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Electric Energy T&D MAGAZINE

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The Digital Utility: Preparing Today's Utilities for Tomorrow

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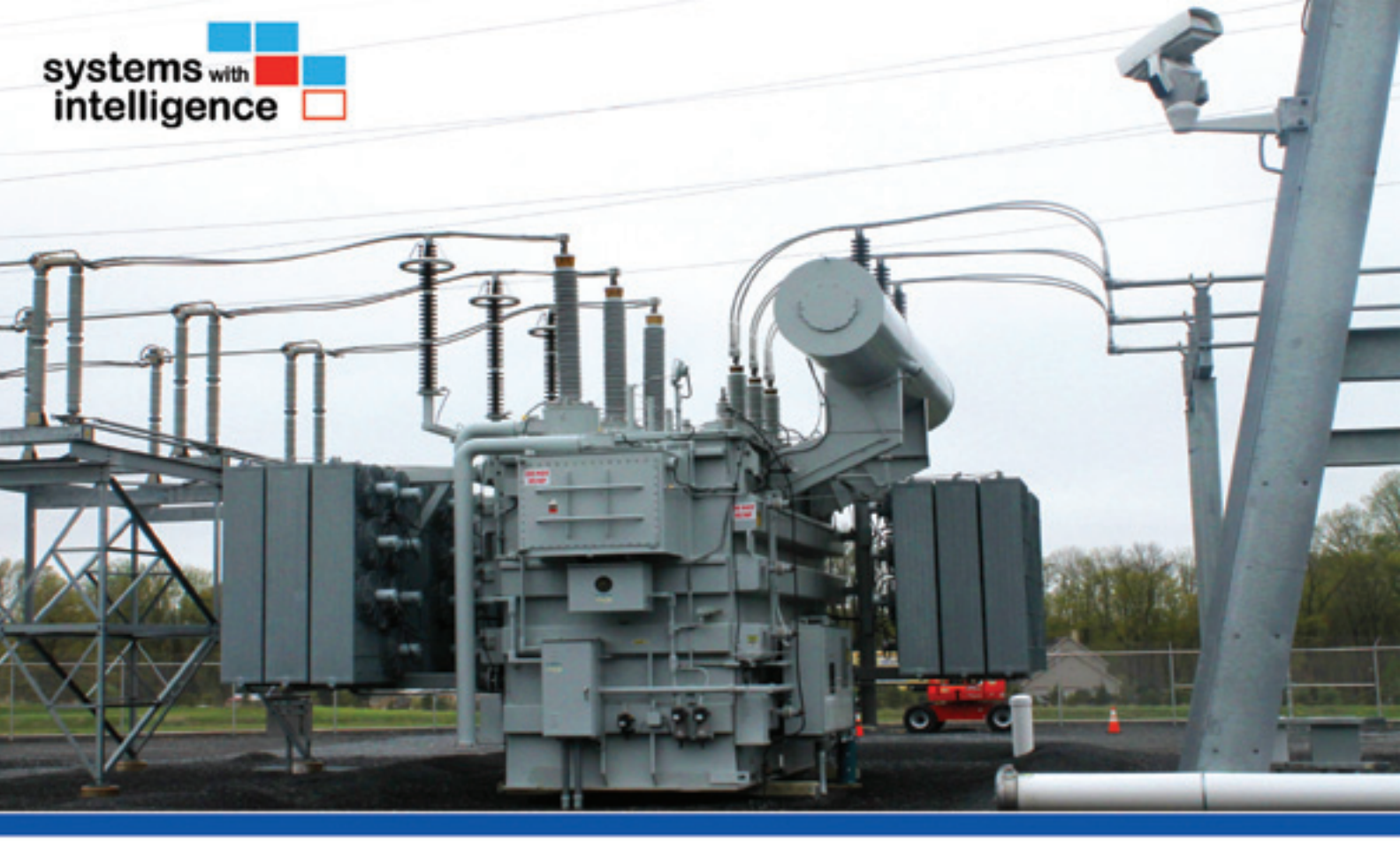

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Editor-in-Chief
ELISABETH MONAGHAN

POWERPOINTS

An Inspirational Year in Infrastructure

In October, I had the opportunity to attend the Bentley System's Year in Infrastructure Conference 2017. This annual meeting brings together executives, government leaders and representatives of industry organizations from around the world to share innovative practices in infrastructure, project design, engineering, construction and operations. This year, the conference took place at the Sands Expo and Convention Centre at Marina Bay Sands in Singapore and was the first time the event was held in Asia.

Getting to Singapore was not without its challenges. With one delayed flight, which meant a missed connection, one canceled flight and an errant suitcase that got lost along the way; I didn't arrive at my hotel until 3 a.m. on October 9. The incredible architecture of the Marina Bay Sands and stunning landscape surrounding it made up for the fatigue I experienced later in the day.

Unfortunately, because of the missed connection, I did not get to Singapore in time for the Media Day Dinner. I did have the pleasure of attending the Welcome Reception at the ArtScience Museum.

In keeping with this year's conference theme "Going Digital" Bentley sent out a link in advance of the event to download the "Year in Infrastructure" app. Of the myriad conference apps I've tested over the past few years, this was by far the easiest to use. It had all of the information I needed. There was also messaging capability to contact others at the conference or set an appointment with them.

To make it easier for attendees to focus on the specific areas of infrastructure in which they operate, conference sessions were broken down into six industry forums: Building and Campuses; Digital Cities; Industrial; Rail and Transportation; Roads and Bridges; and Utilities and Water.

Today's utilities must be ready to respond to changing business environments, regulatory constraints, grid modernization and renewables integration. On top of that, much of the infrastructure is old and in need of major upgrades. Utilities must determine how to face these challenges by investing in and implementing new technologies while also responding to increasing service demands. The Utilities and Water forum explored these industry challenges and shared case studies on how others in the industry have successfully addressed them.

The event culminated in a black tie dinner and ceremony that honored winners of the before 2017 Be Inspired Awards. These awards recognize the greatest Building Information Modeling (BIM) advancements in infrastructure. Of the 409 nominations received from organizations representing 50 different countries, 51 finalists were selected.

For each of the 17 categories of the Be Inspired Awards, jurors selected three finalists. Leading up to the awards ceremony, the finalists presented their nominated projects, explaining how, with the use of Bentley's solutions, they were able to overcome a number of stumbling blocks they encountered along the way.

I was most interested in hearing from the finalists in the BIM Advancements in Utilities and Industrial Asset Performance and the BIM Advancements in Utilities Transmission and Distribution categories.

POWER POINTS

For the Advancements in Utilities and Industrial Asset Performance, jurors looked at enterprise deployments in the operation, inspection, maintenance and management of utility plants and networks, power generation facilities, oil and gas production facilities or any other industrial site that provided improved reliability, integrity, performance and operational efficiency and effectiveness, along with enhanced safety and reduced risk.

The finalists In the Utilities and Industrial Asset Performance category were:

- AES Indianapolis Power and Light – T&D Implementation of Asset Risk at Indianapolis Power & Light – (Indianapolis, Indiana, United States)
- BP – Khazzan Central Information Store (CIS) – Khazzan Field, Block 61, Ad (Dhahirah Governorate, Oman)
- North Caspian Operating Company N.V. – Kashagan Oilfield Corrosion and Inspection Management Project in the North Caspian Sea and Bolashak Operating Production Facility – (Atyrau Region, North Caspian Sea, Kazakhstan)

BP was the award winner in this category.

For the Utilities Transmission and Distribution category, jurors selected from utilities and communications network projects that demonstrated excellence in the planning, design, construction and operations and maintenance of electric, gas or communications network infrastructure for distribution or transmission.

In the Utilities Transmission and Distribution category, the finalists were:

- Hubei Electric Power Survey and Design Institute – Macheng Caijiazhai Wind Farm Project – (Macheng, Hubei Province, China)
- Pestech International Berhad – Automation and Integration of Substation Design Work for 230kV Project – (Kratie and Kampong Cham, Cambodia)
- Pacific Gas & Electric Company – Reality Modeling in Bentley Substation – (San Francisco, California, United States)

Receiving the award for this category was Pestech International Berhad.

The summary of this project was included in the description of the finalist's presentation as follows:

Diamond Power Limited awarded a USD 100 million contract to PESTECH International Berhad to design, supply, erect and commission a 230-kilovolt substation and transmission system from the town of Kratié to the city of Kampong Cham, Cambodia. PESTECH also secured a USD 92.2 million EPC contract upgrade to build, operate and transmit, followed by a 25-year concession to operate and maintain the power transmission system.

PESTECH replaced the manual design process of past projects with Bentley Substation, which provided an integrated platform for electrical and power design. Working with Bentley Channel Partner Hertford MES Sdn Bhd, the project team also implemented ProjectWise, Promis.e, MicroStation and Bentley Navigator to enhance productivity, facilitate collaboration, minimize errors, and enforce standards. Bentley applications helped the team to cut design work from weeks to days, saving an estimated 70 percent in project time.

Not all who embark on major infrastructure projects have the budget or technology to execute end results like those of the Be Inspired Award winners, but listening to the comments of fellow attendees during the conference and around my table at the awards dinner, it is clear people truly are inspired by the vision, innovation and collaboration of those who, in the last year, completed some of the world's most notable and complex infrastructure projects.

Whether it was in a keynote address, industry forum, finalists talking about their projects, or the awards ceremony, the quality of presentation and video production was topnotch. The Bentley staff was efficient, helpful and accommodating. Best of all, I made contacts with others in the utility space whom I look forward to seeing at the next conference.

I thought getting to Singapore was complex and required a lot of patience, but hearing from infrastructure experts who deal with so many aspects of the projects they execute, I have a greater appreciation for what true complexity and overcoming real obstacles looks like.

Check out our media kit for 2018 to see what topics we will be covering. If you would like to contribute an article, or have an idea about interesting technology, solutions, or suggestions, please email me at *Elisabeth@ElectricEnergyOnline.com*.

Elisabeth

Department of Energy Announces Five New Projects Through BIRD Energy Partnership with Israel

November, 2017

On November 1, 2017, The U.S. Department of Energy (DOE) in partnership with Israel's Ministry of Energy (MOE) and the Israel Innovation Authority announced $4.8 million for five newly selected energy projects as part of the Binational Industrial Research and Development (BIRD) Energy program. The approved projects will leverage cost-share for a total project value of $10.5 million in the areas of hydrogen storage, advanced biofuels, sustainable transportation, and energy efficiency. Today's announcement represents the ninth annual selection of BIRD Energy projects, which promote energy innovation, economic security, and bilateral cooperation.

"The BIRD Foundation has served as a matchmaker to develop partnerships between U.S. and Israeli researchers at the forefront of technology across the industrial spectrum. This kind of collaboration will be mutually beneficial and allow both countries to achieve their economic and energy security goals," said Secretary of Energy Rick Perry.

This announcement builds on the robust and ongoing cooperation between DOE and MOE under the U.S. Israel Energy Dialogue, which brings together experts from both nations to encourage innovation of sustainable energy technologies, explore the energy-water nexus, and enhance energy cybersecurity.

"Together with the BIRD Foundation we can encourage joint R&D efforts that will contribute significantly to the bright and safe future of our world. We would like even to accelerate and to enhance it, and to expand it in the years to come," said Israel's Minister of Energy Yuval Steinitz.

