of utilities with one million or more customers now have some form of an analytics center of excellence (CoE). This is an important step in being able to align and apply data and analytics skills sets across the enterprise.

Where the CoE resides, however, is still a work-in-progress as noted in Figure 1. While the natural choice might be to plunk down the CoE in the IT department, every organization should look at how to best leverage those valuable analytics resources.

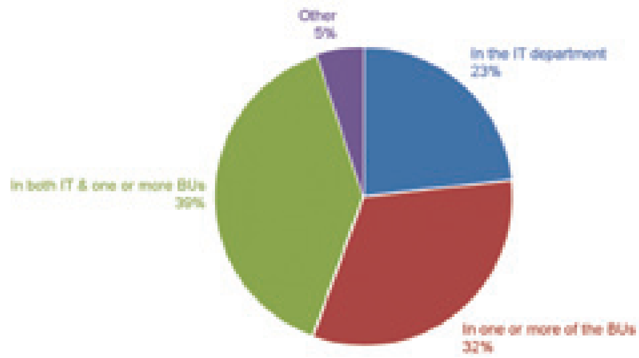


Figure 1. Where does the Analytics Center of Excellence reside?

We are also seeing changes in how utilities will deploy analytics solutions and manage masses of data in today's data-rich environments. One area getting a lot of attention in utilities is the use of cloud technologies and solutions. While utilities are arguably behind the adoption curve in this space (and for good reason), we do see "SaaS" (Software as a Service) getting traction in the utility industry. Half of all utility responses indicate the use of SaaS to solve their analytics challenges as being very likely or somewhat likely. As recently as a few years ago this was virtually unheard of in the utility industry.

And what about some of the other newer approaches to making analytics work in utilities? Figure 2 shows where utility analytics leaders are jumping in with both feet to drive analytics value in their organizations. Note that issues around data and systems integration continue to rank high; these are as critical today as they were a generation ago. Also note that the use of open source tools might still be relatively low, but this will surely rise as a new crop of analysts and data scientists enter the industry, many of whom spent much of their college careers working in the open source environment. For instance, in a separate question in the survey nearly two-thirds of responses indicate that "R" is currently in use or will be by the end of 2017.

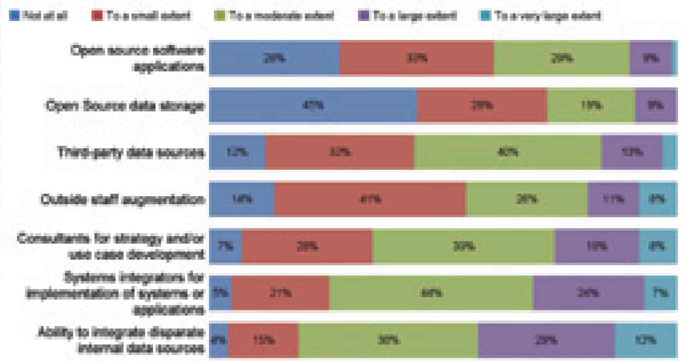


Figure 2. To what extent does your utility depend on the following for analytics initiatives?

One observation about how the utility industry has adopted analytics over the last five years is that the rate of adoption can vary widely within one utility from department to department. Some of this is driven by need; other times it is driven by organizational sub-cultures (some are simply more likely to be early adopters of what's new). While these variations of analytics adoption has traditionally varied greatly over the last five years, we will see this evolve to more consistent analytics adoption within the utility enterprise as the concept of enterprise analytics platforms takes hold.

The development and appointment of new positions will help with the movement towards an enterprise-wide approach. The survey indicated that only 15 percent of utilities have a Chief Data/ Analytics Officer. As this and similar positions (recently observed examples include "VP, Analytics" and "Chief Data Strategist") become more the norm, the ability to take an enterprise approach will grow.

Either with or without an enterprise platform, the needs of the business will ultimately dictate the priorities of which areas of the business will move forward with analytics initiatives. Figure 3 looks

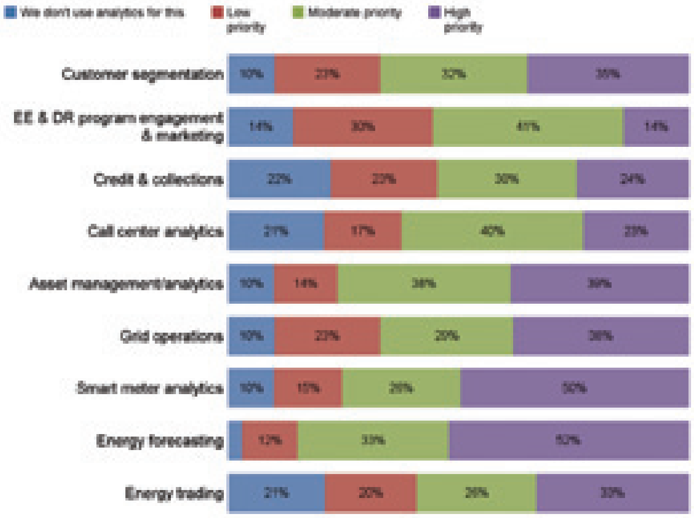


Figure 3. Relative priority of different analytics application areas in utilities

at the relative priority of different analytics application areas.

Note that energy forecasting has the highest priority as measured by "high priority" responses, as well as by adding the "high priority" with the "moderate priority" responses. As utilities continue to face flat-to-declining revenues, executives will be looking for areas where efficiencies can be realized and costs can be cut. The days of "business as usual" are over and this is perhaps most pronounced in the energy forecasting space where "good enough" is no longer the standard.

