20 YEARS

EET&D MAGAZINE

January/February 2018 Issue 1 – Volume 22

DEPLOYING EV FAST CHARGING STATIONS IN ALBERTA

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TURNING 20 YEARS IN 2018

ELISABETH MONAGHAN
Editor in Chief

By the time this issue of *Electric EE T&D* magazine is in the hands of our readers (along with DistribuTECH attendees), 2018 will be in full swing.

With the arrival of this New Year comes *EE T&D* magazine's 20th anniversary. While the official anniversary hits in September, we expect to celebrate this milestone throughout the year. Just in time for the 20th anniversary, we have unveiled a new look for the magazine and the Electric Energy Online website: ***www.electricenergyonline.com***.

As we began mapping out the editorial calendar for 2018, we reviewed the market/application focus areas we covered this past year. We took a look at those topics we wanted to keep, as well as any additional trends or issues we should include. One area we felt we needed to address is women's place in the power sector. Considering that women make up only 24 percent of this industry, this seems like a good time for *EE T&D* to showcase the role they have played and continue to play in moving our industry forward. With this in mind, we have launched our newest column, Powherful Forces, where we spotlight those women whose tenacity, intelligence and leadership have helped shape the industry.

In our first Powherful Forces column, we introduce our readers to Sharon Allan, currently serving as chief innovation officer for SEPA. Allan is one of the six percent of women holding a C-level position in the power sector. In the many years Allan has worked as an engineer in the male-dominant industries of IT and energy, she has witnessed an abundance of transformational change and offers her insights on some of the most notable developments in the utility space.

During 2018, *EE T&D* will continue to cover market/application topics like distributed energy resources, IoT, smart grid workforce management and electric vehicles. New topics on which we will focus include artificial intelligence in the power grid, machine learning/augmented reality and software as a service.

One of the more recent topics to emerge that did not make it into our list of market/application topics is blockchain. It appears blockchain will assume a more prominent role in the industry, but currently, there are a lot of questions about what the technology is and what it can do. With that in mind, I thought it might be helpful to share how Anuj Thakkar, an engineering student at Duke University explained the technology in his paper titled "How Blockchain and Peer-to-Peer Energy Markets Could Make DERs More Attractive".

As Thakkar explains, "A blockchain is a distributed chronological ledger that is hosted, updated, and validated by several peer 'nodes,' rather than by a single centralized authority; by eliminating the central authority and having immutable transaction records that are validated by several peers, the blockchain increases the simplicity, speed, and transparency of transactions between two peers. An example implementation of blockchain is in the cryptocurrency Bitcoin: while typical credit card transactions require validation from a bank and can take time, blockchain doesn't require this central validation, and transactions can happen immediately between two parties."

Writing for "Harvard Business Review," James Basden and Michael Cottrell discuss how utilities are deploying blockchain. According to Basden and Cottrell, "Blockchain has grabbed the attention of the heavily regulated power industry as it braces for an energy revolution in which both utilities and consumers will produce and sell electricity. Blockchain could offer a reliable, low-cost way for financial or operational transactions to be recorded and validated across a distributed network with no central point of authority. As in the financial services industry, this capability has prompted some people to explore whether blockchain may one day replace a portion of utilities' businesses by doing away with the need for intermediaries altogether."

It could be a while before blockchain is a widely adopted technology in the energy industry, or it may take no time to find its way into the mainstream. While we wait, if you or your company has a story about plans for integrating blockchain, or if you already have a case study of successfully implementing the technology, let me know, as I would like to pass along that information to our readers.

In fact, if any of these trends I've listed, or if any of those in our media kit are areas about which you would like to share information with our readers, send me an abstract of your proposed article.

To all of our readers, advertisers, and industry partners, thank you for helping us achieve our 20-year landmark. We could not have reached this milestone without your support.

As we move into the next chapter of *EE T&D* magazine, we look forward to sharing your accomplishments and informative articles and hope you will continue to update us on your discoveries and successes.

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

Elisabeth

DEPLOYING EV FAST CHARGING STATIONS

IN ALBERTA

WAYNE STENSBY AND LOUIS TREMBLAY

FOR THIS ISSUE, WE SPOKE WITH WAYNE STENSBY WITH ATCO AND LOUIS TREMBLAY WITH ADDÉNERGIE ABOUT THE DEPLOYMENT OF FAST CHANGING STATIONS IN THREE OF ALBERTA'S MAJOR CITIES.

EET&D: Tell us about the electric vehicle fast charging corridor that are coming to Alberta.

TREMBLAY – The deployment covers electric vehicle (EV) fast charging stations in three of Alberta's major cities: Red Deer, Calgary, and greater Edmonton, in collaboration with Canadian Tire Gas+ and supported by Canada's Department of Natural Resources. These three sites will form the province's first universal, fast charging station corridor. The stations are currently being installed and the project is expected to be completed early in 2018.

This project promises to dramatically improve the electric vehicle charging infrastructure in Alberta.

STENSBY – The companies behind this deployment have shared responsibility for the project. One partner will supply the infrastructure and serve as the network operator of the charging stations as part of its Canada-wide network. The other is providing planning, engineering and project management expertise, as well as supporting the construction and installation of the charging stations.

EET&D: How were the locations selected?

TREMBLAY – Distance, convenience and compatibility were important considerations. The selected locations ensure universal fast charging infrastructure is available every 150 km or so along the fastest route from Edmonton to Calgary. Even though the technology is constantly improving, most EVs currently on the market would not be able to make this journey on a single charge. This corridor will allow EV drivers to travel more freely between these two major cities, knowing they can make a quick stop midway in Red Deer to get a full charge.

Plus, all three sites are all conveniently located close to Highway 2 exits and near amenities such as rest areas, shops or restaurants, so EV drivers will be able to grab a snack or do some shopping while they charge.

EET&D: Tell us more about the type of charging stations that will be installed

TREMBLAY – Each location will be equipped with a universal direct current fast charger (DCFC), as well as a dual Level 2 charging station.

The fast charging stations will charge most electric vehicles up to 80 percent of their battery capacity in about 20 to 30 minutes. They are equipped with two different connectors (CHAdeMO and SAE Combo) to be compatible with all models of electric vehicles currently available in North America.

The Level 2 charging stations will provide about 30 km of range per hour of charging. Although much slower, these chargers will act as secondary options for drivers in case the DCFC is already in use and will allow plug-in hybrid vehicles to charge, as these vehicles do not support fast charging. →


flo
ATCO
ATCO

EET&D: Will those charging stations be enough to convince someone to purchase an electric vehicle?

TREMBLAY – There is currently just one universal fast charging station in Alberta. Other than that, there are a number of Level 2 charging stations and five Tesla superchargers, though these are only compatible with Tesla vehicles.

Public charging infrastructure is crucial to allow long-distance travel and to help EV drivers overcome "range anxiety"—the fear of not having enough battery power to get to their destination. The fast charging corridor will directly fill this void.

Although public charging is important, it's part of a larger charging "ecosystem." Typically, between 60 percent and 80 percent of EV charging is done at home, at night, meaning EV drivers leave home each morning with a fully charged vehicle. Considering the average Canadian driver travels less than 50 km a day, most drivers will be able to do their daily driving on a single charge.

It is already possible for Albertans to drive electric vehicles today, but it will certainly become easier and more convenient as public charging infrastructure continues to grow.

EET&D: Where does Alberta stand in terms of electric vehicle adoption?

TREMBLAY – There are currently more than 1,000 electric vehicles registered in Alberta. Although it's not a huge number, this is a 60 percent increase from the previous year, and Alberta currently has the fourth-largest number of EVs in Canada after Quebec, Ontario and British Columbia.

EET&D: Why invest in charging stations when electric vehicle represents just a tiny fraction of total car sales?