BIRD Energy began in 2009 as a result of the Energy Independence and Security Act of 2007. Since then, BIRD Energy has funded 37 projects with a total investment of about $30 million, including the five selected projects announced today. To date, BIRD Energy awardees have attracted more than $200 million in venture capital and other follow-on funding to commercialize clean energy technologies. The program encourages cooperation between Israeli and American companies through funding joint research and development in a range of technologies, including solar, wind, biofuels, energy storage, fuel cells, smart grid, and water and energy efficiency.

BIRD Energy projects address energy challenges and opportunities of interest to both countries, while focusing on commercializing sustainable energy technologies that improve economic competitiveness, create jobs, and support innovative companies.

During the last seven years, four BIRD Energy projects have reached the commercialization stage, including a self-powered wireless sensor for monitoring energy use in buildings, a new enzyme for the production of biodiesel, a utility scale solar concentrated photovoltaic system employing a new active cooling module, and a new system to facilitate wind speed and power output forecasting for wind generation.

Projects that qualify for BIRD Energy funding must include one U.S. and one Israeli company, or a company in one of the countries paired with a university or research institution in the other. The companies must present a project that involves innovation in the area of sustainable and clean energy and is of mutual interest to both countries. After undergoing a rigorous, meritable review process, qualified projects must contribute at least 50 percent to project costs and commit to repay up to 150 percent of the grant if the project leads to commercial success.

Below are the five approved projects announced today:

- Brenmiller Energy Ltd. (Rosh Ha'ayin, Israel) and Power Authority of the State of New York (White Plains, New York) - will develop high temperature storage based in combined heat and power (CHP).
- CelDezyner Ltd. (Rehovot, Israel) and AdvanceBio LLC (Milford, Ohio) - will develop a process for production of ethanol from lignocellulosic feedstocks.
- QDM Ltd. (Rehovot, Israel) and ALD NanoSolutions Inc. (Broomfield, Colorado) - will develop 3rd generation high-temperature superconducting (HTS) cables.
- SoftWheel Ltd. (Tel Aviv, Israel) and Detroit Bikes (Detroit, Michigan) - will develop an energy-efficient, low-maintenance, high-performance bicycle.
- TerraGenic Ltd. (Kadima, Israel) and Triton Systems, Inc. (Chelmsford, Massachusetts) - will develop a safe hydrogen transport and storage system.

DEWA signs MoA with DAFZA to strengthen cooperation to achieve goals of Smart Dubai initiative

October, 2017

In the presence of HH Sheikh Ahmed Bin Saeed Al Maktoum, President of Dubai Civil Aviation Authority, Chairman of Dubai Airports, and Chairman of the Dubai Supreme Council of Energy; HE Saeed Mohammed Al Tayer, MD & CEO of Dubai Electricity and Water Authority (DEWA), and HE Dr. Mohammed Al Zarooni, Director General of the Dubai Airport Free Zone Authority (DAFZA), signed a Memorandum of Agreement (MoA) during the 19th Water, Energy, Technology, and Environment Exhibition (WETEX 2017), which is organised by DEWA at the Dubai International Convention and Exhibition Centre. The agreement aims to strengthen cooperation between the two parties to achieve the goals of the Smart Dubai initiative, which was 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.

The MoA calls for strengthening cooperation, combining efforts, uniting capabilities and resources, exchanging knowledge and ideas and facilitating effective communication to implement DEWA's smart initiatives that support the Smart Dubai initiative, at DAFZA. These are Shams Dubai, Smart Applications through Smart Meters and Grids and the Green Charger initiatives. Shams Dubai encourages customers to install photovoltaic solar panels on their rooftops to generate electricity from solar power and export any excess back to the power grid. The smart applications initiative uses smart networks to respond quickly in reconnecting to the power supply. The initiative also supports the smart rationalisation of energy consumption using smart meters. This allows on-the-spot monitoring of consumption details, anytime, anywhere, and supports sustainability of resources. The Green Charger initiative aims to build infrastructure and charging stations for electric cars.

"This agreement comes in line with efforts to strengthen cooperation and consolidate the efforts of government entities in Dubai to achieve the goals of the Smart Dubai initiative, which was launched by His Highness 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 contribute to this initiative by implementing the three smart initiatives we launched to further drive Dubai's smart transformation and implement the sustainable initiatives and programmes in Dubai," said Al Tayer.

"DEWA adopts an integrated strategy and creative plans to attract the latest solutions and technological systems and implement them to achieve the Dubai Plan 2021, which aims to make Dubai a smart, integrated, and connected city and DEWA's vision to become a sustainable innovative world-class utility," added Al Tayer.

Al Zarooni noted that the agreement with DEWA is key to building solid foundations for making technology and innovation a driver for Dubai as the world's smartest city. He emphasised that it paves the way for new horizons in excellence by providing innovative and smart services that ensure the quality of life in Dubai.

"As HH Sheikh Mohammed bin Rashid Al Maktoum, Vice President and Prime Minister of the UAE and Ruler of Dubai once observed, Our goal is to improve the quality of life as we aim to harness technology for the establishment of a new reality in the city of Dubai, a different life, and a different development model,' " said Al Zarooni.

"At DAFZA, we have always been keen on improving the quality of services, adopting excellence, innovation and smart transformation to take the lead, reinforcing our role in supporting the overall economic renaissance and making Dubai a central player in shaping the new era. This agreement reflects our mission in providing quality services and applying best practices, in order to provide an exceptional and sustainable experience for the free zone investors within a unique, creative, and positive work environment. We look forward to working with DEWA to harness the creative and technological potential to serve the objectives of Smart Dubai, and realise the aspirations to position the UAE at the top position globally," concluded Al Zarooni.

INDUSTRY NEWS

Georgia Power named top utility for economic development by Site Selection magazine

November, 2017

Georgia Power has once again been named to Site Selection magazine's Top Utilities in North America for Economic Development list. The company has been named to the list consistently for nearly two decades and more times than any other utility. Georgia Power was named to the list this year in recognition of the company's strong partnership with the state of Georgia in economic development resulting in an estimated $2.9 billion in projects and more than 20,000 associated jobs for Georgia.

"We would like to thank Site Selection for recognizing the role that utilities throughout the country play in local and state economic development," said Anne Kaiser, vice president of community and economic development for Georgia Power. "Keeping the state of Georgia competitive as a top destination for national and international business is the result not only of our commitment to make our communities stronger, but also our collaboration with the state of Georgia and many other organizations every day."

Site Selection analyzed a variety of factors for this year's list including corporate end-user project activity and submitted materials from utilities; website tools and data; innovative programs and incentives for business, including energy efficiency and renewable energy programs; and the utility's own job-creating infrastructure and facility investment trends. The list is featured in the September issue of Site Selection, available at www.siteselection.com.

Georgia Power has been cultivating economic vitality in Georgia for 90 years. Georgia Power Community & Economic Development is internationally recognized as one of the top economic development organizations in the world, helping to create or retain an estimated 134,000 jobs in Georgia over the past decade alone.

To learn more about Georgia Power's commitment to make Georgia a better place to live and work through robust economic development initiatives, visit www.GeorgiaPower.com/Growth. Businesses and organizations seeking to expand or relocate to Georgia are invited to access a variety of information, tools and resources at www.SelectGeorgia.com.

Xcel Energy recognized as a top company and best employer by Forbes magazine

November, 2017

Xcel Energy, headquartered in Minneapolis, has been recognized by Forbes magazine as one of the World's Top Regarded Companies and one of the World's Best Employers.

Forbes' World's Top Regarded Companies
Of the 2,000 public companies considered, Xcel Energy was among 250 that earned a place on Forbes' Global 2000: World's Top Regarded Companies list. To compile the rankings, 15,000 international respondents evaluated businesses based on trustworthiness, social conduct and the performance of the company's product or service.

Xcel Energy, the nation's No. 1 utility wind energy provider for more than a decade, is transitioning to cleaner energy sources while keeping customer bills low. The company provides many benefits to the communities it serves, including economic development and energy assistance support.

Forbes' World's Best Employers Based on results from survey responses, Xcel Energy earned a place on another prestigious Forbes list, Global 2000: World's Best Employers. Of the 2,000 public companies considered, Xcel Energy was among 500 recognized. Employees rated their employer, how likely they would be to recommend the company to another person and to identify companies they admired.

In recent years, Xcel Energy has earned recognition for investing in its employees with innovative workforce development initiatives. Approximately 96 percent of employee hiring is local within the states that the company serves, and more than 14 percent of newly hired employees last year were military veterans.

Novinium Presents Environmental Stewardship Award to Oncor

November, 2017

Novinium, provider of electrical cable rejuvenation for power utilities, presented an Environmental Stewardship award to Oncor for their efforts in finding innovative ways to deliver electricity to millions of customers while also minimizing the impact on the environment.

Novinium established an Environmental Stewardship Award to honor the environmental commitment of electrical utilities that choose rejuvenation of their electrical cables when upgrading their underground power networks.

Oncor is receiving the award based on the number of feet of electrical cable they rejuvenated and the resulting CO2 mitigation. Rejuvenating existing electrical cable allows the cable to be recycled in place, eliminating waste created by otherwise abandoning and replacing the wires. In 2016, Oncor rejuvenated more than 700,000 feet of underground power cables mitigating 49,472 metric tons of CO2 that would have otherwise been released into the environment.

"Our mission at Novinium is to help the electrical industry rehabilitate its infrastructure at a fraction of the capital cost of replacement and to do so in a way that is safer and more environmentally friendly than replacement alternatives," says Glen Bertini, CEO of Novinium. "This award recognizes the commitment by electrical utilities to choose a solution that is good for the planet and their clients."

Oncor is one of 10 utilities across the United States and Canada that were presented with the award in 2017 based on the number of feet of electrical cable injected in 2016.

"We are honored to be recognized by Novinium for our efforts in environmental sustainability," said Ray Averitt, Senior Director of Risk Management. "Oncor has a long history of acting sustainably and finding innovative ways to protect our environment and we are grateful to have Novinium's support to continue these efforts."

To learn more about the specific injection projects at each of the winning utilities, visit www.novinium.com.

INDUSTRY NEWS

Duke Energy plans solar, energy storage projects to advance reliability, cleaner energy for Indiana

November, 2017

As part of a commitment to advance cleaner energy for its customers, Duke Energy is planning to install battery storage equipment and solar panels that will operate as a microgrid at the Indiana National Guard's Camp Atterbury training operation in Johnson County, Ind. The company will also install battery storage equipment at a substation in Nabb, Ind., in Clark County.

Plans for the projects must be approved by the Indiana Utility Regulatory Commission before work can begin. The microgrid at Camp Atterbury would be the first microgrid installed at a National Guard facility in Indiana.

"Given our recent success with the installation of a 17-megawatt solar power plant at Naval Support Activity Crane, we were eager to find another opportunity to join with the U.S. military to incorporate new technology into our grid operations," said Melody Birmingham-Byrd, Duke Energy Indiana state president. "The project at Camp Atterbury will help us gain valuable operating experience and may help determine how best to expand the new technology to other areas."