Not to be lost in this analysis is the proliferation of customer analytics applications in the mix. Utility customer care groups have a long history of working with data, often with a decades-old legacy CIS. These groups will continue to drill deeper into customer service and cost improvements as the data gets richer and as the ability to sharpen their focuses with data and advanced analytics tools becomes more of a business imperative in today's challenging business climate.

Today's utility business environment has turned many of the old assumptions on their head. Never before have we seen the convergence of increasing cost to serve with decreasing costs of energy – not an easy recipe to master. Proactive utility leaders will be continuing along their analytics journeys with the resulting digital transformations to remain viable for customers for the long term.

About the author

Mike Smith is a principal industry consultant with SAS. He has more than 27 years of experience in the utility IT, automation, smart grid, and analytics markets. Smith has led numerous industry research initiatives and has founded and co-founded numerous industry-leading research, media, and event initiatives and organizations, providing insights and forums for thought leaders and market participants. Smith has a B.A. in economics from San Jose State University and is a veteran of the US Army (Captain, Infantry).

Protecting the US Power System: The Science of Space Weather

By Jennifer Gannon

Space weather continually affects the earth, as plasma ejected from the sun interacts with the earth's natural magnetic field. We are often unaware of the geomagnetic storms that occur from month to month, due to solar coronal holes, high-speed streams, and coronal mass ejections. However, these storms regularly impact human society behind the scenes, as rapid and widespread fluctuations in the earth's magnetic field disrupt polar flights, magnetic guidance, and long-range communications systems. Power systems, in particular, can be significantly affected by space weather.

During a geomagnetic storm, power systems, oil pipelines, and other technologies that use long conductors experience quasi-DC currents called Geomagnetically Induced Currents (GICs). The geo-electric fields that are induced by rapidly fluctuating magnetic fields, interacting with the earth's geological structures, affect long transmission lines. The extraneous currents that are induced in long transmission lines during periods of active space weather are usually small. However, when a large storm occurs, GICs are enhanced, and significant damage to transformers can occur.

Transformers can be affected by GICs in two ways—through half-cycle saturation and through physical damage to the transformers due to overheating. Half-cycle saturation increases reactive power absorption and can cause an increase in harmonics, which, in extreme cases, may lead to voltage collapse. Overheating can occur when transient fields damage and melt insulators. Recognition of these dangers at the federal and regulatory levels has resulted in a new focus on the science of GICs, and the development of new tools and capabilities for understanding the potential threat. The best risk mitigation plan is to know the geophysical hazard, understand the system response and monitor local conditions.

Which Systems Are at Highest Risk from GICs?

Determination of the risk from GICs is not simple, but there are a few general guidelines that can be used as a starting point. Natural geophysical hazard conditions, as well as transmission system characteristics, both play a role in making a system susceptible to damage from GICs. For example, systems with connections to long, high-voltage transmission lines, three phase transformers, and certain substation grounding parameters can be at increased risk. However, these components are common and the risk can vary greatly between similar systems. This is because the geophysical hazard is primarily based on location. Latitude, geology and the specific features of each unique geomagnetic storm all play a significant role.

High latitude regions are generally at higher risk for GIC effects because that is where the largest fluctuations in the magnetic field often occur during typical geomagnetic storms. The most obvious manifestation of this is the appearance of the aurora, which can be a visual indicator of GIC hazard. Proximity to the ionospheric current systems that produce the aurora greatly increases GIC hazard.

Certain areas of the US have geological conductivity structures that result in higher induced electric fields during a geomagnetic storm and therefore a higher expected level of GICs. This is due to the deep earth geology of a region beneath the substation and transmission lines, which determines the intensity of the induced electric field. These locations have been mapped by federal, academic and private surveys.

Specific storm characteristics can also increase GIC hazard. Since the largest geomagnetic storms are not simply bigger versions of commonly occurring small events, the effects can be hard to predict. For example, during a very large event, the aurora may extend much further towards the equator than expected or the magnetic variation may have higher frequency components than previously experienced. Some storms have different magnetic spectral characteristics and therefore interact differently with geological structures. The direction of the magnetic field, which determines the coupling with the transmission line, fluctuates wildly and unpredictably during large events. So while knowing geophysical conditions is critical to predicting GIC hazard, it is important to remember that each storm is unique, and the largest storms may be drastically different from what has been experienced in the past.

What is the Largest Storm We can Expect?

Although we don't know exactly what to expect for the largest possible storm, there have been several large recorded events that can provide clues. While not all of these resulted in system damage, studying these past events provides a basis to plan for and mitigate potential damage due to GICs.