TREMBLAY – Although the EV market is still small in Alberta, developing public charging infrastructure is

Wayne Stensby is managing director of the Electricity Global Business Unit for Canadian Utilities Limited, an ATCO company. The Electricity Global Business Unit delivers electricity generation, transmission and distribution solutions, along with related infrastructure development, to its global customers. As managing director, Stensby is responsible for the Electricity Global Business Unit's overall operation including leading the overall strategy and development for long-term growth. Stensby joined the ATCO Group of Companies in 1988 and has held a variety of operational and engineering leadership positions, including assignments in Canada, the U.K. and Australia. He was appointed to his current role in 2015 following his tenure as managing director and Chief Operating Officer of ATCO Australia. Stensby holds a Bachelor of Science in electrical engineering from the University of Alberta and is registered as a Professional Engineer with APEGA.

a crucial first step to support EV adoption. It's a chicken-and-egg situation; the more charging stations available, the more people will switch to electric mobility; and as the number of EV drivers grows, more businesses will be interested to invest in charging stations.

Based on our experience in building out charging networks in other Canadian provinces, we believe this new charging corridor will be a strong catalyst for electric mobility. We've seen firsthand that the availability of a reliable and extensive charging infrastructure is a key factor in driving adoption.

EET&D: How will this project benefit the customer?

STENSBY – It is important to make sure all Albertans have access to energy, whether they live in cities or in the most remote and isolated communities in the world.

This project ensures that we are improving the lives of our customers by providing sustainable, innovative and comprehensive energy solutions.

Electric vehicles will continue to play a growing role in meeting our collective transportation needs in the years to come, and we are incredibly proud to help bring this cutting-edge charging infrastructure to Alberta.

EET&D: What makes you think electric vehicles represent the future of transportation?

TREMBLAY – There is a growing consensus that electric vehicles are the future of personal transportation, not just in Canada, but worldwide. Almost every car manufacturer now has at least one model of plug-in vehicle on the market, and global EV sales reached 735,000 in 2016.

Here in Canada, governments in Quebec, Ontario and British Columbia have been offering incentives to support electric mobility, which have fueled exponential growth of the adoption rates in these provinces. The federal government also plans to develop a national Zero-Emission Vehicle Strategy by 2018.

We've now reached a point where it's not a question of "if" electric vehicles will become the norm, but "when".

EET&D: Are there plans to install more charging stations in Alberta? What's next for the province?

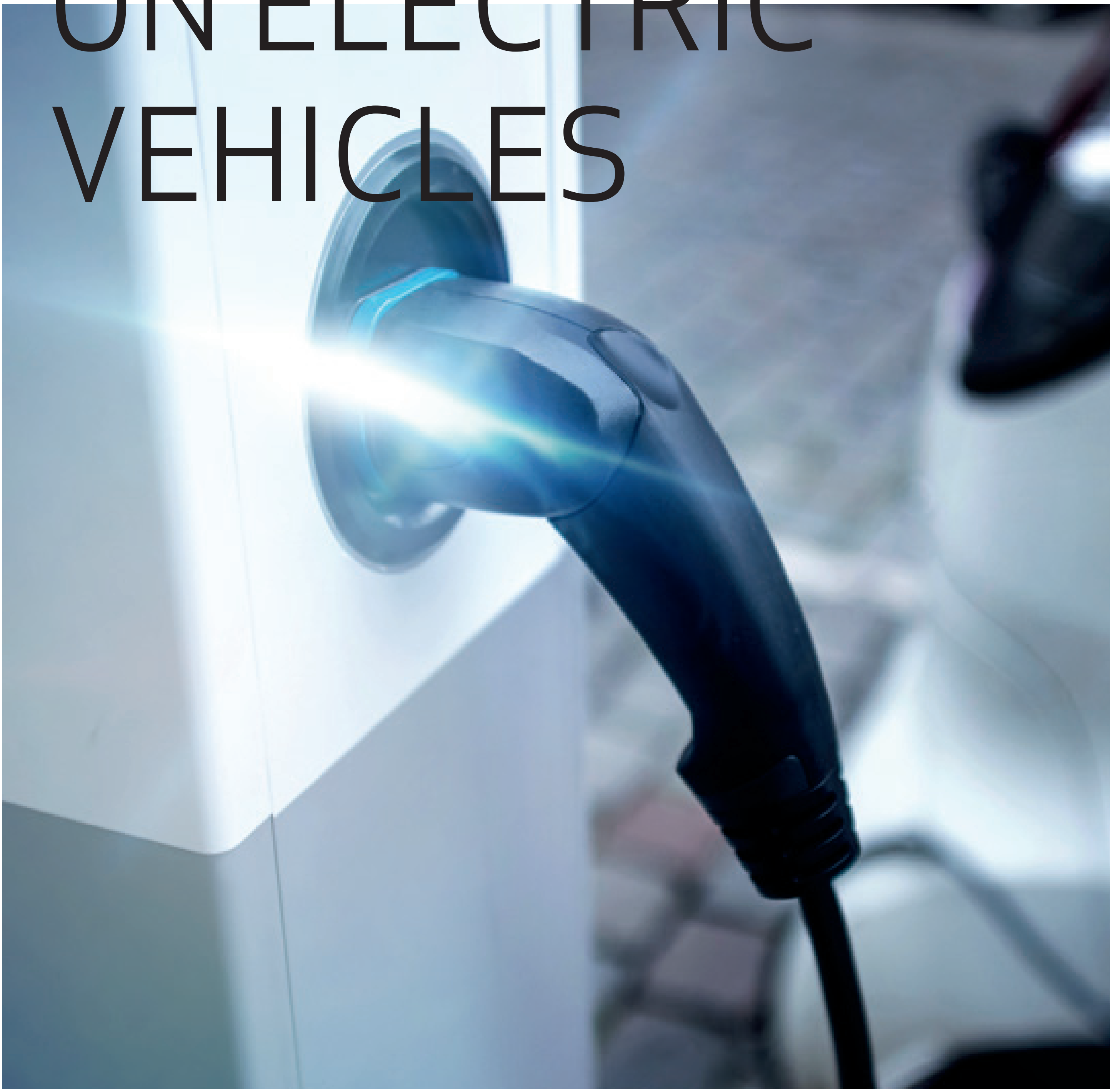
STENSBY – For now, only these three sites are officially announced, but the initiative will be the first project in a strategic partnership between ATCO and FLO. We are also exploring opportunities to do more with EV charging stations in several Alberta municipalities, as well as working on other highway, residential and workplace charging projects.

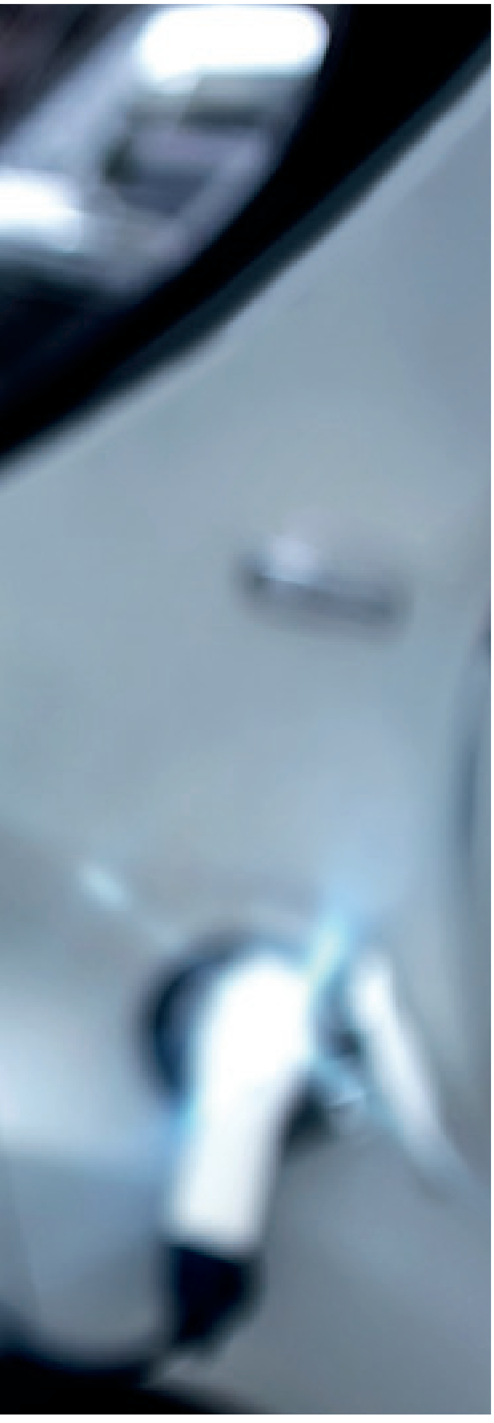
TREMBLAY – As we roll out more charging stations in Alberta, the province's infrastructure will connect with our existing network across Canada. We are currently working with various private and public partners to grow our network in Eastern British Columbia, right up to the border. This will soon allow EV drivers to travel even longer distances between provinces.