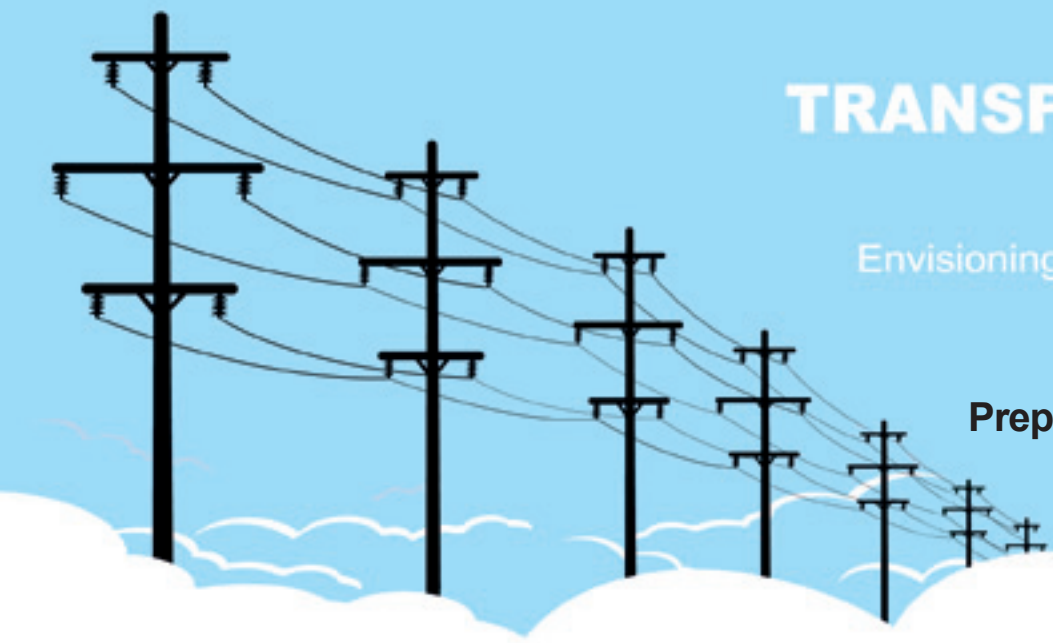
"Camp Atterbury, the Indiana National Guard and Duke Energy have worked together on several mutually beneficial projects over the years," said Col. John Silva, Camp Atterbury's commanding officer. "This proposed project will increase our strategic value and give us the ability to continue our mission-critical operations in the unlikely event of a large grid outage."

A microgrid is a self-contained power system, confined to a small geographic area that has one or more power plants, which are usually relatively small in size. It might also have some means to store energy, such as batteries. Battery storage benefits include shifting energy from lower-usage periods to higher-usage periods, as well as providing more stable grid frequency operation.

Duke Energy is a national leader in energy storage research and development, having deployed approximately 40 megawatts of energy storage capacity, representing 15 national projects demonstrating 10 different grid applications and functions and eight different battery chemistries.

At Camp Atterbury, the battery and solar panels will primarily provide grid benefits to customers in the region. In the unlikely event of a major grid failure, the microgrid could continue serving customer power demand. The storage battery has a capacity of 5 megawatts. The solar installation will generate approximately 2 megawatts.

At the Nabb, Ind., substation, a similar-size battery will be installed near the existing substation. This battery will also be used to provide grid benefits as well as back-up customer power in the event of an outage.



THE GRID TRANSFORMATION FORUM

Envisioning the 21st Century Grid

The Digital Utility: Preparing Today's Utilities for Tomorrow

By Bart Thielbar

While the utility industry has long been a traditional bricks and mortar business, today disruptive digital technologies are driving utilities to go beyond simply providing energy.

Companies are grappling with questions like: What does the modern consumer expect of their utility? How proactive should providers be to get ahead of regulatory changes? What partnerships need to be made with other companies outside of the utility sector for them to thrive?

Traditional utilities are having to reinvent themselves by mastering technologies that include social, mobility, analytics, and cloud to meet current market trends and demands, while also grappling with the growth of renewables such as solar and wind generation and the introduction of large-scale storage.

To delve further into the topic of utilities and digital transformation, we are speaking with Bart Thielbar, who leads the North American utilities practice at Capgemini.

EET&D: *When it comes to the digital transformation of the utility sector, what are the main shifts you're seeing?*

BT: In the old days of the industry, we were all takers of utility services – we received a paper bill in the mail, wrote a check, perhaps dealt with a power outage, and that was the extent of our interaction. Over the past few years, utility consumers are becoming much more active in the relationship with their provider, a shift that will continue in the future.

This is because, on both sides of the North American border, there's been a regulatory and legal push to facilitate innovative approaches to the provisioning and distribution of energy. The push is rooted in environmental concerns, but another aspect of this change is about enabling better interactions with consumers.

We've now seen utilities respond with solutions to give consumers more access. (For example, customer portals, and near real-time multi-channel, multi-device communication between providers and consumers that are promoting a more empowered consumer.)

In some cases, customers are even becoming active participants – "prosumers" in the generation of power, through rooftop solar or storage devices, which they can feed back into the grid.

The industry is facing a complex challenge: managing a downturn in revenue while meeting the demands of its consumers who are much more technologically conscious than what they were five-to-10 years ago. Digital disruption is helping utilities manage and work through that challenge.

EET&D: *When you mention digital disruption, are there specific disruptive technologies that are shifting utility headwinds?*

BT: On top of solutions like web portals, there's a significant move to mobility in the utility sector. Beyond smartphone apps between consumers and utilities, mobility can be understood in terms of how utilities operate in the field. For example, pushing near real-time information to consumers, field workers, and back office professionals ensures everyone has the same data at the same time.

Another area where we're seeing a lot of disruption is around analytics and increasing business insights into the various workstreams within utilities. Companies will recognize that analytics can enhance financial and operational performance, and will attract industry investment.

Finally, due to rising cost pressure on the operational side, utilities are now looking to move things into the cloud. The cloud helps them reduce cost and increase performance. Many companies have used cloud-based solutions for non-critical systems and will seek to replicate the success for operational and consumer-facing solutions.

EET&D: *How far along are companies in transforming into digital utility services?*

BT: In a recent study conducted with MIT on this topic, it was concluded that only 20 percent of utilities have used digital technology to transform their business. This is problematic, considering the same study found "digital masters" (what we call technology adopters) across industries are on average 26 percent more profitable than their industry peers, and earn nine percent higher revenue from their physical assets.

This research also revealed that 40 percent of utilities are "conservatives," which face the following challenges: how to turn vision into action, implementing a digital culture and nurturing digital skills, developing advanced digital features, and strong digital governance across silos.

At the same time, many utilities have begun to execute and implement digital transformation strategies, including industry leaders such as London Hydro in London, Ontario.

EET&D: *Aside from generally higher consumer consciousness with technology, are there other market forces shaping the future of utilities?*

BT: Overall, North American utilities are seeing flat and sometimes declining growth from consumption of power. This is creating an economic squeeze, which puts more pressure to monetize new revenue streams.

The basic premise is this: now that utilities have a digital gateway to their consumers through smart meters and other technologies, how do they monetize that for other revenue streams?

For example, we see utilities interacting with areas like smart city initiatives, such as smart streetlights. Communities recognize that intelligent devices can make cities safer, and since energy infrastructure enables city services, utilities will be a main player in expanding such devices.

London Hydro is a good example of a company finding new revenue streams. While it can't sell power in the United States, it can leverage the investment it made in its IT platform as part of the Green Button Initiative and merchandize it outside of Canada as a ready-made platform to organizations in need.

EET&D: *You've mentioned ambitious projects that utility companies would like to take on. What else do you think is required to transform utilities into full-fledged services companies?*

BT: Many utilities have systems for accounting, customer service, work management, etc. that are still siloed and are not fully integrated. Each may have a different level of maturity and sophistication, and they do not always effectively communicate with each other. Some utilities are developing a more modern flow of information between the different systems that support utility operation and creating intelligence and analytics that can drive efficiency and optimization.

We also need to see a reinvention of IT platforms to keep utilities more aligned with what consumers are asking of them, through the channel they want their data to be consumed. Not everyone wants to be all mobile or physical paper, so utilities must be nimble and adaptable. While doing so, they must reduce their cost footprint.

Finally, a utility's ability to play "behind-the-meter" within the home can be constrained by regulatory rules in their operating jurisdictions. In those jurisdictions, changes to the rules will be required to enable utilities to provide different types of services to their consumers.

EET&D: *What type of regulatory framework do you think would be beneficial?*

BT: It varies by geography and regulatory environment, but generally speaking, utilities are often rewarded based on their investments. For example, investments in centralized generation, whether that be in large coal or gas fire plants. In the future, investment in newer technologies needs to be able to compete on an even playing field with other market participants. In some cases, the regulatory construct prevents them from fully participating in behind-the-meter opportunities, or in emerging areas like large-scale storage, so we need to see rules evolve to create a fair playing field for utilities

EET&D: *What's trending in terms of the organizations that can cannibalize the utilities business?*

BT: A good example would be storage. Right now, we're seeing investments in the newer mass storage technologies. One of the issues with renewable energies is it's not as predictable as a coal fire plant, which is why storage is important for times when the wind isn't blowing or the sun isn't shining.

Much of the investment in storage is coming from outside the market, and utilities are not moving as aggressively on this front. Some of it is the risk-averse nature of utilities, and some of it is constrained by regulations where they don't have an adequate, risk-adjusted avenue to make that investment. Storage is an area where clarity on the regulatory front and the risk portfolio associated with it could be useful to help utilities.

EET&D: *Earlier you mentioned the possibility of utilities moving into the smart city initiatives. Can you give examples of a partnership that you're looking forward to seeing developed in the next era of digital utilities?*

BT: There are opportunities developing that utilities haven't even dreamed about and that are just starting to find their way into the conversation. A simple example is home security and home monitoring. For illustration, consider an elderly person who lives on his/her own and follows routine energy consumption patterns (starting every morning with getting up at the same time, turning on the lights, making a pot of coffee, and going about their day). With a smart meter and the right analytics, utilities could easily message loved ones indicating to them everything is normal. But if the elderly person fell in the night, her energy consumption pattern would be unusual, which could trigger an alert that something is wrong. These types of scenarios create meaningful opportunities for utilities to develop closer relationships with their consumers and provide value-added service. Several years ago, utilities couldn't have even considered being in the "elder care" business, but it is a real possibility today.

Alternatively, these analytics can be relevant in a commercial setting. With intelligence and diagnostics, utilities and their commercial customers can understand if a compressor is running abnormally or not running at all. By dissecting the energy usage, we can uncover information that can be relevant to a variety of consumers and providers to optimize the whole experience.

Overall, there are profound safety benefits that utilities can offer. I'm looking forward to the next era of digital utilities when these are available to everyday consumers.

About the author

Bart Thielbar is a vice president and the North American utilities practice lead at Capgemini, one of the world's foremost providers of consulting, technology and outsourcing services. A utilities industry veteran and former COO of utilities IT advisory firm TMG Consulting, Thielbar leads go-to-market activities and client delivery at Capgemini. Thielbar has more than 25 years of operational and delivery experience. He has led advisory and technology engagements with many of the largest utilities in North America and has worked with many software and technology providers. Thielbar's prior experience includes serving as a senior vice president at Five Point Partners and as president of Itility Solutions, both utility strategy, research and technology advisory firms. He has extensive industry experience, having served previously as CIO for a combination gas and electric utility serving the Midwest and Northwest. He also served as co-chair of the Edison Electric Institute's and American Gas Association's Technology Advisory Council.