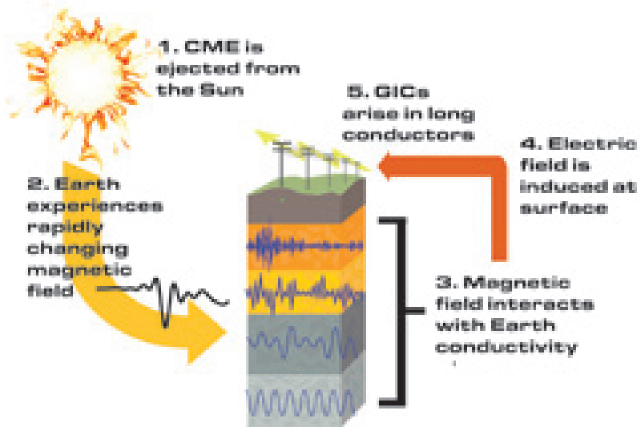
The Carrington Event is the largest recorded geomagnetic storm. It occurred in 1859, prior to the widespread use of technological systems we employ today. The solar flare that preceded the ejection of plasma from the sun was so large that it was observed by eye on Earth. Because the time of the flare and the arrival of the coronal mass ejection at Earth were recorded, we know that it moved extremely quickly through interplanetary space. Observations of the magnetic field taken at the Colaba Observatory in India showed an extremely large geomagnetic storm. GICs were induced on long telegraph wires, which, in some cases, operated without power. The Carrington Event, if it happened today, would have a definite impact on power systems, which is why it is often used as a worst-case scenario for planning purposes.

There have been other large events since 1859 that have motivated modern GIC science and engineering efforts. The geomagnetic storm of 1989, even though it was not as large as other events in history, is well known to have caused a wide-scale cascading blackout in the Canadian province of Quebec. The "Halloween" event of 2001 may have caused damage to the South African power grid. Although these events are not as extreme as the Carrington Event, they demonstrate the potential for GICs to affect power systems. We also know, through the benefit of full-time satellite observations of the sun, that there are frequent occurrences of large coronal mass ejections that miss the earth, including a near-miss in 2012. These observations prove the potential for large geomagnetic storms and provide the basis for planning and mitigation strategies

Can Geomagnetic Storms and Impacts Be Predicted?

Some day in the future, space weather might be reliably predicted like terrestrial weather, but for now, we still have a long way to go. Predictive models based on solar wind conditions are becoming more widely available, but are not yet common in operation. The science behind these models is improving as more data and resources become available. The NOAA Space Weather Prediction Center provides alerts of potential for GIC hazard based on satellite observations of the sun, and forecaster analysis. A confirmation of an impending geomagnetic storm may occur approximately 30 minutes ahead of time, based on NOAA solar wind observations. These alerts are useful indicators but must be used in combination with local monitoring and metrics to provide actionable GIC hazard information.

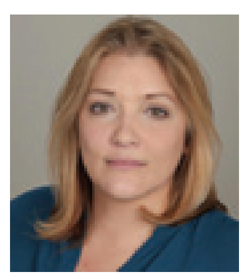
Although we can't yet predict when or where a large storm will occur, there is much that can be done in planning and operations to prepare for a geomagnetic storm. Several off-the-shelf products are available for GIC analysis and mitigation planning. These require the use of an accurate power system model that uses inputs derived from direct magnetic field measurements or a worst-case hazard scenario to estimate GIC in each line and transformer. This information can be used to model which transformers are most vulnerable, as well as how changes in the system, storm orientation, and storm intensity affect the system vulnerability.



Based on hazard analyses, mitigation strategies and response plans can be implemented and tested. A response plan might incorporate NOAA alerts with local monitoring, and system-specific storm impact metrics. Tools such as local magnetometers or GIC monitors can be placed in critical areas and used in operations to understand GIC conditions as they unfold. Metrics can be developed on a system-by-system basis to estimate GIC levels for different storm conditions. By combining planning studies with available operational tools, the GIC hazard can be well understood.

Recognition of the GIC threat to critical infrastructure has strengthened science and engineering efforts in recent years, but there remain many open questions. As prediction improves and mitigation strategies are formed, there is still much that can be done to prepare for GIC hazard. The keys to successful GIC planning and operations are local and system-specific—know the geophysical hazard, understand the system response, and monitor local conditions.

About the Author



Jennifer L. Gannon has been studying charged particles and electromagnetic phenomena in near-earth space and the solid earth throughout her scientific career. Gannon served as a scientist at the NOAA Space Environment Center and its successor agency, the NOAA Space Weather Prediction Center, and later as a federal researcher at the U.S. Geological Survey. Moving to the private sector, Gannon co-founded Space Hazards Applications, LLC, of Boulder, Colorado, a consulting firm for space hazards to built infrastructure. Gannon is the author or co-author of many publications in the peer-reviewed literature, as well as several U.S.G.S. Open-file Reports and conference presentations. She received her B.S. from the University of Virginia in 2000 and her Ph.D. from the University of Colorado in 2005. Gannon currently serves in CPI's Boulder office as geomagnetic disturbance division lead. You can reach her at *gannon@cpi.com* or *303-442-3992*.

Guest Editorial 1

What it Takes to be a Successful Innovator

By Pranav Shanbhag and Shaswat Anand

Senior leaders at global energy and utility companies have the vision and passion needed to make innovation happen. Yet they do not often enough see their efforts as being successful in driving growth, according to recent industry research. Only 38 percent of leaders in energy and utility companies believe that recent innovation was successful in driving growth. And when compared to a cross-sector group of "successful innovators," (those surveyed who said that 100 percent of recent innovation has driven growth), the energy and utilities sector seems less confident in the results innovation can stimulate. So what can companies in the energy and utility sector do to drive more innovation, see results, and communicate to the organizations why this is important?

When we think about why innovation isn't driving growth in the energy and utility sector, there are a few major lessons that can be learned. We've examined global companies that have succeeded in achieving innovation success, both within and outside the energy and utility sector, and identified three main similarities. Here are three steps that energy and utility leaders should follow in order to drive innovation in their companies:

1. **Listen to your customers' needs today, and plan for the future**

   Be like Elon Musk. The automotive innovator is a strong example of a leader who is listening to his customers, while always considering innovations to reshape the future. In mid-August, Musk spent time responding to Tesla customer tweets personally, addressing concerns about steering wheel issues, and headrest positions. And this isn't the first time Musk has taken time out of his day to listen and respond to his customers.