Louis Tremblay is the CEO and co-founder of AddÉnergie, the leading Canadian smart charging solutions provider for electric vehicles. AddÉnergie develops, manufactures and operates its own charging stations, software and systems. As a pioneer of electric mobility in Canada, Mr. Tremblay and his team have deployed FLO, the largest charging network in Canada with more than 4,000 charging stations operating throughout the country. AddÉnergie is also the supplier and operator of Hydro-Quebec's Electric Circuit (Quebec) and NB Power's eCharge Network (New Brunswick). Louis Tremblay graduated from Laval University with a Bachelor's Degree in Electrical Engineering and a Master's Degree in Power electronics. He is a Board member of the Grappe industrielle des véhicules électriques et intelligents (Industrial Cluster for Electric and Smart Vehicles) and a member of the Generation Energy Council, initiated by Natural Resources Canada.

FROM RESEARCH TO ACTION

THE LATEST ON ELECTRIC VEHICLES





MARK DUVALL

The electric vehicle (EV) industry expanded tremendously in 2017 (up 26 percent over 2016, compared to an overall car market decline of one percent), and as prices continue to drop and adoption rates grow, we at EPRI predict that 2018 will prove equally as transformative.

In 2018, we'll continue to see momentum around EVs, predominantly as a result of manufacturers establishing production facilities on a global, multi-disciplinary scale and bringing more EVs to market. Less than a decade ago, if someone asked me what the key indicators of EVs becoming a profitable market trend were, I would have told them to look at automaker investment and adoption rates. But today, we're seeing the source of the trend stem from consumer demand and automakers, sustained by large investments, governing bodies, and emerging technology.

Automakers will always invest carefully in technology that will help them appeal to consumers in order to meet sales goals, so this investment isn't that surprising. However, we're seeing monetary investments higher than ever before. In September of 2017, Volkswagen announced an $84 billion investment in EVs and batteries. Years ago, we'd see announcements about a single EV option per automaker. In 2016, major automakers offered 24 different electric vehicle models to consumers and just a year later, we're seeing fully developed company roadmaps and complete EV series. Automakers have announced nearly 100 different EV models that will be available to customers and dealers by 2021. Electric vehicles are no longer a company "one-off" to maintain relevance and profitability. They are now an intricate part of an automaker's technology portfolio and its future strategy. →

Due to increased adoption rates, EVs are also being further integrated into company growth strategies – for both automakers and utilities – and are even being incorporated into economic development strategies and regulatory policies. Government institutions and entire nations are now having thoughtful conversations and putting forth large investments into electric vehicle technologies. In 2017, several nations indicated that they're going to begin phasing out combustion engine vehicles as a strategy to speed up their country's EV adoption. China, the world's largest auto market, recently announced that it would set a deadline for automakers to stop selling non-electric vehicles. This is a move to eventually end the creation of gas automobiles. Additionally, in early December, New York Governor Andrew Cuomo announced the availability of $3.5 million in new funding to spur EV adoption, as part of the state's goal of to cut greenhouse gas emissions by 40 percent by 2030.

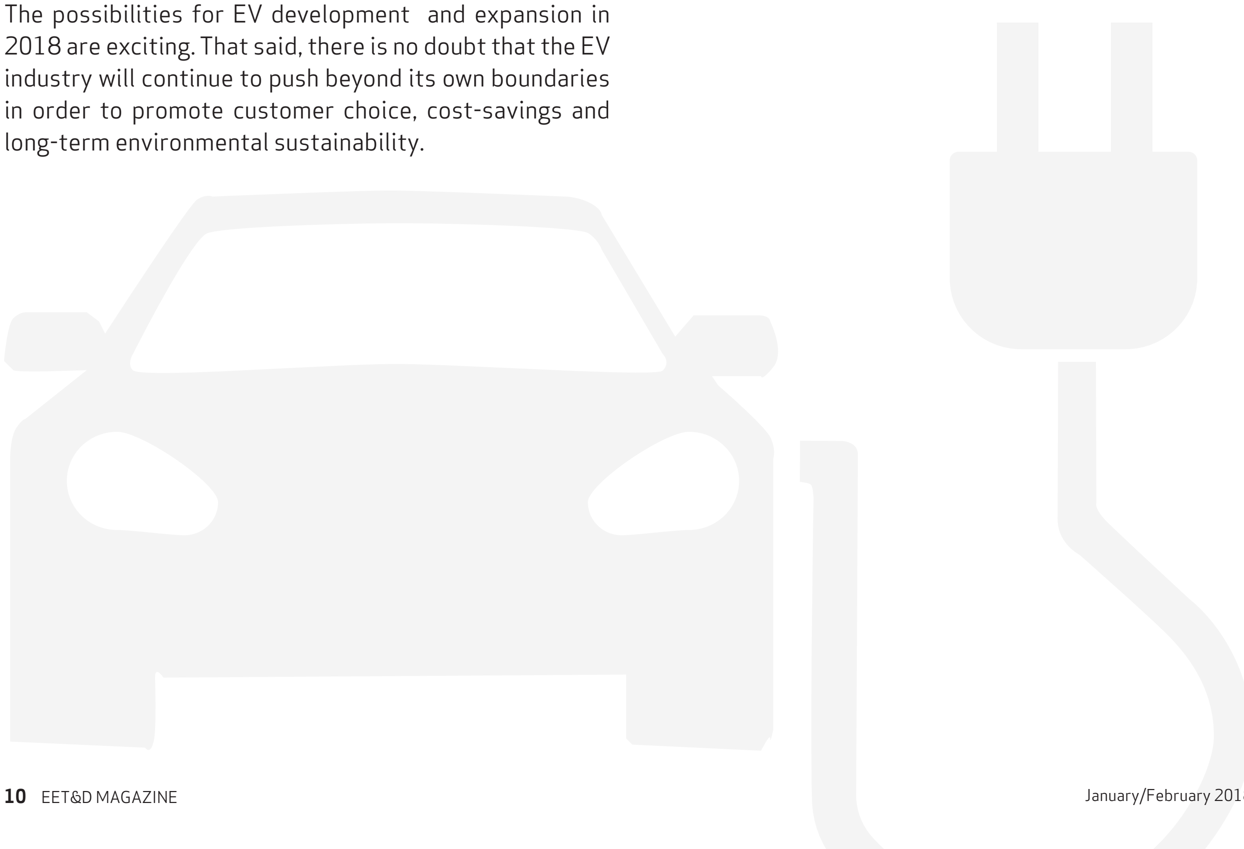
At the same time, barriers will break down in 2018 as the EV product portfolio expands. City transportation authorities and delivery companies are increasingly interested in creating an EV infrastructure to convert heavy-duty diesel-powered transit buses and delivery trucks to cleaner technologies. There are even prototypes of electric ferries. These developments are building excitement and providing great opportunities. By providing impartial information as the customer's trusted energy advisor and establishing EV charging programs to increase customer options, utilities can also help to further the adoption of EVs in their own communities.