GREEN OVATIONS

Innovations in Green Technologies

Smart Homes: What You Haven't Thought Of

By Erik Drost

Homeowners are beginning to expect their homes to be connected and are turning to builders and electricians to add intelligence. To deliver a truly "smart home" to a customer, builders must think ahead during renovations and new builds, adding smart home hubs and intelligent devices that communicate over the same protocol as the hub.
Before a builder can deliver on the smart home demand, it's important to understand the components, benefits and risks involved with these connected homes.

What Makes a Home Smart?

The internet of things (IoT) is here: Smart technologies that help make our home's appliances and core functions like lighting more convenient and increase security and energy efficiency. Take almost any device and add embedded intelligence, and that device can be a part of the internet of things.

Devices that were once "dumb" are becoming "smart." A refrigerator is no longer just for keeping food fresh but also is helping homeowners keep track of their grocery lists by providing a live view of the fridge's interior to a smartphone. Lights, door locks, security systems and more can be accessed, adjusted, opened or closed and turned on or off with a few taps of a device. Even washers and dryers are becoming smart, with embedded Wi-Fi that allows homeowners to monitor the wash or dry cycles and know immediately when it's time to change the load.

These devices are just part of what makes a home smart. For a home to truly be considered smart, it not only needs to be connected to the internet with controllable intelligence embedded, but the devices must be networked together. These intelligent devices can then be controlled remotely through a touchpad, tablet, PC or mobile device – inside the home or remotely. With this enhanced technology comes a level of safety, security and convenience that consumers demand. A smart home isn't just a trend – it's becoming a more-cost effective and simpler way to deliver

Already, this growing consumer demand is having a big effect on the way we build and renovate homes. Smart homes collect a great deal of data, are dependent on software and software updates, and as more and more products are added to the smart home market, it's important for builders to know the variance in product quality and capability, how to install and commission systems, and how to educate homeowners or buyers about their options.

What Do Builders Need to Know?

As smart homes become more prevalent and higher in demand, builders and electricians need to consider new practices in terms of smart device installation, troubleshooting and testing. It is important to keep in mind there not any consistent standards governing smart devices, smart hubs or other smart home equipment. Underwriters Laboratory (UL) and other agencies are starting to review, but there are no substantial guidelines at this point; which means that devices might not be designed to the highest standard a consumer might otherwise expect.

Similarly, while no standards govern smart devices, no standards govern the installation or commissioning of these devices either. It is important for builders to find qualified, knowledgeable subcontractors to install the devices and explain the features, benefits and security precautions to homeowners.

To provide the best service and product to homeowners, it is also important that builders educate themselves on the emerging technologies and products in this space. Whether as a direct or third-party offering, homeowners are expecting builders to be prepared to answer questions about and provide options for smart home installations. By working with product manufacturers, distributors and subcontractors familiar with smart home products, builders can create a network of experts to keep themselves and their customers at the forefront of smart home technology.

What to Consider Once Installation is Complete

Commissioning is the most obvious step once the physical product installation is complete. Particularly in new home builds or major renovations, it is important to look for hub products that allow for commissioning without an internet connection – otherwise, the homeowner would need to set up internet service before the devices can be fully commissioned and tested.

Educating the homeowner is key here as well. As smart devices proliferate homes, it is important to understand the cybersecurity aspects involving the installed devices. Can the system be hacked? How secure is the internet connection? Input from a builder or subcontractor on topics like password protection and the importance of multi-factor authentication can help reinforce key security steps to the homeowner to help avoid these cybersecurity risks.

Once all the devices are installed, other protections can be considered as well. The average home has approximately $15,000 worth of sensitive electronics and appliances. It only takes one electrical surge to do irreparable damage to those devices. As more and more smart – and expensive – devices are added to homes, builders and electricians need to educate homeowners on protecting this equipment through two-stage surge protection.

Though most homeowners use surge protection strips at the point of use to protect expensive electronics like computers and televisions, sometimes it's not enough. And many appliances and personal devices – from smartphones to smart fridges – go without any protection at all. Two-stage protection gives homeowners peace of mind in knowing that their valued electronics are protected from electrical surges.

Stage One: Stage one protection is at the breaker box, rather than the point of use. In the case of an electrical surge, this stage can reduce surges to an acceptable level for surge strips and receptacles to handle.

Stage Two: Stage two protection is on the actual device, providing additional peace of mind for pricey electronics.

Surge protection can also be an important consideration in the event of severe weather. During a storm, lightning strikes that hit power lines or utilities can cause electrical surges. If the storm is severe enough to knock the power out, momentary surges during outages or as the power comes back on can also be damaging to sensitive electronics. Unplugging appliances – even though the power is out – can prevent surge damage, but surge protection is more reliable in case you cannot get to the appliances to unplug them, for example, if you have evacuated or parts of your home are flooded.

As the investment in smart technology within the home goes up, it's important for homeowners and builders to understand and consider investment in surge protection options as well.

What are the Hub Communication Options?

Currently, there are four major protocols positioned for consumer adoption within the smart home space ZigBee, Wi-Fi, Bluetooth and Z-wave.

ZigBee: This wireless technology is intended for low-cost, battery-operated devices and can have battery life lasting several years.

Z-wave: This is a wireless protocol intended for home automation use and performs well with larger networks of devices.

Wi-Fi: The most widely known protocol associated with smart homes, Wi-Fi is typically the leading choice for cameras and data-intensive devices.

Bluetooth: This is used for low energy and small point solutions.

About the Author

Erik Drost is a product manager with Eaton's Residential Wiring Devices Division in Pittsburgh, Pennsylvania. With more than17 years of business experience, Drost currently specializes in residential surge protective devices. In addition, he has extended experience with telecommunications, networking and wireless routing.

From Research to Action

Innovation in Electrification: Energy Management Circuit Breakers

By Tom Reddoch and John Halliwell

As part of a collaborative R&D project with utilities, EPRI and Eaton are testing Eaton's new circuit breaker, which is designed to improve utility service reliability through monitoring and control of consumer loads – and to provide customers information on their electricity use patterns. EPRI is testing and evaluating the impact of Eaton's energy management circuit breaker (EMCB) in the field and will provide testing data to the 12 participating utilities. Research results are expected to be useful in helping participants better understand how to manage power demand. The device offers the potential to integrate new energy sources such as solar and battery energy storage with the grid while enabling residential customers to manage their energy use.

With its ease of use and accurate circuit load monitoring, the EMCB can be instrumental in measuring and verifying activities, including any substitution of electrified loads such as energy efficiency and customer-owned generation. Studies are needed to verify its effective performance, especially with respect to its role in any efficient electrification strategy.

Two versions of EMCB are operating: 1) a standard version, suitable for conventional loads, and 2) an electric vehicle (EV)-compatible version, suitable for monitoring and controlling the charging of plug-in EVs. It's expected that EMCBs will support the effective integration of EVs as an electrification technology option.

"The EMCB technology puts some of the benefits of a smart, integrated grid in the hands of homeowners, and could transform the way consumers interact with electricity," said Arshad Mansoor, EPRI senior vice president for research and development. "This field test also provides a real-time, in-home assessment of how the EMCB can improve utility service and optimize the grid by supporting demand response, distributed energy resources, solar installation monitoring, energy storage, and energy management."

The EMCB combines circuit breaker protection in the customer's load center, with Internet connectivity and on-board intelligence. It can make residential and commercial circuits "smart" and provide energy use information for on-site energy management. Existing electrical panels can be retrofitted with ECMBs, requiring no additional hardware.

In EPRI's EMCB field test 12 utilities installed them in approximately 500 residences and businesses across the country. As of early August 2017, 373 EMCBs had been shipped, and 216 were active in the field. Participating utilities are American Electric Power, CenterPoint Energy, Dairyland Power Cooperative, Duke Energy, Exelon subsidiaries ComEd, PECO, and Pepco, Nebraska Public Power District, Seattle City Light, Southern Company, and Tri-State Generation and Transmission Association, Inc.

With the first phase scheduled to end in late summer of 2018, EPRI is looking to expand the project in a second phase in which current participants can continue their field activities and additional utilities can join the project. Phase I has identified new applications that can be expanded into full-scale projects in their own right, and potential pilot programs can be identified. Feld deployments of EMCBs can use an experimental design that provides data sufficient to expand into pilot programs.

For more information, contact EPRI's Tom Reddoch (*treddoch@epri.com*) or John Halliwell (*jhalliwell@epri.com*).

About the authors

Dr. Thomas (Tom) Reddoch is a senior technical executive at the Electric Power Research Institute (EPRI) in the Power Delivery and Utilization sector. His areas of responsibility include EPRI's consumer-based activities known as utility customer-facing programs. Over the past four years, he has a led an initiative on education and training for developing the next generation of electric power engineers by working with universities and utilities through a Department of Energy grant. Before joining EPRI in 2007, Dr. Reddoch had a 30-year career specializing in the development and deployment of new methodology and technology. He served as an executive officer at several early-stage and developmental technology companies. Prior to that, he was co-founder and executive vice president of Electrotek Concepts, Inc. Dr. Reddoch received a bachelor's degree in electrical engineering and a master's of engineering science degree from Lamar University in Beaumont, Texas. He holds a doctorate in electrical engineering from Louisiana State University in Baton Rouge.

John Halliwell is a technical executive at the Electric Power Research Institute (EPRI) in the Electric Transportation Group of the Power Delivery and Utilization Sector. Halliwell's primary focus is smart charging development for plug-in electric vehicles. His other research activities focus on improving the efficiency of power supply systems, solid-state lighting, and seeking new ways to deliver power to products and systems that optimize energy use. Halliwell has broad experience in design and application of electronic circuits and electronic systems in instrumentation, controls, embedded systems, and power supplies. Before joining EPRI, he worked at AGT, where he was responsible for the design of high-voltage power supplies for atmospheric plasma systems, instrumentation of experimental systems, and project oversight. His previous employers include Vacuum Technology, Incorporated, working in residual gas analysis and industrial leak testing; the Oak Ridge National Laboratory (ORNL), working in electronics design and systems integration; and EG&G Energy Measurements, working in test instrumentation development.

Distributed Battery Energy Storage Intro to Battery DR and How Baselining Techniques Can Fail

Part 1 of a two-part series taking a closer look at existing efforts to solve Battery DR Challenges and areas where more attention is needed.

By Sean Morash

In a recent pilot project, utilizing commercial and industrial customers' stationary energy storage battery resources, the performance of large capacity battery storage systems, as they responded to demand response signals from a utility, was measured, analyzed and verified. The monitoring was done with high-quality sensors in addition to the meter information provided by both the utility and battery system. Energy storage systems introduce a host of benefits for the electricity grid, but the behavior of these devices alter the landscape, as soon as the devices are in place and their behavior must be properly modeled in order to maximize their effectiveness.

In many ways, the project was a glimpse into the utility of the future, as utilities will increasingly rely upon distributed energy resources to meet customer expectations. The energy industry is anticipating a shift in operations as distributed (physically located near an end user) battery systems open new markets and more efficient operations in a world where rooftop solar generation is more common. Energy storage systems, batteries, in this case, have capabilities and applications for a variety of grid services that mostly utilize very basic economic theories: Buy and store energy when it's most available and less expensive, then sell energy back when it's scarce and more expensive.