   Musk is also focused on enhancing the world and solving some of our greatest challenges. He has said that the overarching purpose of Tesla Motors is to help expedite the move from a mine-and-burn hydrocarbon economy towards a solar electric economy. He has made heavy investments in solar battery facilities and worked to get solar roofs on top of American's houses. While other automakers have been busy making small and steady improvements in their gasoline and diesel vehicle models, an innovative company like Tesla is not just making highly desirable cars, but in the process, it is breaking new ground and opening up a whole new market for electric vehicles. This steady focus on the vision of the future has made it possible for Tesla to transform from a company that made the US$100K Roadster, which catered to the niche luxury sports car market, to developing the US$35K Model 3 that caters to a broader customer base, and growing revenues at the same time. While the utility sector, in general, has some work to do in this area, some utilities like San Diego Gas & Electric (SDG&E) have engaged customers in their strategic planning process. For example, SDG&E has talked directly to customer groups to complete journey mapping to inform allocation of resources, development of technologies, and ultimately future vision development.

2. **Develop a "design for innovation" culture**

   We are also seeing that an interest in "design for innovation" separates the most innovative leaders from the rest of the pack. It enables companies to meet and exceed customers' needs through superior customer experience. The design for innovation approach necessitates a culture shift and focus on R&D not only to improve existing products but also to develop products that open up whole new markets. An example is Apple's success with the iPod. The backbone of this success was the ecosystem provided by Apple that made it easy to purchase music through the iTunes store and sync it with your iPod via your computer with little effort. Before Apple created the iPod, the only way to buy and listen to music was through the purchase of CDs, where consumers had to buy the entire album even if they were interested in one song. With the iPod and the iTunes store, Apple disrupted not only the CD player industry but also the entire way in which the music industry operated. In essence, Apple used the principle of design for innovation by starting with the customer experience and then worked backward to develop the technology. Currently, as the race is on to create a similar customer experience of a "connected-home" through proliferation of home management devices by Amazon's Alexa and Google's Nest, opportunities might lie for utilities to take advantage of these developments.

3. **Create partnerships outside the industry to build capabilities where necessary**
Partnerships are a quick way to enhance your innovation capabilities. Take for example a current microgrid project in Canada, where a consortium of utilities and technology companies are working to create a transactive marketplace by linking three widely dispersed microgrids in Toronto, Nova Scotia, and upstate Maine. A startup called Opus One is providing the core technology that will help monitor, analyze and manage distributed energy resources down to the feeder level in real time, and serve as the basic framework for the transactive marketplace. Through partnering with companies such as Opus One, utilities are a step closer to a transactive marketplace that could have thousands of independent energy actors, from central power plants to dispersed solar panels, batteries, smart thermostats and other grid edge assets, all telling each other what their energy needs are and what they're willing to pay for them.

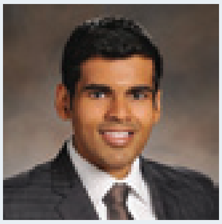
Conclusion

In the end, we've seen that being an innovation leader pays off. An innovation-focused culture can yield financial rewards and growth from innovation. Look at 3M, a company which operates in a capital-intensive industry like utilities, and has been responsible for some of the best-known products ever manufactured, including Scotch Tape, Nexcare health products, and Post-it Notes. The company is constantly recognized for its innovations, and has even won the National Medal of Technology and Innovation award. Over the last 10 years, 3M's net profit margin has averaged over 15 percent while the rest of the industry has hovered around 8.5%. Why is this? Perhaps because 3M's leadership team is focused on creating smartly designed, useful day-to-day products. Their success
is seen in the nearly double net profit margin compared to their industry competitors – being truly innovative pays off.

Innovation can be a game changer for any industry. In a nutshell, the more successfully a company can utilize innovation the further they can pull away from their competitors. Within the global energy and utility sector, there is ample room for growth and profit through innovation. Leaders need to learn from successful innovative peers. The time for energy and utility companies to garner growth from innovation is now.

ABOUT THE AUTHORS

Shaswat Anand graduated with a master's degree in mechanical engineering from MIT before joining PA Consulting as an energy and utility expert. He also holds an undergraduate degree in mechanical engineering from the University of Delhi and had a three-year stint at a global steel manufacturing company, *Tata Steel Ltd* between his two degrees. He has worked on various Six Sigma projects dealing with process improvements and quality control. He is also an expert in the fields of optimization, supply chain design, manufacturing systems and processes, product and machine design, and statistical process control.



Pranav Shanbhag is an energy and utilities expert with the PA Consulting group. He has expertise in utility strategy, utility operations, and utility finance through experience such as M&A due-diligence work for energy investors and various process improvement projects for electric and water utilities. Shanbhag is passionate about helping utilities drive lasting improvement and is currently focused on delivering complex initiatives within utilities. He has attained a unique global business perspective through work and study across three continents. He holds a master's degree in engineering management from Duke University and has completed his undergraduate studies in mechanical engineering from the University of Bristol.

Guest Editorial 2

Trickle Down Trickle Up Innovation

Does Utility Size Matter in the Adoption of New Technology?