The possibilities for EV development and expansion in 2018 are exciting. That said, there is no doubt that the EV industry will continue to push beyond its own boundaries in order to promote customer choice, cost-savings and long-term environmental sustainability.

ABOUT THE AUTHOR:

Mark Duvall is the director of Energy Utilization at the Electric Power Research Institute (EPRI), an independent, non-profit center for public interest energy and environmental collaborative research. He is responsible for EPRI's research and development programs for all end-use and customer electric technologies, including electric transportation, energy efficiency, demand response, energy storage, distributed generation, power quality, electrification and customer behavior. His areas of technical expertise include vehicle design, electric and plug-in hybrid powertrain systems, energy storage system design, end-use electrification and infrastructure, and testing.

Prior to joining EPRI in 2001, Duvall held the position of principal development engineer at the Hybrid Electric Vehicle Center of the University of California, Davis. He began working in the field of advanced transportation in 1990 and has led the development of several prototype advanced plug-in electric vehicles. He received his bachelor's degree in 1990 and his master's degree in 1994, both in mechanical engineering, from the University of California, Davis and a doctorate in mechanical engineering in 1998 from Purdue University. He is a member of SAE and IEEE.



GREEN OVATIONS

NEW GLOBAL ATTITUDES

JOHN HARGROVE

ENERGY EFFICIENCY, DEMAND-SIDE MANAGEMENT, DISTRIBUTED ENERGY AND THE INTERNET OF THINGS: WHAT DO ENERGY SERVICES MEAN IN THE CONTEXT OF DIGITALIZATION, A CHANGING GLOBAL ECONOMY AND NEW GLOBAL ATTITUDES?

What do the various iterations of the energy services industry mean to utility professionals, energy consumers, and to the developers of the transformative technologies that are advancing toward overall connectedness?

With its roots in the conservation movement of the 1970s, energy efficiency and its equally significant but lesser known counterpart, demand-side management, now comprise an entire industry within the national energy economy.

According to the Department of Energy's 2017 U.S. Energy and Employment Report, there are 2.2 million workers across the construction, manufacturing, wholesale trade, and professional and business service industries that spend some or all of their time working with energy-efficient technologies and services. It was one of the only areas of our economy that was growing during the Great Recession. In fact, the report projects an annual growth rate in employment of roughly nine percent.

Not included in those numbers, the U.S. Bureau of Labor Statistics finds that retail trade industries that sell and distribute ENERGY STAR® appliances and building materials (as well as non-qualifying appliances and building materials) employ approximately another three million Americans. →

The job functions of those millions of Americans are changing daily; adapting to new technologies, changing behaviors, ensuring privacy, assessing risk, and marketing and communicating the tangible benefits of about energy efficiency. So what does this mean for the industry, those who work in it, and those who are served by it?

An association for energy professionals, in conjunction with a strategic marketing firm specializing in energy, conducted a "deep dive" research project to measure changes, and placed all of the developments in a proper context to see where we are as a country, where we are going in the future, and most importantly, how the utility sector can retain and grow consumer trust in an era of rapid change.

Two surveys were conducted among industry professionals and consumers, with a collective sample size just shy of 3,000 respondents.

The research project focused on four primary areas: the Internet of Things (IoT), program participation, jobs and the use of distributed energy resources.

The Internet of Things

Devices that are connected in the home to the "Internet of Things" demonstrate savings of energy and money on utility bills, but in spite of what we may intuitively believe, adoption rates of these devices are still low.

Despite all the "smart home" news in the media, only about 25 percent of the consumers surveyed said they owned at least one IoT device:

- Smart thermostat - 12 percent
- Smart speaker, (i.e. Google Home, Amazon Echo) - 7 percent
- Smart power strip - 5 percent
- Smart washing machine - 4 percent
- Smart doorbell - 2 percent
- Smart air conditioning unit (those controlled by remote devices such as a smart phone) - 1 percent

Interestingly, and counter-intuitively, IoT product ownership is led by consumers in the two middle-age brackets. Those who are between the ages of 30 and 44 are most likely to own at least one Internet of Things product, and those who are between the ages of 45 and 59 are most likely to own multiple devices.

And most of these devices noticeably save energy. In fact, a fair amount of energy, when you ask the owners. Among owners of smart thermostats, 45 percent said the device had decreased energy usage. Smart power strips saved energy for 22 percent of the respondents who reported owning one. And smart room air conditioners reduced energy usage for 60 percent of those who reported owning one.

Participation in Programs

Utility-driven energy management programs are growing; although participation rates are still somewhat low, the survey found.

Only 31 percent of the consumers surveyed had participated in a utility-run energy management program. However, over the last two years, 32 percent of energy efficiency professionals reported that program participation rates had grown from three to 10 percent, and 21 percent reported that participation rates had grown by more than 10 percent. Those trends are expected to continue over the next two years.

In the survey, program sizes ranged from 140 participants to 50,000, with an average of 11,000. Customer participation rates ranged from one percent to 80 percent, with an average of 17 percent.

The survey found a counterintuitive disparity between the utility perspectives of what is important to consumers, and what consumers say is important to them. Only 18 percent of those polled on the utility side said that energy efficiency was "very important" to consumers, but 58 percent of the consumers said that energy efficiency was "very important." This is a great example of the utility's potentially underselling the energy savings value of a product or program.

Utilities are working to redesign programs by increasing and improving communications with customers by making it easier to participate online, improving incentives, and reaching out more through social media.

Among the top factors generating growth in programs, according to consumers:

- Improved value and incentives (61 percent)
- Improved communications between consumers and utilities (46 percent)
- Improved digital interfaces, tools and energy data (36 percent)
- Redesign with consumer friendliness in mind (29 percent)

One surprising trend is that older consumers are more likely to participate in programs. Younger people may be purchasing homes later, but the industry needs to reach out and communicate better with millennials.

Jobs in Energy Efficiency

The number of utility program jobs is increasing steadily across utility companies. On average, energy efficiency program departments have grown 20% in the past five years, according to the survey.

More than half of the respondents reported having open positions – some of which have been open for six months or longer. The hardest positions to fill, according to the respondents are those in data analytics, followed by technical support, field staff, managers and program managers.

Distributed Energy Resources

A little less than a third of all consumers reported owning one of several forms of distributed energy resources that were polled in the survey: an electric car or plug-in electric hybrid car, a rooftop solar system, a backup generator, and/or a heat pump water heater.

However, even if they hadn't yet purchased one of these devices, interest levels are ahead of ownership rates:

- Rooftop solar
  Own - 4 percent; interested - 34 percent
- Backup generator
  Own - 13 percent; interested - 35 percent
- Electric vehicles
  Own - 3 percent; interested - 26 percent
- Heat pump water heater
  Own - 10 percent, interested - 13 percent

Today, without even looking too hard, we can see the trends identified in our survey in our daily life and activities. Changes are everywhere. The shopping center has parking spaces and charging stations for electricor hybrid vehicles. Homes have smart devices such as Amazon's Echo or Google Home that can be used to power down heating and air conditioning systems. And that eccentric neighbor who has gone completely off the grid with a generator and/or solar panels, well, he doesn't seem so strange anymore.

Are we, as individuals, energy-independent? Far from it. Are we on our way? The findings from this research say most definitely. While we are a long way from it, which has far-ranging implications for global economics and politics, our generation and use of fossil fuels, relationships with oil-producing nations, and job creation domestically and abroad.