This idea is that energy is more valuable at certain times, but energy storage batteries also have potentially valuable applications in the near-term. Both customers and utilities are interested in lowering their peak demand (the highest amount of energy consumed within a given timeframe) as these peaks require the most generation capacity; that marginal capacity often represents the most expensive or highest greenhouse gas emitting electricity generation. The reserve storage capacity of batteries placed at customer sites enables customers to reduce electricity demand and lower any demand charges on their bill. Utilities also have an interest in these customer-sited batteries as their performance impacts utility operation and the stability of the grid.

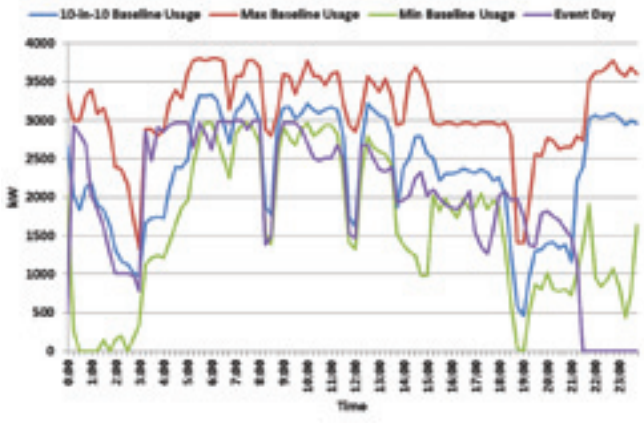
Energy storage devices find their value in providing a local source for both increasing demand and decreasing system demand by surgically providing capacity/energy. The systems tasked with maintaining the balance of electricity supply and demand must take into account the activities of a swath of energy consumers located in different areas. It's a complicated task often run by balancing authorities like Independent System Operators (ISOs) and Regional Transmission Operators (RTOs), which have day-ahead markets as well as real-time markets with "ancillary services" working to balance supply, demand and voltage frequency within the four-second timeframe.

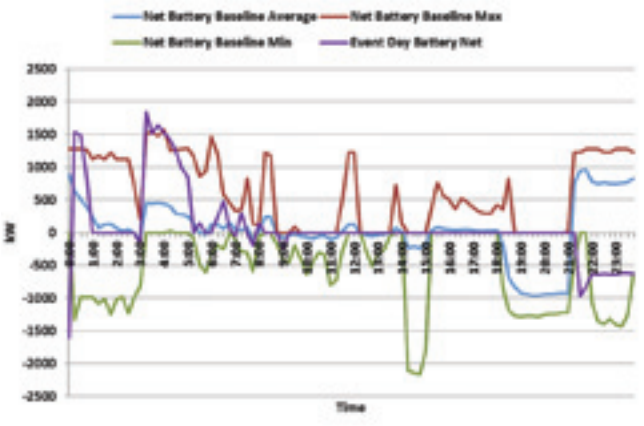
The California ISO (CAISO) has set up rules to allow non-generating resources (batteries) to provide ancillary services. On the surface, energy storage (and the services it provides) can be naturally incorporated into the existing wholesale electricity markets, but their inclusion is still predicated on accurate and timely performance in response to dispatch signals. Imagine asking the battery to discharge, but it is already fully discharged. If that were the case, then this "reliability" resource wouldn't be very reliable.

Not only must batteries perform the requested action when dispatched, they must be precise in the amount provided. If the device does not meet the dispatch instructions from the utility or balancing authority, the energy storage system creates a situation where another resource is needed to compensate in order to maintain the balance between supply and demand. There are a variety of ways that a battery system can deviate from the desired performance with the two basic situations:

- Overperformance: Discharging/exporting more than requested (providing too many kW) or charging/importing more than requested (absorbing too many kW)
- Underperformance: Discharging less than requested (not providing enough kW) or charging less than requested (absorbing too little kW)

This is a fairly straightforward problem when we have sufficient metering in place – simply penalize the battery for not performing as requested. However, the problem gets immensely more complicated when the battery is placed behind the meter and the utility must attempt to filter through the noise of the other customer loads that are measured by the utility meter. Take a look at the two graphs shown from the pilot project. The first graph shows the utility meter load. The second shows the battery import and export of power.





There is some significant noise in these charts related to "baselines." The baselines used for this project were known as 10-in-10, an average 15-minute usage from the past 10 non-holiday workdays. These charts also display the maximum the maximum usage across that 10-day baseline period (Max baseline usage) and minimum usage in the same period. "Event day" is the day in which the DR event was called.

With such a large facility load, it's tough to extract the battery performance from the normal load. This is not a new problem to batteries; it's been a known problem with demand response programs. How do we quantify performance with such a squishy asset with so many things going on?

The baselining technique that was employed in the pilot project is the most common. There are other variations, including those that the California Baseline Accuracy Working Group recently submitted, but each amount to trying to predict what would have happened in the absence of a demand response event based on historical information. What if production begins late one day? What if the company deploys new, more efficient computers or electric vehicle charging stations? There is a ton of noise.

Any new technology application takes time to refine and distributed energy storage is no different. The study referenced above observed a variety of behaviors and nuances that deviated from the anticipated and desired response of the battery storage system's demand response performance. The ability of a battery storage system to respond with precision to utility or balancing authority dispatch instructions will be refined over time. However, measuring the performance with a classic demand response baseline approach may prove inadequate for the variety of battery energy storage applications.

Batteries hold tremendous value across a variety of applications, but there are still quantification and compensation problems to solve before we start mass deployment. These baselining problems are acute to batteries placed behind customer meters, but part two of this series will focus on problems that can arise from a lack of foresight or sufficient understanding of the system needs.

About the author

Sean Morash excels in creating simple solutions of complex electricity sector themes based on a working knowledge of grid modernization related technologies and policies. He is a consultant at EnerNex, where he works across a variety of projects, including helping clients to assess the value of next-generation demand response technologies aiming to capture multiple simultaneous value streams.

Replacing Aging Transformers with Customized, Drop-in Units

By Alan Ober

As power transformers at generation facilities near end-of-life cycles, a number of potentially dangerous events can come into play – in addition to untimely power outages and costly repairs.

Because many transformers are exposed to dust and high operating temperatures, over time they incur such problems as clogged air inlets, clogged cooling ducts, and deterioration of winding insulation, all of which can degrade capacity. If a transformer is operating under such conditions - particularly operating at or above its rated load - unexpected outages can occur.

Among the more catastrophic of those events are explosions, fires and meltdowns that result in immediate outages, plus, the risk of worker safety, fines, security lapses and community ire. Occasionally, such events occur because of failure of the transformer lightning arrester, or an inadequate fire protection system.

More often, problems due to end of life cycles for high-voltage transformers stem from transient overvoltage switching surges or surges due to degraded insulation of coil windings.

Insulation breakdown often results due to high heat, which is one of the biggest enemies of power transformers, as well as overvoltage and high current loads above the rated values. Over a 20-year period, insulation can deteriorate to the point where the coil windings are exposed to moisture, dust - which leads to tracking, flashover-to-ground of the winding turns and resulting short circuits.

Photo Credit: ELSCO

Such was the case at Avista Corporation's Kettle Falls Generating Station in northeastern Washington State. Built in 1983, the Kettle Falls plant was the first utility-owned electric generating station of its kind in the U.S. constructed for the sole purpose of producing electricity from wood waste, or biomass, making it a major contributor to Avista becoming one of the greenest utilities in the country.

The Kettle Falls 60 MW (megawatt) station utilizes a variety of wet-type transformers for its power transmission functions but also uses four dry-type transformers inside their plants to run motors for pumps, evaporators, pollution control systems, and clean air filtration systems.

It is these four transformers, enclosed in a dedicated room with switchgear, that came into question in 2015 during the station's annual preventive maintenance outage. The insulation of the four transformers, each of them 35 years old, had already deteriorated to a concerning degree.

The power station decided to replace two of the units immediately, and replace the other two in the next year.

Tailoring a Neat Fit

The Kettle Falls station team worked with a Cincinnati-based electric service company to design and build the replacement units as well as provide for any modifications that could enhance service life or performance.

Photo Credit: ELSCO

Tailoring the new transformer to fit the existing space not only facilitated successful installation but also ensured that the new transformer would integrate directly with existing switchgear.

Nathan Sarber, general foreman of the Kettle Falls facility, explains that not only was matching a tight transformer footprint a challenge, but also getting the replacement units in place was a strenuous task. "These are 10,000-lb. transformers that are located in a room inside of a building, so we had to make sure we would be able to stay within our current footprint, installation and connection requirements," he said.

Sarber worked directly with the manufacturer to ensure that the dimensions of the new units would not only meet the existing transformer specs but would also facilitate the installation requirements of fitting through the transformer room and having compatibility with the existing switchgear connections.

"Using this process we were able to match up exactly the measurements for the dimensions of where our bus connects onto our low voltage control center, so we were able to basically replicate the original connections from the new transformer," Sarber said. "As a result, the footprint stayed exactly the same as it was with the original equipment. This was important because we didn't have any room to spare."

Although the new units were dimensionally identical to the original ones, the Kettle Falls utility also received upgrades for all four replacements. Instead of installing aluminum windings and connections, the manufacturer suggested that copper be used.

"Copper provides greater conductivity and longevity, with fewer chances of poor electrical connections," Sarber said. "Also, in the old days, they used to manufacture transformers that were somewhat overdesigned in terms of capacity and durability. Today, with tighter profit margins, if you want a 1500 kVA transformer, that's exactly what you will get. You won't have the ability to overload it without the risk of a breakdown. So, now the quality of transformers is especially important – including windings and connections."

Photo Credit: ELSCO

Upgrading the Solution

The Kettle Falls station engineers also upgraded the new transformer enclosures. The old enclosures had inlets and outlets that were basically wide open near the top and bottom of each unit, except for arc-flash screening. There was the potential that if a transformer would fail and go through a meltdown, the aluminum or copper of the windings could be thrown or splatter onto nearby equipment or personnel.

The enclosures were upgraded to NEMA Type- 2 indoor specifications that feature drip-proof ventilation louvers instead of slots, which would prevent any dripping water from entering the transformer. Also, if an arc flash or meltdown were to occur, any molten aluminum or copper would be directed downward, providing a measure of added safety for personnel and surrounding equipment.

This project of replacing four aging transformers with new, drop-in units was a first for the plant. However, due to the lower cost and overall ease of the process, Saber intends to continue replacing aging transformers at the Kettle Falls Power Generation Station in this manner.

Photo Credit: ELSCO

About the Author

Alan Ober is vice president, engineering and manufacturing at transformer manufacturer and service provider ELSCO (Cincinnati, OH). Founded in 1912 by former Westinghouse engineers, ELSCO specializes in providing quality new, repaired and rebuilt transformers ratings range from 500 through 3750 kVA in 2.5, 5 and 15kV primary voltages, including both liquid-filled and dry-type models.

On Load Tap Changer Condition Assessment Using Dynamic Recording and Measurement (DRM)

By Raka Levi

Abstract

Managing On Load Tap Changer (OLTC) fleet depends on the assessment of their condition. In addition to the insulation condition, dynamic performance characteristic is the most important factor defining suitability for operation. The Dynamic Recording and Measurement (DRM) is a new off-line test technique showing its diagnostic power in detecting OLTC operational problems. A graph of a test current is analyzed where mechanical motion issues and contact bouncing, coking or wear is detected. Multiple tap changers on the same drive can be checked for synchronization in operation. Such insightful tests have not been possible prior to this new tool.