By Brad Harkavy

Few analysts have ever accused the utility industry of being an early adopter of cutting edge technology. Unlike other industries where fierce competition demands constant technological innovation, the utility's main concern is reliability. Utilities are laser focused on making sure things work, so they are somewhat less focused on making them work more efficiently or inexpensively. However, the grid is undergoing a rapid transformation. Changing demographics and workforce distribution, along with the explosion of Distributed Energy Resources (DER) and the new business models DERs will create mean that reliability will require a lot more than good maintenance and workforce management. Utilities will need new software technologies that can make sense of all additional grid assets required to support the new model – a complex system of systems. Who will lead this technological change? Will it be the large utility with the big budget allocated for projects several years in advance, or will it be the smaller municipality or coop that is forced to do more with less internal resources?

Based on my observations working with utilities across the globe, innovation flows in both directions. Most innovation is driven by big utilities, but sometimes smaller utilities are the innovation leaders. When new technologies are introduced to the utility sector, particularly operational technology (OT) systems, typically there is a substantial "wait and see" period until the publication of successful use cases at early adopters. During this introductory period, when the new technologies are not understood or widely deployed, they are generally viewed as unimportant.

OT Cloud Computing Innovation Driven by Smaller Utilities

Traditionally, adoption of new technology by Tier 1 utilities pushes smaller utilities to reexamine their own technology best practices. As this cycle occurs, the perceived importance of the new technology begins to rise, and the industry as a whole begins to adopt the next generation of technology. Interestingly with the adoption cloud-based OT system, this trend seems to be going the other way. Cloud Computing solutions for SCADA and OMS systems are gaining traction in the Operational Technology strategies of smaller utilities, while the larger utilities remain resistant to using cloud-based OT systems until concerns related to latency and security have been overcome.

Zpryme recently surveyed 70 municipal utilities (Munis) attending a smart grid conference, most of which served fewer than 100,000 consumers and fewer than 25,000 C&I customers. Findings revealed that 43 percent of the Munis polled already use or expect to use cloud-based solutions. 41 percent of respondents are considering cloud-based OMS solutions and 26 percent are considering cloud-based SCADA solutions. The penetration rate is much lower for core OT cloud solutions at large IOUs. Smaller utilities typically have a smaller staff and a smaller operating budget. Cloud-based solutions appeal to smaller utilities due to their lower up-front cost and quicker deployment. As with many emerging technologies, smaller deployments are easier to manage, which may explain some of the reluctance among larger utilities to explore cloud-based solutions. Additionally, security is a major concern for OT cloud solutions at the big utilities. In smaller organizations, OT cloud solutions can often provide better cyber security than on-premise solutions managed by highly leveraged IT groups.

If I Don't Fully Understand It, It Can't Be that Important

The Zpryme survey also produced some other stats I found interesting. At smaller utilities, there appears to be a correlation between the perceived maturity of technologies and the importance of those technologies to their operations. For example, AMI is seen as very mature and very important. On the other hand, emerging technologies like IoT, microgrids and Distributed Energy Resource Management Systems (DERMS) are seen as immature and unimportant. AMI is a great example of a technology that is largely paid for by rate-payers and benefits both the energy supplier and consumer. Any economist will tell you that perceptions of importance or maturity will be influenced by such an easy sell.

The survey also showed a correlation between the survey group's admitted understanding of a technology and the value they placed on it—including respondents that claimed a low understanding of IoT, microgrids and DERMS—while also identifying these technologies as noncritical components of success. Munis, for the most part, have other fish to fry, but DERs are going to impact utilities of every size over the near term.

It is only a matter of time before all utilities will be forced to integrate DERs. Opportunities exist to leverage these technologies within utilities of any size, but will smaller utilities work to increase their understanding of these technologies so that they may be properly deployed?

The exception to this trend seems to be Distribution Automation (DA). While the survey group claimed this technology was minimally understood and relatively immature, DA has been field proven over many years. Despite perceived immaturity, the majority of respondents viewed DA as important to future success. Munis are in a race to roll out DA programs. Fifty-six percent of the survey group plans to deploy Distribution Automation in the next three years. DA is projected to be the top spending area for 41 percent of responding utilities, behind spending on AMI meters, only.

While the participation of experienced IT/OT engineers is needed to drive the proliferation of DA throughout the smart grid, the reality is that this is an easily understood technology. Operators who have been dealing with the distribution grid for their entire career can easily put their finger on the benefits and requirements of Distribution Automation. While the business case is easy to present, implementation again relies on deep IT/OT talent at the utility, unless the utility brings in a third party to manage DA initiatives or they deploy cloud solutions to reduce the requirements for on-site architectural expertise.

Does Innovation Require More IT-Savvy Engineers?

Based on survey responses, the smaller utilities seem to be very focused on updating legacy technologies such as SCADA, GIS, and OMS before they explore what's new. Sixty-one percent of these utilities plan to spend on SCADA in the coming years. Fifty-three percent of the respondents do not have an OMS, but 55 percent plan to spend a substantial amount of money on that technology. It is interesting to note that when survey respondents were asked to self-identify their respective areas of expertise, unsurprisingly, Operations, Engineering, and Maintenance were the most well-represented areas of proficiency. Only 13 percent of respondents identified as having Information Technology expertise. This could account for the proclivity towards more established operational technology and the marginalization of newer, more IT intensive technologies. Smaller utilities have smaller IT departments, which can make adoption of new technology more daunting, and hosted, cloud-based applications more appealing.