It has long been said the greenest kilowatt is the one that is never used. But it's about more than just being green. It's about being smart economically and ecologically. For energy efficiency to truly take hold, it must make sense for the consumer. And with tremendous advances in technology, easier to use products and a strong and obvious financial incentive, it does more today than ever and shows no signs of slowing.

ABOUT THE AUTHOR:

John Hargrove is the president and CEO of the Association of Energy Services Professionals. He served as the chair of the Association of Energy Services Professionals' (AESP) board from 2012 to 2013. Previously, Hargrove was the director of renewable programs at NV Energy in Nevada.

BYLINE

DISTRIBUTED BATTERY ENERGY STORAGE:

HOW BATTERY STORAGE SYSTEMS CAN CAUSE MORE HARM THAN GOOD

SEAN MORASH

PART 2 OF A TWO-PART SERIES TAKING A CLOSER LOOK AT EXISTING EFFORTS TO SOLVE BATTERY DR CHALLENGES AND AREAS WHERE MORE ATTENTION IS NEEDED

In Part 1, we discussed the usefulness of batteries in managing the grid while mentioning that battery performance can be hard to quantify when placed behind the utility meter. In Part 2, we will look at how battery charging strategies must be planned with sufficient foresight of system needs.

While contemplating new technology investments, it is often worthwhile to consider if there are any unintended consequences. On the small scale it could look like this: If I buy a new iPhone, do I receive a more expensive phone bill due to increased usage? For battery investments, the unintended consequences have more to do with strategically controlling the charging and discharging.

For the purposes of this article, the difference between direct and indirect effects center on the time in which they occur. Direct effects occur in conjunction with an event dispatch instruction (see **Figure 1**). An indirect effect occurs at some other point throughout the day (see **Figure 2**). These effects need to be understood and accounted for by the grid operator in order to provide adequate forecasts and properly identify the appropriate resource mix to balance generation and demand.

Essentially, the storage system should make the customer load more predictable and not deviate from the normal schedule until receiving the dispatch instruction. The customer load should then return to the normal schedule after termination of the DR event so as to minimize indirect and unintended impacts that may necessitate more issues and reactionary events. As far as I know, the naming conventions (e.g. direct rebound, indirect, etc.) used within this piece are original.

Direct Rebound Following Performance

Even successful direct rebound (DR) events often see a slight direct rebound effect, a demand profile greater than average immediately following the event. This slight increase in usage immediately following an event may be attributable to an air conditioning compressor working hard to return a large facility to a comfortable temperature after responding to a DR event by shutting off for an hour or more. Maybe the usage increase is the result of a battery charging back up after a response to a DR signal caused a discharge below the necessary capacity to maintain functionality for other services, such as peak demand shaving. Regardless of the reason, this type of rebound is shown in **Figure 1**. →


180 pts
19

FIGURE 1
BATTERY PERFORMANCE PROFILS 14:00-15:00 DR EVENT

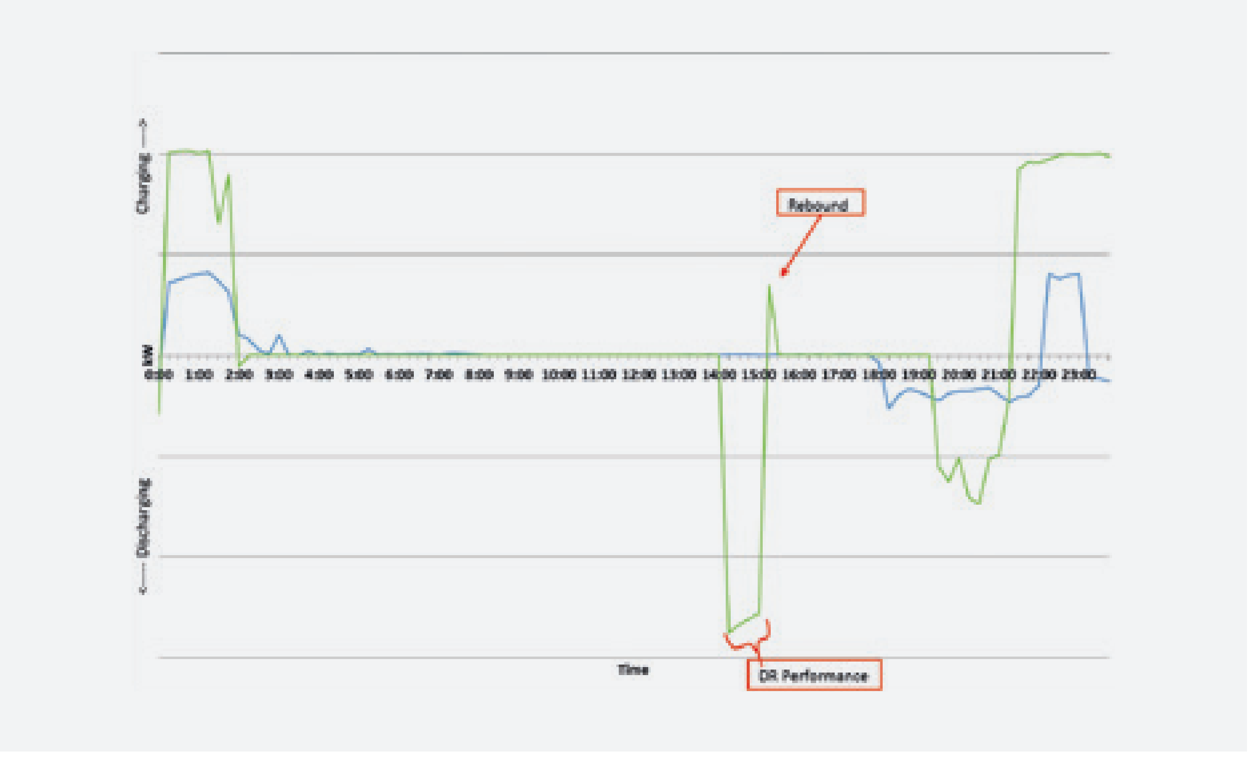


Figure 1: *Direct Rebound Effect Example*

Average Battery Perforance   Event Day Perforance

This type of direct rebound should be accounted for when modeling DR events. Often, any negative effects of a quick direct rebound are far outweighed by the benefits associated with the performance of the event. Still, depending on the application and the sensitivity of the local electric infrastructure, direct rebound effects may stress the margins and nullify the benefits of the DR event.

Indirect Performance Effects

During the recent **Battery DR Pilot project**, there were days when the storage system was called upon to perform, with the initial assumption that the batteries would perform in the same fashion each day and could, therefore, be forecast into the system. On days when the utility signaled the storage device to perform (event days), the storage device often deviated from the range of how it performed on previous days even during hours that it was not expected to perform. It is possible that the typically programmed schedule, which is optimized to minimize energy and demand charges via peak shaving techniques, was manually overridden on test event days prior to the expected performance period. Unfortunately, this deviation from the standard schedule in the timeframe before and after test events had a significant impact on the projected load profiles that the DR event was intended to improve. Event day performance of a battery storage system can change the value proposition and necessity of the event, to begin with.

For the pilot project, the schedule of events was pre-established weeks in advance. Similarly, day-ahead energy market awards would have known dispatch and restoration times. Building a resource stack to balance electricity supply and demand is predicated on known usage profiles that assist decision makers in finding the most cost-effective answer. Increasingly, utility decision makers and end-use customers are turning to energy

FIGURE 2
BATTERY PERFORMANCE PROFILS 12:00-13:00 DR EVENT

Figure 2: Example of Indirect Effects of Battery Energy Storage

Average Battery Perforance   Event Day Perforance

storage as a cost-effective tool in their resource stack. However, the performance of the storage in the hours outside of the focus timeframe must also be considered so as to avoid creating different, possibly more extreme, system balancing issues.