Introduction

The asset manager's task is to define the suitability of each apparatus for normal operation and review the risk of putting a compromised asset, such as a transformer in service. The only moving part in a power transformer, the On Load Tap Changer is one of the main contributors to the failure rates of high voltage power transformers. The OLTC principle was patented in 1927 by Dr. Bernhard Jansen and its premise was very simple: "make before break", or connect with the next tap before breaking with the previous one. This is still true today, and tap changers are designed following this approach. As this is a tap changer that operates under a transformer full load condition, the circuit should never be broken. Thus, opening the circuit is one of the biggest OLTC problems. It creates gases and can cause transformer tripping or even a failure. Detecting this was impossible using old-fashioned static measurement techniques, as the process of transition lasts only a fraction of a second.

The AMforum association has created a working group to investigate and standardize the methodology, and some cases collected over the years are presented here. The IEEE transformer committee, through the performance characteristics subcommittee, just created a task force to standardize this method. The IEC and IEEE are coming out with a joint OLTC user guide including this test.

OLTC

A utility population of tap changers may contain many different designs and principles of OLTC operation. They can be in the tank or in a separate compartment attached to the tank. They can use reactors (preventive autotransformer - PA) or resistors in their operation to lower the circulating current during the transition. The switching can be in oil or contained in the vacuum bottles. For high currents, a booster or a series transformer may be added to lower the current while increasing the voltage the OLTC deals with. The current switching and selection of taps can be performed using the same pair of contacts (arcing tap switch), or using two sets of contacts (a selector, and a separate transfer or diverter switch). Then, two or three tap changers can operate on the same mechanism in one transformer and their synchronization needs to be verified. Many variations require the knowledge of exact tap changer type in order to analyze test results.

Reactor OLTC

The reactor type tap changers are predominant in the USA networks, while European tap changers use resistors for circulating current limitation during the tap transition. These reactor OLTC constructions rely on Preventive Autotransformers (PA) to limit this current and provide double the number of tap positions, compared with resistor ones, for the same number of taps brought-out from the regulating winding. The PA is a gapped core reactor with dual windings, wound in opposite directions; in fact an additional small transformer inside the main transformer tank. As the PA does not permit the current to circulate, a bridging position is allowed with reactor OLTC indefinitely.

Test Methods for OLTC Condition Assessment

Various tools exist where OLTC can be visually observed or scanned using thermography. Dissolved gas can be used as a tool to find a problem with excessive heating or arcing. These tests can indicate the existence of a problem. The turns ratio can be measured on each tap, and winding resistance for all taps test results should be consistent. Vibration methods look into signatures collected using vibro-acoustic sensors or accelerometers. Monitoring various on-line parameters can provide an indication of torque, mechanical issues, overcurrent, overheating, etc. The possibility for the test crew to see the problem off-line, if any with OLTC operation was, based in the past on flicker in the test voltage, or induced voltage when performing some AC tests, like turns ratio while operating the tap changer. Many times OLTC was open on these indications and nothing unusual could be observed.

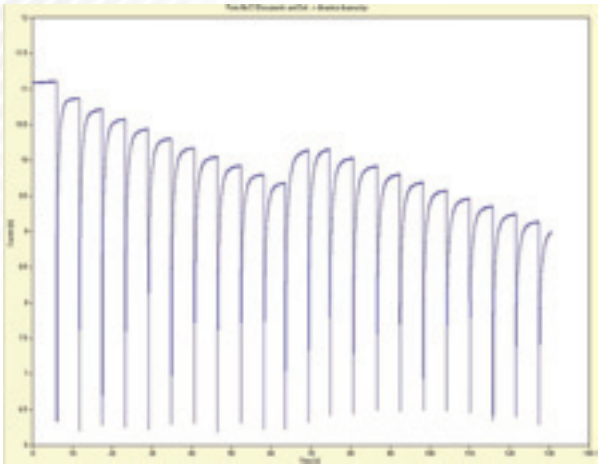


Figure 1. Graph of a good resistor type OLTC

The Dynamic Recording and Measurement

With modern electronics, the recording of a test current at high frequency allowed us to see the performance of an OLTC at high speed, providing asset managers the important information of its mechanical motion, and contact bouncing, opening, coking etc. The same test set can measure traditional contact resistance as well, plus demagnetize a core which was magnetized by the DC current applied during this test or other magnetization causes. The DRM methodology is only 10- to 15 years old, but it has shown a great potential in detecting problems otherwise invisible to repair technicians. The benefit of this method is the simplicity of analysis - it does not require great experience when viewing the graph. When the applied DC test current is stable, it creates a straight horizontal line on a time graph. Any increase in resistance or reactance makes the current drop, visible as a dip on the graph. Any resistance drop makes the current jump, as with lowering the number of turns the current will go up. A good tap changer makes the graph very smooth and any discrepancy indicates a problem. **Figure 1** shows a good DRM graph of a resistor tap changer. **Figure 2** is a graph of a brand new reactor tap changer. These graphs provide benchmarks, so when the tap changer is new, a fingerprint of its operation should serve as a base for comparison during the maintenance periods.

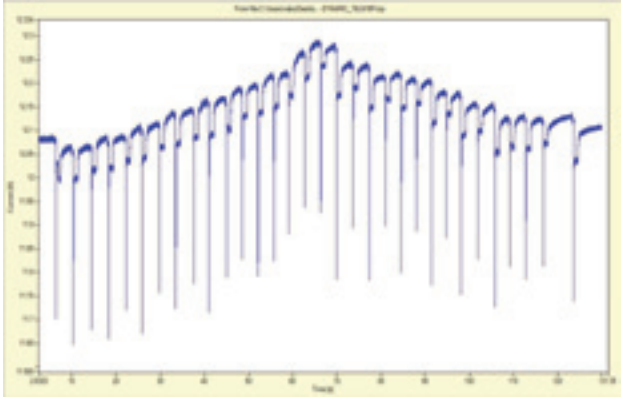


Figure 2. Graph of a good reactor type OLTC

The DRM test lead connection is identical to the transformer winding resistance measurement, and the instrument is usually the same. In fact, both can be obtained in the same process; the first one sometimes called static resistance, as opposed to this "dynamic resistance" graph.

Each tap changer transition during this DRM test creates a "dip" in the current graph. These dips are called ripples and we analyze values and shapes of the ripple for each transition. The ripple value is expressed in percentages, and they all should be consistent. A ripple value of 100 percent, or close to that, is an indication of the circuit opening, and as we said before, this is not acceptable for normal OLTC operation. For resistor type tap changers ripples are very consistent, while for the reactor types, ripples alternate – longer and shorter, for bridging and non-bridging position transitions.

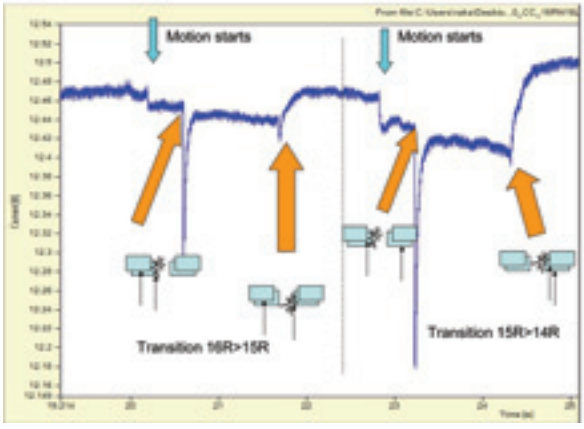


Figure 3. Key features of a reactance graph –two transitions shown

The current trace in the graph of **Figure 3** shows the key points of a good GE type LRT200 tap changer operation. Events are identified by these sudden current changes. Six key feature points are visible in this graph that represents two transitions of OLTC: from non-bridging to bridging, and then from bridging to non-bridging positions (in this example: from 16R to 15R, then 15R to 14R).

Synchronization

Multiple OLTC operation coordination needs to be checked, and the synchronization mode is used – where all three phases are tested together. When located in the delta winding, tap changers at higher voltages need to be isolated from each other. Thus, two or even three separate tap changers are operated from the same motor and mechanical drive. The connection for YN configuration is with three parallel phases, where for Delta winding, they are tested two by two. **Figure 4** shows a synchronization graph of a YN configuration, where one phase is leading the other two by a significant 100msec difference. While this difference is not crucial, any change and increase over time may indicate a deterioration of the mechanical gear connection, and potential failure in the future.

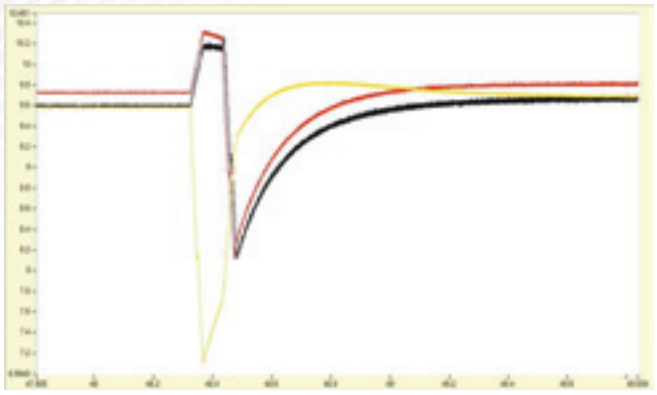


Figure 4. Graph of a three-phase synchronization test

Cases

Simple problems, which may lead to a major failure if detected early, can save a lot of problems and money for the operator, finding the defect early and requiring an easy fix to rectify it. The AMforum is a European association of asset managers in electric utilities. We have looked into this test method at our previous meetings and decided to form a working group to define the procedure and standard method of evaluating test results. The group collected a large number of test graphs from all over the world with the focus on the USA and some interesting cases are shown here.

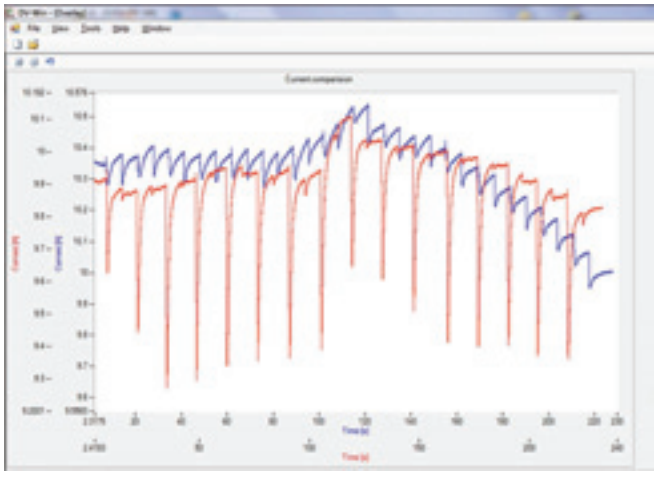


Figure 5. Overlay of two test graphs, good and bad

On Load Tap Changer model 546 manufactured by Federal Pacific Electric is an older type and prone to various problems. This particular one exhibited a significant difference in the ripple value for the phases X2 compared to X1 and X3. **Figure 5** shows an overlay of two graphs – phase X2 shown in red and X1 in blue.