Our industry will increasingly be ruled by IT capabilities. While it's not entirely necessary for the decision makers surveyed to have direct IT experience, it would certainly accelerate organizational understanding of these IT-heavy technologies. As smart grid technologies proliferate, the capacity to interface devices and make smart architecture choices is a necessity. Understanding the inner workings of OT and IT systems or applications allows for the type of active management and engagement that tames the complexity of the smart grid and pushes the adoption of new technologies. Adopting cloud technologies will lessen the burden to understand the granular architectural details, so I expect we will continue to see accelerating adoption rates of cloud OT technologies at Munis.

DER Management Innovation Offers High ROI but at a High Upfront Cost

Two examples of technologies that are undeniably going to impact the entire utility industry, but suffer from the innovation stalemate at smaller Munis, are DERMS and IoT. Only 25 percent of the Zpryme survey respondents claim to have a strong understanding of DERMS. The speed at which utilities integrate DERMS will be based on two things: the utility's exposure to distributed generation projects, and how deep the utility's IT and OT capabilities go. The penetration of distributed energy into Munis will increase over time and make it even more difficult for Munis to maintain their grids, and surely DERMS (likely cloud-based) will rise on their radar in coming years.

IoT, on the other hand, will take longer for Munis to benefit from - the link between IoT and the priorities of municipal utilities is tangential at this time. IoT remains in the exploratory phase as utilities determine how and why to leverage such resources. Of those responding to Zpryme's study, the perceived maturity of IoT was very low at 15 percent, and only 15 percent felt they had a strong understanding of IoT within the context of the smart grid. The one place we are seeing early interest in IoT from Munis is for behind the meter services. Munis are just starting to deal with reduced revenue from lower consumption and thinking about how to offer more home services. IoT is part of these home services.

Innovation is Adopting New Technologies and Making Existing Technologies Better

Large utilities have sizable IT departments. Unsurprisingly, they have the strongest interest in IT-driven grid edge technologies, in spite of the fact that these technologies require large up-front investments. Larger utilities are looking to IoT solutions to fill the data gaps beyond smart meters, while shouldering the majority of the financial burden associated with introducing IoT technology to the grid. Smaller utilities often have a smaller staff, consisting of varied backgrounds. These are the utilities ultimately driving the adoption of OT cloud computing solutions at this time, as larger utilities maintain focus on proving business cases for big data initiatives.

Today, 43 percent of the Munis have or expect to use cloud-based solutions. The penetration rate is much lower for cloud solutions at large IOUs. Even while security conscious industries such as Financial Services are moving to cloud-based solutions, the big IOUs continue to cling to much of their on-premise IT infrastructure. That means that utility industry software technology innovation will continue to be a "trickle down, trickle up" transfer process. IOUs will build successful use cases on Big Data, IoT and DERMS that smaller utilities can evaluate, while smaller utilities introduce the larger IOUs to the early OT wins of cloud-based OMS and SCADA solutions.

ABOUT THE AUTHOR

Brad Harkavy is the general manager of LiveData Utilities, Inc., a provider of smart grid integration solutions for the utilities industry. He is responsible for business development, strategy, and overall management. With more than 20 years' executive-level experience growing public and private industrial and high-tech businesses, Harkavy joined LiveData Utilities in 2014 from Sagewell, Inc., an early stage energy efficiency company, where he was chief operating officer.

Through his executive positions, advisory, and board work, he has successfully accelerated ideas and technology into innovative products and services for over 20 companies, including BPG, CoolChip, GrabCAD, GSI, Purchased, Sagewell, SMTP, Teradyne, and Vert. Harkavy received a BSEE from Carnegie Mellon University and holds three patents.

Source: https://etsinsights.com/reports/utility-innovation-series-iou-outlook/

By Dr. Tim Shaw

SECURITY SESSIONS

What Cyber Security Experts Need to Know

Recently I overheard a couple of supposedly-knowledgeable cyber security experts discussing the amazing (to them) range of microprocessor-based devices they were running into in a power generating station where they were working with the electric utility to achieve compliance with the ever-evolving NERC CIP requirements. One of them was lamenting that far too many of the NIST 800-53 recommended cyber security controls had not been applied, and that the plant automation staff kept claiming that it was not possible to implement them. The other was responding that it was probably okay in some cases since the devices had their program code in ROM so malware could not infect them.

Look at All the Funny Little Boxes!

Well, both of those two experts were somewhat correct but also very, very wrong. I have used this column in the past to reflect on the general lack of knowledge among cyber security practitioners in the area of industrial automation. Specifically, I see an amazing lack of knowledge about technologies such as SCADA, DCS and PLC-based systems, in addition to commonly used industrial protocols such as EtherNET/IP, Modbus/TCP and ProfiNET. Even more glaring, based on the overheard conversation with which I opened this column, is the lack of knowledge about commonly used "smart" instrumentation and devices such as protective relays, PID controllers, digital trend recorders, smart annunciator panels and the like. I realize that IT personnel don't run into that kind of stuff all that often, if ever, in their careers. But if you don't know about that stuff, and claim to be able to properly assess and establish adequate cyber security protections in an industrial facility, you are kidding yourself (and misleading your clients.)