Does the behavior of the storage device in order to achieve the desired performance outweigh the benefits associated with that desired performance? In Figure 2, does the charging that occurs from 8:45-10:00 disrupt the predictive models in such a way that it changes the necessity of the DR performance? Does the system now have enough demand to justify utilization of a different resource? What are the effects of that unexpected demand after the event? These are questions that must be considered in today's electricity architecture. In other words, we must ensure that the battery is charging and discharging to maximize its potential. This isn't a new idea, but the application is important. When asking a storage device to perform differently than typical, we must consider ***how it*** achieves that performance, not just ***when or if*** it will perform.

These indirect effects can be controlled, modeled and maximized. Energy storage can be a great asset to improve grid efficiency, but only if deployed with a comprehensive outlook.

In addition to the effects from charging and discharging laid out above, the behavior of energy storage resources also impacts the grid in the following meaningful ways. →

Indirect Rebound Effect

The idea of indirect energy impacts was articulated in the June 2016 *United States Data Center Energy Usage Report* from Lawrence Berkeley National Laboratory. Within that report, the authors lay out that ICT (information and communication technology) direct energy consumption, the energy consumed by the ICT devices and infrastructure themselves, "is likely the simplest and ultimately the least important ICT energy effect [although it made up 1.8% of total U.S. electricity consumption]… the indirect energy effects are likely to be of much greater magnitude, owing to the breadth of the various mechanisms by which ICT services alter energy use." To more fully understand that claim, it is important to appreciate how indirect energy effects become complex and far-reaching very quickly. The authors mention how teleconferencing, enabled by ICT advances, has replaced some of the need to fly across the globe for meetings. With respect to energy storage, the effect is not as straightforward. Energy storage is part of the decentralization paradigm shift in electricity generation enabling customers to own their own renewable energy generation. To an extent, energy storage can displace conventional fast response generation resources that adjust output to balance electricity supply and demand, but there are many more factors.

Another example outlined in the US Data Center Energy Usage Report described how a less costly e-book might lead consumers to purchasing more books. Consumers could also apply these savings to other goods and services, whose prices themselves are dependent on consumer income. These ***indirect rebound effects*** consider "consumer and market responses to the energy efficiency improvement. Such consumer and market-wide responses are likely to occur because the energy efficiency improvement itself changes relative prices (and, thus, real income)."[1] Adjusting that terminology to the energy storage market is a relatively straightforward exercise in adjusting jargon. Rather than using words like ***consumer and market*** that are so common in economic vocabulary, the energy storage community often refers to the same actors as distributed energy resources (DERs) and the grid/wholesale energy market, wherein "the grid" refers to the host of technologies, platforms and operators that enable the reliable delivery of electricity. As such, applying the ***indirect rebound effect*** definition to energy storage begins to clarify the parallels: DERs and the grid respond to the energy demand improvement. Such DER and grid responses are likely to occur because the improvement in consumer energy demand management changes relative reliability scenarios (and, thus, the grid outlook).

Put another way, the theory of indirect rebound effects originally applied to energy efficiency in a fairly straightforward manner: Utilizing more energy efficient devices can beget utilization of that device more frequently. By utilizing an efficient device more frequently, the positive effects associated with its more efficient operations are slightly negated. The same can be said of storage: Utilizing energy storage enables more effective utilization of more energy storage devices. But also, by utilizing a single energy storage device across more applications, the benefits associated with its performance become increasingly fuzzy.

Indirect System Effects

At the heart of identifying indirect effects is pinpointing how the original desired solution affects other components in the system. Identifying the eventual system effects for the deployment of energy storage is still very much an act of gazing upon a crystal ball. However, it is clear that the industry is trending towards increasingly distributed variable generation, and energy storage can help mitigate this variability. Additional variable generation improves the value proposition for energy storage (assuming the cost of the storage is less than traditional infrastructure improvements), making the value proposition for more variable generation (and the additional storage) more attractive (the cycle continues).

The Gridwise Architecture Council is working through what it calls the *Transactive Energy Framework*. In this scenario, energy resources are constantly negotiating the value of energy locally at the source of the distributed generation as well as an aggregation of distributed resources in the wholesale energy market. The indirect performance effects outlined earlier would be naturally handled by a distribution market that responds in real time to the local factors balancing supply and demand. Rather than each resource serving its own self-interests with little regard to the bigger picture, such a market would necessitate a balancing of both local factors and larger system level considerations.

Summary

Within this piece, multiple effects of disrupting the normal performance of energy storage systems were covered. Brief descriptions of each are below:

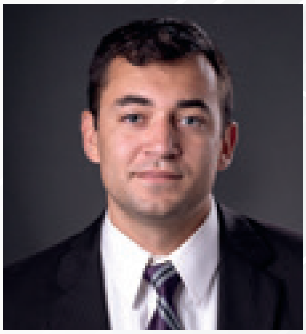
- ***Direct Rebound Effect*** – The energy storage system returns to higher levels than average immediately following a DR event before returning to roughly average performance.
- ***Indirect Performance Effect*** – The energy storage system offsets DR performance by performing differently during other parts of the day.
- ***Indirect Rebound Effect*** – Utilization of energy storage across multiple applications reduces the benefits associated with any single application.
- ***Indirect System Effect*** – Energy storage transitions the electricity architecture to a new paradigm.

While each of these effects may be weighted differently by different stakeholders, the performance of a distributed storage device does not occur in a bubble. The greater context of the surrounding landscape must be considered. These effects must be built into predictive models as we consider the future of our distribution system.

[1] Gillingham, K., Rapson, D., Wagner, G., 2015. The rebound effect and energy efficiency policy.

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 assisting clients assess the value of next generation demand response technologies aiming to capture multiple simultaneous value streams.



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AWARD WINNER 2017

CYNDI SMITH

PESTECH'S BUILD, OPERATE, TRANSFER PROJECT FOR CAMBODIA SUBSTATION AND TRANSMISSION SYSTEM BOLSTERS REGIONS ELECTRICITY

Introduction

Bentley System's Year in Infrastructure Conference 2017 wrapped up with its Be Inspired Awards. The Be Inspired Awards recognize the greatest BIM advancements in infrastructure in 17 categories. In the BIM Advancements in Utilities Transmission and Distribution category, PESTECH International Berhad won for its work on the 230-kilovolt substation and transmission system from the town of Kratié to the city of Kampong Cham, Cambodia.

Following is the case study for this award-winning project. Solutions from Bentley played a significant role in enabling PESTECH to complete this challenging project while saving time and money.

Substations and Transmission Line to Bring the Power

A new network in Cambodia was designed to meet the power needs of an area that is experiencing development and urbanization. Diamond Power Limited awarded a contract to PESTECH International Berhad to design, supply, deliver, erect, and commission the 230-kilovolt Kratie and Kampong Cham Substation and Transmission System in Cambodia. An obje tive of the custom-designed high voltage (HV) and extra high voltage (EHV) system is to prolong the life and reliability of the transmission and distribution assets.

Kratie, a province located in northeastern Cambodia and Kampong Cham, is the third-largest city in the country, situated about 57 miles away from Kratie. Both areas are not tourist destinations, but backpackers pass through Kampong Cham during the high season seeking accommodations as it is a transit point between Siem Reap and Phnom Penh, both of which are popular tourist spots.

The new Kratie 230/22-kilovolt substation will serve as a major collection center of electricity power from additional mini-hydropower plants and will be connected to the national power grid of Cambodia. The 125-kilometer 230-kilovolt duplex ACSR bittern transmission line will connect the new Kratie Substation to an updated Kampong Cham Substation. This line will transfer 700 megawatts of electrical power from Sesan Hydropower Plant, which is nearing completion in the upper Mekong area, to the Kratie and Kampong Cham regions. Power from the plant will also be transmitted through the Kampong Cham-Kratie transmission line to Cambodia's capital, Phnom Penh.