This difference was significant enough to prompt a corrective action including draining the oil and opening the OLTC tank. Upon investigation, it was found that the bolt for the feed on phase X2 from the transformer to the collector ring had vibrated loose. The maintenance personnel cleaned and retightened the bolt. Once the transformer was repaired and ready for service a retest was performed to verify that corrective action was successful. Ripple values were normal and compared favorably with the other two phases. This simple and timely correction saved a major problem that could have developed if the bolt was left loose, creating overheating and arcing.

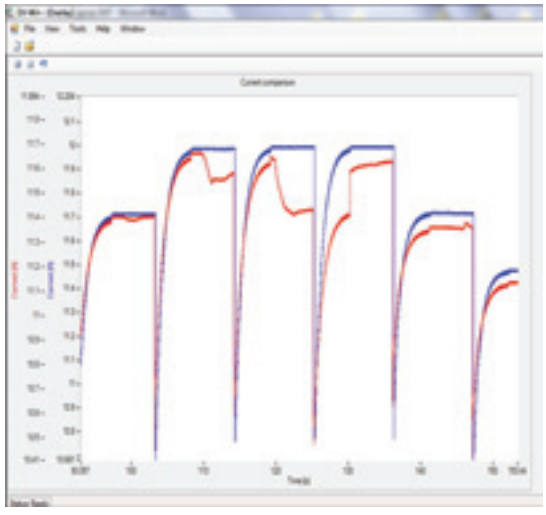


Figure 6. Overlay of two graphs, good and bad

One diagnostic tool, the DGA, indicated an increased concentration of gasses in a VRC type tap changer. Finding a source of this would have been impossible without the dynamic record. Here a reversal switch connection was found loose. **Figure 6** shows a correlation of two phases, the good one in blue and bad one in red. It is clearly visible that the red current trace is not a straight line during the stable period of tap changer idling at the neutral position. The wiggly trace is pointing to a bad contact or connection, in this case, the K (+/-) contact. The photo in **Figure 7** shows the exact position of the loose bolt that was tightened very easily using the manhole at the selector.

Figure 7. View of the selector through the manhole, loose bolt indicated

The graph in **Figure 8** proves an important point that the procedure has to be followed exactly. The two traces were recorded when a reactor type tap changer was switching from one position to the next, first in one direction and then in the other direction. It is almost a mirror image of the transitions. For that reason a standardized procedure should be defined: Perform the test always in the same direction – either from 16L to 16R, or opposite. Even better, if the tests were performed in both directions, the various switches are investigated in their action regardless of the tap changer direction.

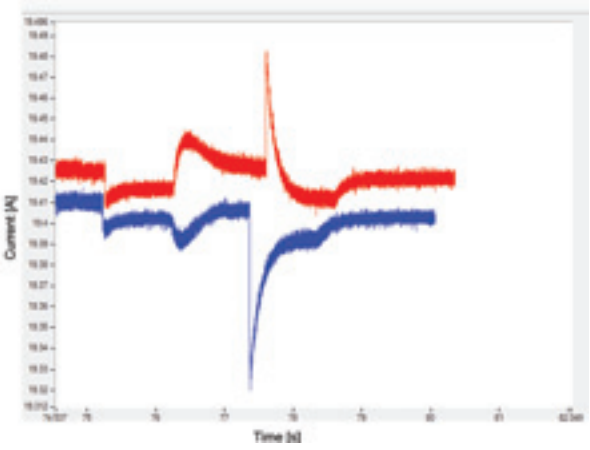


Figure 8. Two transitions recorded in opposite directions

Conclusion

Asset managers now have a new tool to investigate dynamic performance of an OLTC. It provides a direct assessment of its condition and suitability to perform its intended function, and that is to allow transformer regulation to operate uninterrupted in a full load condition. Dynamic Recording and Measurement gives a very simple graph to evaluate and indicates any troublesome component in the complex moving mechanism such as an OLTC. The benefit is defining exactly which component is defective, so an early spare part request can be made before the repair. This test can be done with oil still in the OLTC compartment, thereby reducing manpower and out of service hours, or it can be done on a drained compartment. This reduces costs of inspections for the asset management and maintenance teams. Mechanism defects or maladjustments were detected; contact bouncing and coking were found. Spring breaking, transfer switch loosening, loose bolts and circuit opening are some of the problems detected. More importantly, the result analysis defines which phase and which switches were defective. The beauty of the method is the ease at which analysis is visually performed, and no high expertise is required to observe a problem when evaluating the DRM graphs. Asset management can use this on suspect OLTCs, regularly scheduled maintenance, or on new asset acceptance, which provides a footprint for later testing comparisons.

About the author

Dr. Raka Levi is an application expert at DV-Power Sweden and convener of the AMforum association. He has more than 30 years of asset performance and condition assessment experience, specializing in apparatus testing, monitoring, and diagnostics. Levi is a vice chairman of the IEEE Task force for LTC field-testing guide. Seven years ago he started within the AMforum organization a working group on DRM test methodology for tap changers. For 20 years, he has been running committees that assemble asset managers, organizing AMforum conferences in Europe, LTC Universities in the USA, and LTC Colleges in Asia. His education includes a Ph.D. in the field of HV apparatus diagnostics, and an ME in electric power from the RPI, New York.

Guest Editorial

21st Century Smart Asset Lifecycle and Performance Management: Making use of the data

By Brian Bradford

Tremendous transformational capabilities have been wrought in the electric utility industry thanks to the Internet of Things (IoT) and the introduction of distributed energy resources at the edge of the distribution grid. Billions of connected devices and sensors are generating ever-increasing quantities of data, creating increased opportunities for new utility business solutions based on IoT technology.

Smart meters are providing a lot of the new data: A 2016 Edison Foundation study reported that the United States alone has more than 70 million smart meters already installed, with a total of 90 million forecast to be installed by 2020. With the digital information about power usage from smart meters, utilities have—on the customer side—been better able to monitor usage and, based on that data, help consumers conserve energy. And on the grid side, utilities have been able to analyze smart meter data to improve distribution and outage operations.

But smart meters aren't the only devices pouring data back to the utility: there are millions of smart field devices and sensors on the distribution grid as well, including customer-owned distributed energy resources (DER). Integration and analysis of real-time data across all of these devices—much more data than ever available before—is becoming an essential part of today's grid operations.

Each of these smart devices has its own unique requirements for maintenance, inspection, firmware upgrades and security. This presents new issues for utilities as they endeavour to manage the lifecycles of so many new and different assets in a single, manageable, centralized way.

A New Approach to Asset Lifecycle Management

In the past, traditional utility asset management systems handle a relatively limited number of specifications: manufacturer, serial number and maintenance schedule. Smart equipment, however, requires a far greater number of specifications: tables to support configuration compatibility, calibration measurements, firmware versions and patches applied to each device module (for example, metrology or telecommunications), scheduled battery replacements, and audit compliance that can grow to support millions of devices for large utilities.

Field device management has long been a paper-based process. Often, utilities still manually track smart field devices or build a one-off spreadsheet or database to track them, as most traditional asset management systems don't support this field device management function. (Utilities can add this feature by implementing an integrated smart-device management system or incrementally adding functionality with existing smart grid projects such as advanced metering infrastructure and meter data management.) A manual asset tracking process will fail as the edge device footprint continues to grow.

Given the growing numbers of smart devices on utilities' near-term roadmaps, it becomes relatively easy to justify a smart device asset management system that can provide a registry specifically to handle smart devices. Since many of these devices support two-way communication with smart equipment (including the IoT), a smart device management system can be leveraged to support automated processes for firmware updates and configuration changes.

Additionally, the system provides an audit trail for device activity, recording those device-level configurations and related communications. Particularly with respect to connected customer DER, utilities will need a device registry and lifecycle management process and systems to more completely engage customers and fully leverage their grid-connected devices.

To scale up to millions of devices, utilities will need automated information management processes with customers or their contractors to capture key attributes and populate a DER device registry that, in turn, can be used to model the customer connections and grid impacts. When utilities begin offering value-based services involving customer-owned equipment (or allowing third-party providers to do so), a smart device asset management system will no longer be a choice. Instead, it will be an imperative to support the scalable data management processes required for the exponential growth of these sensor-based devices.

Taking a Phased Approach to DER Lifecycle Management

Utilities must rapidly develop new processes to manage DER assets and maintain them over time. The most effective DER lifecycle management process starts with the customer and ensures that they remain engaged throughout the entire lifecycle. Here's how it plays out.

DER lifecycle management begins with customer engagement and enrollment. As the utility identifies customers with DER, it may qualify them for programs with specific prices tailored for customers with DER assets. To manage these procedures, the utility will need an integrated customer information system with a customer engagement solution, as well as a service order management program.

Note that data plays a key role in the six steps to DER lifecycle management, beginning with comprehensive network planning and modelling:

1. Integrate distribution network planning. Utility operators need to perform a comprehensive network planning and modelling exercise to integrate DER assets. It starts with a network model and inventory of assets. Capacity and impact planning on the existing systems with an integrated distribution management system and outage management system enables utilities to perform capacity and impact planning.

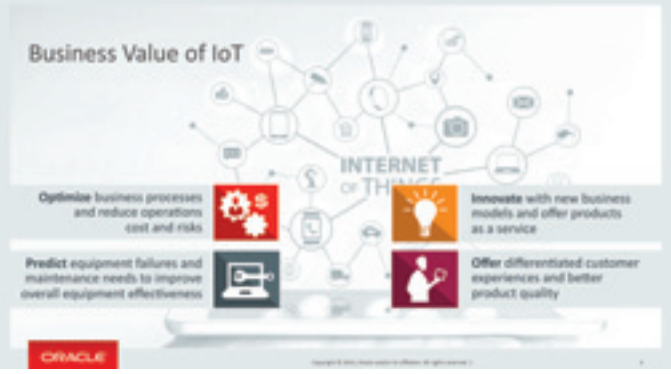
2. Make use of the granular load forecasting and analytics. Grid operators have to account for load models from the customer to the system level. Any reverse feedback on the feeders and circuits can have a negative impact on the distribution system. Utilities are looking for an integrated network model that combines device-level data and advanced analytics to develop a much-improved forecast.

3. Validate customer connection points. Asset registration and connection is an important step to ensure an ongoing record of each DER device. Utility operators need to be able to take care of the whole process associated with asset commissioning and decommissioning.

4. Prepare your asset operations for ongoing DER management and maintenance. Utility operators will need to keep tabs on the health of DER devices, manage configurations and upgrades. An integrated mobile workforce management system with asset management can identify, fix, and restore a DER device much faster. Utilities can offer new services with integrated mobile workforce solutions that constantly track equipment as well as keep the network model up to date.

5. Review your billing systems and settlement processes. Customers need accurate billing based on the granular metering and device data to settle DER consumption. To manage that, utilities need accurate data for settling net metering, critical peak, and time-of-use prices. Customer operations and IT require an integrated view of billing, metering, and customer engagement solutions.

6. Equip your IT operations to support ongoing customer experience. Utilities can improve customer satisfaction when they're able to present unique information tailored for each customer based on their consumption, market participation, rate changes, programs, equipment maintenance and outages. Multi-channel tools are useful to keep customers updated on the channel(s) of their choice about their consumption, or about new programs and events available to them.