I have personally witnessed heated arguments about smart transmitters (HART, in this case, operating in "analog" mode) serving as possible platforms for attacking a control system. The assumption being that the transmitter could somehow become infected with malware (an amazing and mission-impossible-worthy feat in and of itself) and then attack and compromise the associated control system via the wired connection between the two. Now I don't expect an IT person to particularly know what an analog-to-digital converter circuit is and exactly how it works, but I do expect people who purport to be "experts" to do the necessary research and investigation when they run into something they don't understand, rather than to jump to far fetched conclusions with no basis in scientific or engineering reality. One thing that I take away from this sort of experience is that fact that IT education is badly lacking in providing the practitioners with a wide ranging understanding of the various ways in which computer-based devices can be constructed. Not everything that contains a microprocessor is a Microsoft Windows PC or server. It would be useful for IT folks to be exposed to the many ways that microprocessors are embedded into "smart" devices today, from the washing machine that can "phone home" to request a service call to a doorbell that calls your cell phone and initiates a Skype-like video chat session. But it is not enough that they know such things are being built; they need to be told the cyber security implications of such designs.

Going back to that conversation on which I was eavesdropping, one of the parties asserted that it was okay not to have added cyber protections for some of the smart devices since their code was in ROM and thus the devices could not be infected with malware. To begin with, that assertion/assumption could be wrong. Fewer and fewer devices today use ROM memory for much since it is impossible to make updates or patches to code "burned" into ROM without taking the device apart. Today it is more common to have a bootstrap loader in ROM that takes a compressed program image from flash memory (possibly/often stored on removable media) and decompresses/writes it into RAM for execution. In such a design you can overwrite the contents of flash, in the field, to provide a software (firmware) update. In such a design the code is actually running in RAM and thus it can potentially be overwritten with malware. Mind you that task is way more difficult than might be apparent because:

1. You need a detailed understanding of the physical memory locations of the program code you want to overwrite
2. The code for the device is very hardware platform/ CPU specific
3. There needs to be extra RAM available in which to insert the bulk of the malware
4. The source code for the device is vendor proprietary and not generally available for analysis unlike Windows and Linux
5. The device is most likely not running a C.O.T.S. multitasking operating system (and probably does not have a file system), and
6. Any change you make must not interrupt the normal/ expected functions of the device unless all you want from injecting malware is to disable the device or modify its functionality in a manner that will quickly become obvious.

Of course, another factor that needs to be considered is possible access to the device's configuration settings. With a lot of smart devices, the functionality of the device can be drastically modified through the changing of configuration settings. (I differentiate configuration settings from operational settings: the former are usually set during installation and commissioning and rarely if ever need to be altered – think PID tuning constants. The latter may be altered quite often as part of normal operations – think PID setpoint changes.) I don't need to inject malware into a smart device to degrade or disrupt its functionality if I can achieve the same thing by modifying some setting values. A good example of this would be a digital protective relay. Today most such devices come with a broad number of built-in relaying functions and you turn the device into an under-frequency relay or an over-current relay by selecting the protective function(s) you want it to perform using configuration settings. Many modern smart devices support communication connectivity, including Ethernet-TCP/IP network connectivity. In such an arrangement the device may "expose" (make available for reading and possibly writing/changing) its configuration settings through an industrial protocol such as EtherNET/IP or Modbus/TCP and it might also "expose" them via an integral web server running on the device and through SNMP (standard network management protocol) access. However, these setting are made available for modification. If the mechanisms, or means for accessing them, are not adequately secure than I can maliciously impact the device by making such changes. So clearly the second expert in the overheard discussion was not taking that possibility into account and would not have looked into protecting those configuration access mechanisms and pathways.

I mentioned earlier that another problem with many cyber security experts is that they are woefully lacking in their understanding of the communication protocols used in industrial automation applications. If they have any familiarity at all it is usually only with the "modern" variations of older, vendor-proprietary protocols, the ones that have been ported onto an Ethernet-TCP/IP platform as an application layer (ISO/ OSI layer 7) protocol. These are the kinds of protocols that you have some chance of inspecting and monitoring using modern firewalls and network intrusion detection (NIDS) technologies. But of course, to do a good job of this you do need to understand the details of the protocol at the application level, not just the TCP/UDP and IP levels. And if you have one of the legacy variations of these protocols, running on a proprietary LAN such as the Allen-Bradley Datahighway-plus®, then all bets are off since no off-the-shelf IT solutions exist for monitoring and controlling message traffic on such a LAN.

Of course, the argument can be strongly made that a cyber-attacker probably can't do much in that case either, unless they get physical access to the LAN, or (more likely) to one of the attached computers. (And if an attacker is that far inside your plant a cyber attack is probably the least of your worries.) For those old legacy industrial LANs, and for "serial" (asynchronous, low-speed) point-to-point or point-to-multipoint communication links, the only available strategy is to physically protect the communications media and system components from unauthorized physical access. In some limited cases (e.g. a point-to-point "serial" link), you might also consider link encryption if you feel that you can't physically secure the communication circuit.

The challenge, when discussing such legacy communications technology with many IT-knowledgeable cyber security experts, is that they think the same issues apply to these technologies as do to an Ethernet-TCP/IP-based communication scheme. I have had endless arguments with such experts concerning buffer overflow attacks and why they won't happen with something like "serial" Modbus (Modbus-RTU) protocol. In an IP network, with a multitasking operating system, a program that needs to receive data from another program allocates memory space for that data and then asks the network services part of the operating system to receive a message and put it in the allocated memory area (and is then put to "sleep" by the operating system.)