Comprehensive Engineering Design by PESTECH

Established in 1991, PESTECH International Berhad is an electrical trading company in Malaysia that specializes in creating electrical power facilities in developing countries and has a market capitalization of over MYR 1 billion. The company has evolved from delivering power transmission infrastructure to building and operating transmission assets, embedding system software and product development, and most recently power generation and rail electrification. →

PESTECH was contracted to do the transmission portion of the project and the primary and secondary design of the substation system for the $92.2 million dollar project. PESTECH created a conceptual design of the substation systems and assembled, installed, tested, and commissioned the 230-kilovolt switchyard within the existing Kampong Cham Substation, a new Kratie 230/22-kilovolt substation, and the interconnecting 230-kilovolt duplex ACSR bittern transmission line that connects the Kampong Cham Substation to the Kratie Substation. The primary design included designing the substation layout and the secondary design included the control and relay panel protection panels.

Advancing Past Manual Methods

Previously, the engineering team designed and manually updated 2D hand-made drawings, conducted manual component calculation, and used AutoCAD. This methodology was inconsistent, time consuming, labor intensive, and prone to human error. Additionally, the manual method created a divide between the electrical and physical design. Drawings and design deliverables were dispersed among all stakeholders, so information sharing was disorganized and inefficient, often impacting construction when outdated files were referenced, necessitating expensive and time-consuming rework. PESTECH's previous schematic diagram also did not incorporate intelligent functions, such as clash detections, lightning protection design simulation, and automated functions for drawings and report generation.

Visualization of the 3D substation design was essential for preparing work before and during construction, and the software implemented was integral for collaboration across departments, both on and off site.

Integrating 2D Electrical and 3D Physical Designs

Using a robust platform of software solutions for the 3D physical design and 2D electrical design, PESTECH's engineering team created a systematic database and catalog. It took the team about one month to put together a full set of libraries that consisted of hundreds of parts. After the database was fully comprehensive, the design drawings used a pick and drop method for the electrical design of the 3D substation layout and the 2D electrical schematics of the control relay and protection panels. This saved the team time on submissions and revisions.

The combined platform of 3D substation design with 2D electrical protection, along with control schematics and panel design, provided the engineering team with a seamless review of the project, eliminating the need for multiple applications. The unified environment also limited manual coordination needed to keep the electrical and physical designs constant and it promoted greater collaboration across the multi-discipline team. The unified design environment eliminated data re-entry, reduced manual coordination, enabled cross-discipline collaboration, curtailed drawing errors, avoided rework, enhanced efficiencies in design work, and created an interconnected design.

The software for the primary and secondary design phases of the project optimized workflows and the team of electrical and civil engineers designed and constructed the project to meet all standards, electrical parameters, and safety requirements. The engineering team developed libraries, databases, and templates compliant with Cambodian standards.

Visual Simulation During Primary Design Stage

During the primary design, the substation system needed to be laid out, including transformers, gantry towers, large cables, and circuit breakers. It was essential that these designs adhere to regulatory standards and be created via accurate engineering calculations. The team produced visual simulations of lightning protection of the area, grounding grid design functions, and took advantage of navigational functionalities with components interlinked in the parts database.

Also, hook point technology enabled 3D components to snap automatically, saving significant time.

Additionally, an intelligent substation digital engineering model helped the team automate their design drawings and reports. The automatic diagram and report generation, real-time post-process error checking, smart PDF generation, and simple navigation of the intelligent 2D and 3D models saved the team

The software used significantly reduced time for the project team through automatic diagram and report generation, real-time post-process error checking, smart PDF generation, and simple navigation of the intelligent 2D and 3D models.

Plug-ins were developed with the API generated information automatically, saving time. The Automatic Wire Numbering plug-in automatically named thousands of wires within a minute and panel wiring numbers were generated instantly. Over 100 kinds of panels were used in the substation that required thousands of schematics pages, because each panel has over 50 components. With the Graphical Report Plugin, all the schematics pages were generated automatically within a few seconds after the schematic design was complete. Other reports, such as bills of materials, cable schedules, tables of contents, and terminal connection diagrams were all automatically produced with the report templates prepared.

Saving Time and Money

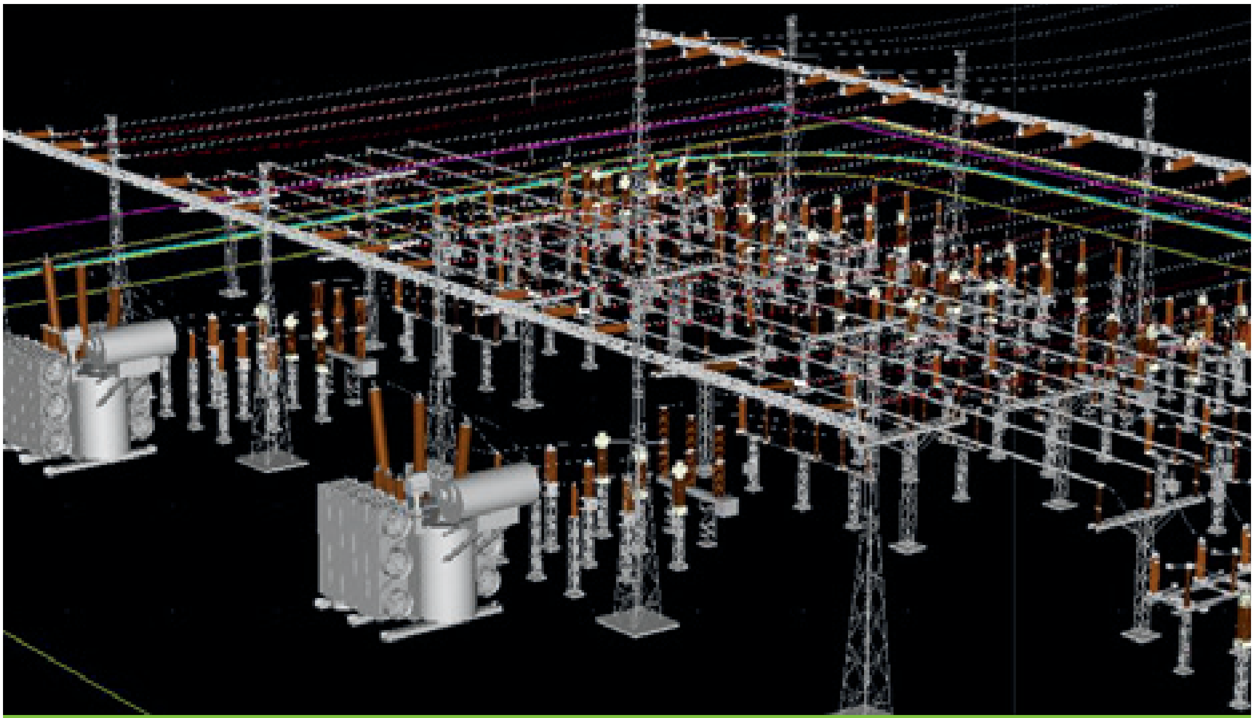
PESTECH has estimated that the project took 70 percent less time than other projects of this scale. Schematic drawings were completed in fewer than seven days, when they would normally take between two to three weeks with prior methods. 3D design with the software took three days, whereas similar 3D design in CAD took two weeks and required each design to be drawn and viewed separately. Additionally, the application automatically generated cable schedules within one hour for the entire project when it would typically take three days to check and document each cable. A further example of the time-savings with the software is evident in how a plug-in allowed terminal function diagrams to be generated in just seconds rather than three days it would have taken to manually document and check the report.

Using the software solutions, the PESTECH engineering team achieved accurate generated drawings and documentation, saved time on drawing production, saved money in procurement, and delivered better visualized substation presentations with 3D primary and 2D secondary engineering design unified in a single application.