Using the Cloud for Asset Performance Management

Asset reliability and performance are core to well-functioning utilities. Historically, work order management, reliability-centric maintenance, asset tracking, advanced analytics, mobile scheduling and operational reporting have been siloed applications. But, with DER adding layers of new complexity that underpin a utility's asset reliability, with pressures coming from regulators and with increased scrutiny on utility cost reduction goals driving the need to extend the life of existing assets, a new, more integrated and comprehensive approach to asset performance management (APM) is needed.

Deploying APM in the cloud has a variety of advantages to utilities under these familiar performance pressures. Cloud deployment delivers immediate value by reducing the cost of ownership. Integrated analytics in the cloud enable utilities to better monitor their assets, find asset failures faster and optimize work and maintenance schedules in real time, allowing for predictive asset maintenance rather than relying on reactive asset management strategies from the past.

As utilities continue to look for more ways to improve operations and cut costs, the cloud infrastructure provides the flexibility to scale up quickly as new assets are added and provides more detailed analytics and deep insights into asset age, health, and performance than were available in traditional asset management processes.

In the end, data analysis and cloud services are providing utilities with better options to handle the incursion of customer-owned DER, monitor and predict asset performance, and decrease costs in the process, all in a scalable way as the edge of the grid continues to grow and change.

ABOUT THE AUTHOR

Brian Bradford is vice president of asset solutions for the Utilities Global Business Unit of Oracle Corporation. Bradford is responsible for the profit and loss of utility operational software applications and delivery. He has more than 20 years of experience in the utility space and joined Oracle from GE, where he was GM of hosted software and analytic solutions. Bradford has an MBA from Harvard Business School and an undergraduate degree in finance from the Wharton School of the University of Pennsylvania.

What Cyber Security Experts Need to Know

The repercussions from 9/11 and continued terrorist threats have put increased pressure on water utilities to secure their physical assets and electronically track anyone that accesses their facilities. Acting under the authority of Congress, the Environmental Protection Agency (EPA) has developed vulnerability assessment guidelines to help water utilities evaluate their susceptibility to potential threats and identify corrective actions needed to reduce risks. Although the EPA is our country's designated water utility enforcement agency, there are no provisions in the water security regulations that give the EPA authority to enforce compliance. Nevertheless, a growing number of water facilities consider security essential to their operations and are giving it precedence.

Taking the Practical Approach to Security

Water utilities, both large and small, are looking for solutions that will allow them to secure their perimeters, track the movements of individuals and prevent unauthorized access to their physical assets. In doing so, they face some unique challenges. Entry gates, well sites, re-pumping stations, chemical feed and other sensitive areas need to be protected. Scheduled water sampling should be electronically documented. Last but not least, utilities are tasked with managing the access of their subcontractors and vendors. Taking a practical, measured approach to sourcing security solutions makes the task more productive and less intimidating.

Will Security Impede Daily Operations?

Water utilities must be progressive in looking at what they perceive to be a security need because security can be considered intrusive--not only by staff--but by those who are maintaining the system. The challenge is to raise overall security without it becoming a barrier. A utility must have clearly defined goals that will support, not impede, daily operations.

There are some things to consider when evaluating a potential access control solution:

- How must employee work processes change in order to accommodate the system?
- What are the recurring costs of maintaining the system? How much time and in-house resources are required for managing the system? What will be the administrative costs to support the system?
- What wiring and structural changes would be required for installing the system?
- How will asbestos containment issues be avoided?
- How will the system electronically secure sensitive areas that have no available power?
- Is there flexibility to expand the system on a limited budget?
- Can the system be easily integrated with other access control solutions?
- Are sufficient funds available to fund the system?

When targeting a "solution" for security, it is easy to get tunnel vision. It is important to keep the big picture in mind and think about how each solution will affect daily operations. The goal is to improve security, not create more problems. In summary, ask: Can we do it? Do we have the people to do it? How many man-hours will it take? Do we have to change the way people currently do things? Will it negatively affect any of our processes?

Gaining Acceptance

No matter how beneficial the security solution might be, if management does not accept the system, it will not be successful. Here are suggestions for gaining acceptance:

- Involve the managers early on, as acceptance from the top will flow down throughout the organization. Managers can help pinpoint specific areas and security concerns. Make them a part of the process and the proposed solution will quickly gain their support.

- Identify departments and processes that will be positively affected by adding security and share this with the managers. After reaching a general consensus, roll out a plan-of-action that includes immediate and long-term security goals.

Keeping It Simple

Utilities need manageable security solutions that allow them to track multiple identities and control access to physical assets spread out over large geographic areas. The task of researching choices may be daunting but well worth the effort. The simplest approach is to:

1. Prioritize identified security weaknesses.
2. Determine those that most urgently need to be addressed.
3. Integrate practical solutions that support day-to-day operations while minimizing risks of sabotage and theft.

Getting Acquainted with Today's Technology

Once a utility has obtained a general consensus of their security needs and established immediate and long-term goals, they can roll out their plan-of-action. It's best to have some knowledge of the different types of systems in today's market so the right questions can be asked as they pertain to a specific utility's requirements.

Multi-location Digital Video for Outdoor Surveillance

Multi-location digital video security systems are a viable option for those that want to set up an efficient outdoor surveillance system. When evaluating video solutions, be aware that the equipment has to stand up to tampering, extreme weather conditions and varying levels of light. As the technology has evolved, visual-light cameras are more compact and are able to produce images under a wider spectrum of light conditions. Thermal imaging cameras in conjunction with analytics and sensors can be used in areas that have no lighting. Live cameras along with an integrated alarm system can be beneficial to utilities that have a security command center that operates 24/7. It can be quickly determined whether an intrusion is non-threatening or something more serious.

Will the Video Files Be Too Big to Handle?

When considering video, note that video files are extremely large and can present challenges to network bandwidth. Bandwidth and file size are closely related to each other. The larger the video image, the larger the bandwidth one needs to transmit the image over a network. When a large number of cameras are installed over a widespread area, compromises usually have to be made in regards to the level of image quality and the number of images reproduced each second. Essentially, digital signals of the images need to be processed and transmitted over the network in a reasonable length of time.

Wireless Video Verification for Securing Areas without Power

Wireless video verification can be considered for utilities that have areas to secure but no available power from which to draw. These systems combine battery-powered cameras, sensors and GPRS radio communication with a central monitoring station. Video verified intrusion alarms are becoming popular, as the costs of CCTV have been declining, making it a practical solution for locally enhanced security.

Are Security Cameras Enough?

For water utilities that do not have personnel monitoring their security 24/7, cameras may not be enough. While cameras may act as a deterrent, they are only one piece of a comprehensive access control solution. Cameras are for observation, not prevention. Cameras cannot control individual access to a facility's physical assets. In most situations, they will not protect a utility from vandalism and theft. Most of all, a video camera system cannot provide the key control and electronic audit reporting water utilities need. The good news is there are key-centric and lock-centric access control solutions available that complement the capabilities of a video camera system.

Key-Centric Solutions

With a key-centric system, the concept of a smart lock is reversed. Key-centric systems interface with software primarily through a smart key that powers the lock. Instead of the processing taking place within the lock, the intelligence is in the key. A key-centric system usually includes smart padlocks, programmable keys and electromechanical lock cylinders. Easy to install, the system uses the lock hardware already at a facility. As no wiring or power is required for installation, a utility's existing mechanical locks can be quickly converted to electronic locks simply by replacing each mechanical lock's cylinder with an electronic cylinder.

Key-centric access solutions are virtually tailor-made for water utilities. A utility can have electronic access control and auditing throughout their facilities regardless of whether or not power is available to the site. They can control who and when someone can open a gate, enter an office, or access sensitive areas. The audit reporting capabilities of this type of system can be valuable when the EPA requests electronic documentation of traffic in an area where there have been security issues.

Lock-Centric Solutions

A lock-centric access solution where the power resides in the lock itself is well-known technology that is commonly seen at the door. There are many on the market from which to choose including smart card, digital keypad, key fob, video entry, biometric door access systems and more. Some require wiring at installation and operate on local power; others are battery-operated. The typical lock-centric solution cannot be expanded to entry gates and areas where wiring is not feasible. Most have full access control capabilities including audit reporting and restricted access.

It's best to assess each product's features and drawbacks before deciding which system best suits your operations. Take note that lock-centric door entry technology will soon offer smartphone integration capabilities.

Biometrics and Dirty Fingers

Biometrics at the door once fascinated "Star Wars" and "James Bond" movie fans. Today, biometrics is considered mainstream, and many of the features of biometrics are scaled-down technology from military systems. Although single door systems that use biometrics are becoming more affordable, large biometric applications can still be impractical because of the cost of replacement hardware and installation. Also, a large amount of memory is required to store biometric templates. Unlike what we see in espionage movies, misreads caused by something as simple as a dirty finger can fool many systems. Keep an eye on this technology as it is evolving rapidly.

Perimeter Protection Solutions

To protect a water utility's perimeters, there are physical security solutions that typically include fence intrusion monitors, photo-beam towers, infrared illumination devices and motion detection towers. Each can be helpful when installed at strategic locations utility-wide. It's important to pre-determine the manpower and equipment required to gain some or all of the benefits of this type of solution. For example, will the system automatically initiate a security response? Will someone have to be actively monitoring the equipment's receivers in order to know that an intrusion event is taking place?

Keep in Mind

The NERC compliance deadline is drawing near. Failure to meet compliance by September 2018 will result in serious fines. NERC CIP is directed towards the safety of Critical Infrastructure Protection. These standards require responsible entities to have minimum-security management controls in place to protect critical cyber assets. Fortunately, key-centric solutions can help meet the following elements of NERC CIP compliance regulations:

- An access control model that **denies access by default**
- Entity shall review or otherwise assess **access logs** for **attempts** at or actual **unauthorized accesses** at least every ninety-calendar days.
- Entity shall document and implement the operational and procedural controls to **manage physical access** at all access points to the physical security **perimeters** twenty-four hours a day, seven days a week.
- Access shall **document** and implement the technical and procedural controls for monitoring physical access at all access points to the physical security **perimeters** 24 hours a day; seven days a week.
- Utilize at least one physical access control to **allow unescorted physical access** into each applicable physical security perimeter **to only those who have authorized unescorted physical access.**
- Where technically feasible, utilize two or more different physical access controls (this does not require two or more different access control systems) to collectively allow unescorted physical access into physical security perimeters to only those individuals who have authorized unescorted physical access.

Summary of How Key-Centric Solutions Can Help

A cost-effective, practical solution that:

- Manages access to protected critical cyber assets
- Denies access by default
- Records physical access attempts
- Manages physical access to facility perimeter(s)
- Controls access for only authorized personnel
- Provides a secondary physical access control solution

Don't Drop the Ball

Implementing an access management solution is just the beginning. Utilities must avoid becoming complacent or assuming "everything is now safe and secure because we have a security system in place." To succeed in meeting NERC CIP regulations, organizations must follow up with education, ongoing training, employee awareness and enforcement.

ABOUT THE AUTHOR

CyberLock, Inc. is a leading supplier of key-centric access control systems. It is part of the Videx family of companies with roots dating back to 2000 when the first CyberLock branded electronic locks and smart keys were introduced to the market.

Videx, Inc, has been designing and manufacturing innovative electronics since the company was founded in Corvallis, Oregon in 1979. In 2013, CyberLock, Inc. was spun off as an independent company but maintains strong ties to Videx. The two companies continue to collaborate on future innovations.

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