IP presumes that the sender is going to send a valid message that won't exceed the allocated space and essentially trusts the sender to do the right thing. Of course, hackers find such situations and use them to send too much data, which overwrites program memory (thus changing the program instructions to do something the hacker wants.) When the operating system then lets the receiving program resume executing the damage has been done. With the "serial" Modbus (Modbus-RTU) protocol the node receiving a Modbus message receives each message byte individually and verifies that the byte value is proper/expected. If they byte does not make sense (e.g. it is supposed to be the Modbus "command" and its value represents a command that the receiving node does not support), the node flushes what has been received to this point and starts waiting to see the start of a new message. A buffer overflow is just not possible.

Likewise, it is not possible to use Modbus-RTU protocol to create a file, write a program into that file, and have the program executed. First because (standard) Modbus doesn't even envision the concept of files and programs, second because no such commands exist in the Modbus command set and finally, because the "coils" and "registers" Modbus can read and write are not usually mapped to executable program memory. IT experts usually presume that any "smart" device will have a command prompt and command line interpreter of some type that enables such activities. It isn't always easy to convince those experts that a "serial" Modbus communications link does not provide such access. This is not to say that a serial Modbus communication link might not offer a target for cyber compromise. If a field device speaks Modbus protocol and controls plant equipment, then injecting forged messages addressed to the field device could cause such equipment to fail. To do this, the attacker still needs to get physical access to the communication circuit or to the "Master" node. So now we are back to physically protecting the communication circuit and system elements or employing link encryption to prevent such an event.

For the Ethernet-TCP/IP based industrial protocols, you DO need to think about cyber security issues because it is possible to both "sniff" and "spoof" such message traffic and because most such protocols do not have intrinsic cyber security mechanisms (e.g. end-point authentication, encryption, etc.) Having said that you also need to be realistic and practical; if your network consists of a few controllers and operator HMIs on an isolated LAN, all located in a locked (or otherwise access controlled) room, then you have a highly constrained cyber security issue where physical access and use of occasionally-connected portable digital devices and use of computer-readable storage media pose the main threat. But if your plant network is extensive and contains many devices and computers you really ought to be taking steps to ensure their cyber security. This is where lack of knowledge of industrial protocols can be an issue.

A good way to protect a critical digital system or device from cyber attack is to place it behind a well-implemented firewall. A firewall allows message traffic you have designated to pass through and blocks all other message traffic. You make this happen by writing "rules" (an ACL – access control list) that describe the criteria of permitted messages. You can say they must come from a specific set of IP addresses, that they must be going to port 20000, that they must be using TCP transport. But all of that is easy enough to fake/spoof using readily available hacker (and penetration testing) tools. But, if you are knowledgeable about the specific industrial protocols you are using, you can extend your rule criteria to the level of the protocol itself. In Modbus/TCP terms that could mean specifying that only specific commands be permitted and only if they reference a specified set of register addresses. In EtherNET/IP terms that could mean that only specific object types and instances are permitted and only if specific methods/commands are being issued to those objects. By having rules down to that level of detail it makes it much more difficult for an attacker to spoof/fake your message traffic. It also increases the likelihood of detecting efforts to forge messages. But, if a cyber security expert doesn't know about the details of your industrial protocols it is unlikely that they could be of assistance in enhancing your firewalls.

In most instances, once a vendor goes to the point of adding Ethernet and TCP/IP communications to their device, they don't limit their efforts to merely implementing one (or more) of the application-layer industrial protocols. They usually add additional network-enabled features to enhance their product offering. It is common to see vendors implement several basic IP "services" such as embedding some form of web server that provides a GUI (graphical user interface), preferably using HTTPS (encrypted/authenticated) access. They also often implement a command-line interpreter such as TELNET (insecure) or SSH (secure shell – secure), and they may support other functions such as (T)FTP upload/download file access to firmware and/or device data and even SNMP access to critical settings, as I mentioned earlier in this article. The bad news is that these services open the device up to a range of possible cyber attacks. The good news is that most IT cyber security experts really DO know how to protect these kinds of services with appropriate firewall rules.

A good general-purpose rule of thumb in cyber security is that convenience and cyber security are opposing forces. Increasing one generally decreases the other. All of those added "services" make it much more convenient to remotely (across a network) administer and support these devices, but it also makes them far more vulnerable to cyber attack and compromise. In an industrial facility most devices and systems are installed, commissioned and acceptance tested and then rarely, if ever, messed with unless something breaks. Even installing security patches and updates is often frowned upon since history has proven time and time again that you have a greater-than-zero chance that something will go wrong when you are making such changes. So, in a plant environment, because of the infrequency of changes, the need for device/system administration services is also infrequent and thus not a major burden, even if said administration has to be performed locally to the device/system rather than remotely. In this case, it is possible to consider disabling the services running on a device/system which are needed for remote administration (e.g. Telnet), but which also provide a potential attack pathway for an adversary. This reduces the device's or systems "attack surface," thus improving their cyber security. But that sort of thinking runs contrary to conventional IT wisdom and so your IT cyber security experts probably won't suggest that approach.

I have written in the past about successful collaborations between OT and IT groups where the domain knowledge of both is merged and results in a far better cyber security end-result. And there is training available on cyber security for Industrial Automation and IT cyber security experts would benefit from getting such training if they are going to be providing cyber security consulting services to industrial clients. A CISSP, or one of the many variations, does not equip a cyber security expert to work in the industrial world. I have often thought that there needs to be a specific certification for industrial automation cyber security. But that will have to be the subject matter for a future column.

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