With More Power Comes a Greater Impact

With Cambodia growing as a tourist destination and Kampong Cham having roads that connect to major Cambodian cities, added electricity to this region of the country through the substation is vital for future development. Concurrent with the construction of the substation is the construction of additional highways between Kampong Cham and the capital city of Phnom Penh. These routes will benefit the tourism industry as well as the surrounding community as it allows for better transit access for cars and buses. Further electricity in the area is also set to spur construction of hotels and resorts.

The two substations are expected to be completed by the end of 2017. After the 24-month project is complete, the Kratie and Kampong Cham area will have enhanced electricity usage that supports the quick development of the region and PESTECH will operate and maintain the power transmission system for a 25-year period. →



Project Summary

Organization
PESTECH International Berhad

Solution
Utilities Transmission and Distribution

Location
Kratie and Kampong Cham, Cambodia

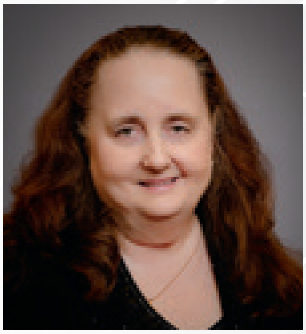
Project Objectives
- To design and construct a new Kratie substation, update the switchyard in the Kampong Cham substation, and erect a 125-kilometer 230-kilovolt duplex ACSR bittern transmission line that connects both.
- To increase electrical power generation to this region of Cambodia in order to further development of buildings and highways to cater to increased tourism in nearby cities.

Fast Facts
- PESTECH was contracted to design, supply, deliver, erect and commission the 230-kilovolt Kratie and Kampong Cham substation and transmission system in Cambodia.
- 3D visualization helped PESTECH overcome site and transportation challenges
- PESTECH was awarded a 25-year contract to operate and maintain the power transmission system.

ROI
- Schematic drawings were completed in less than a week rather than two to three weeks with previous methods.
- Automatic generation with the technology created cable schedules for the entire project in one hour and terminal function diagrams in seconds, rather than three days if done manually.
- 3D design that previously required two weeks was conducted in three days.
- The software used helped streamline engineering design with on overall 70 percent in time savings.

ABOUT THE AUTHOR:

Cyndi Smith is a senior industry marketing director for Bentley Systems' utilities, water, and communications industries. In her 16 years at Bentley, Smith has also led Bentley's product marketing team and the global utilities solutions strategy as solution executive. She has an extensive background in the development, implementation, and marketing of solutions for infrastructure in the communications, defense, oil and gas, and utilities industries.



BATTERY TESTING AND MAINTENANCE

PER NERC PRC-005 GUIDELINES

VOLNEY NARANJO

Batteries are among the least expensive pieces of equipment in a substation, and they are the heart that keeps the protection and control system running. Despite this, they are often not maintained properly. NERC standards make battery maintenance mandatory and its requirements are more stringent than those for other equipment. Very specific activities and maintenances schedules are described in PRC-005. Failing to comply with these requirements can reduce the life and performance of batteries, in addition to incurring fines.

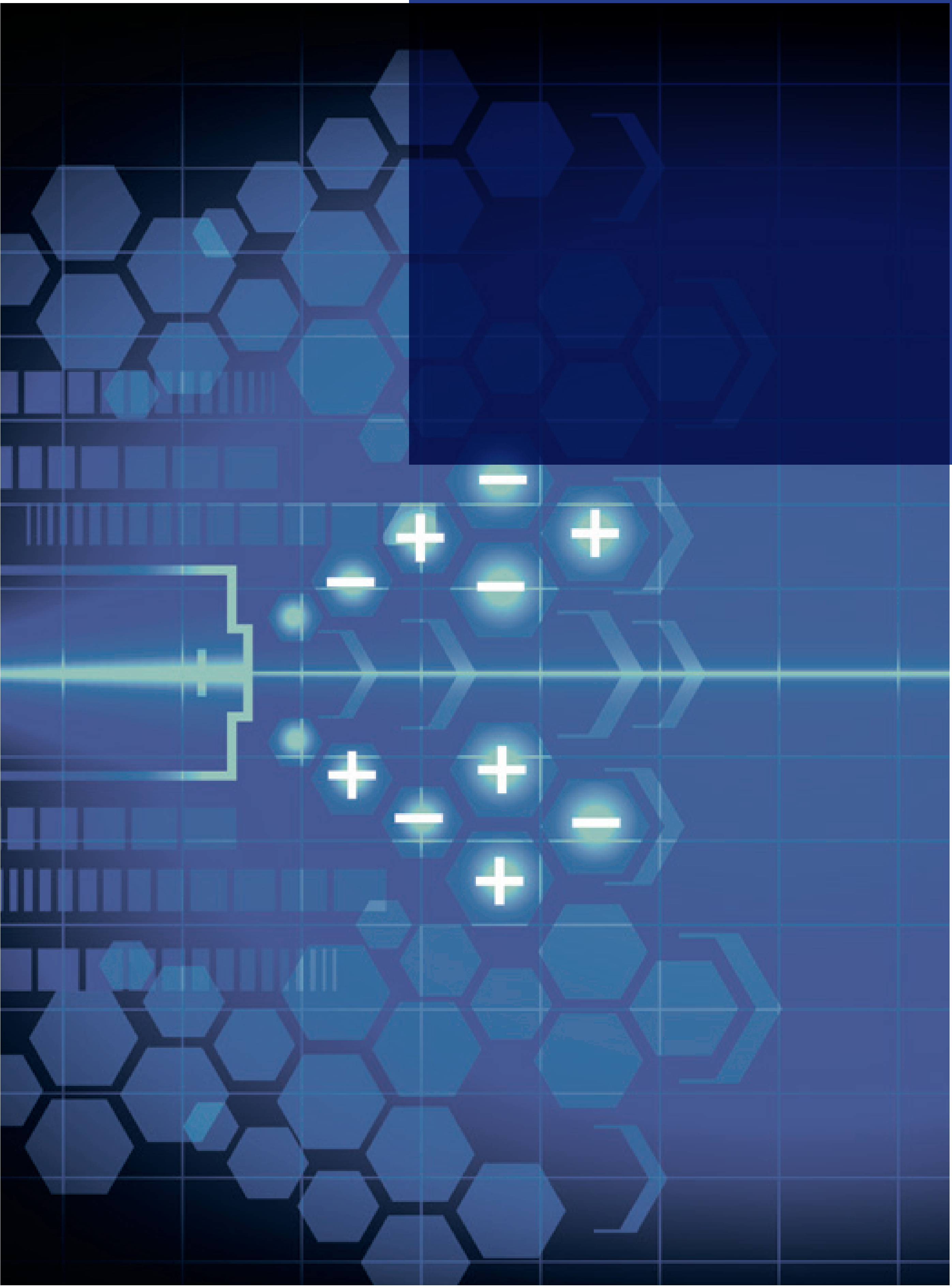
This article provides an update of the battery testing requirements specified in the latest revision of NERC PRC-005, focused to illustrate the required testing schedule, and the scope of the two main electrical tests to be performed for a successful battery maintenance program. NERC requirements are summarized next to existing IEEE and NETA battery testing recommendations to provide a quick reference when determining a maintenance program.

The current NERC standard is PRC-005-6, and enforcement of this revision started on January 1, 2016. This standard applies to generation and transmission and distribution providers, with specific protection facilities associated with the Bulk Electrical System (BES). The purpose of the standard is to document and implement maintenance programs for all protection systems affecting the reliability of the BES to keep them in working order.

PRC-005-6 contains five requirements identified as R1 to R5. The batteries are covered by R1, where it is stated that a Protection System Maintenance Program (PSMP) shall be established, and all batteries associated with the DC supply of a protection system must be included in a time-based program described in **Table 1-4** of the standard. The rest of the requirements for the protection system allow the owner to enact a performance- or time-based maintenance, or a combination of both.

The Compliance Enforcement Authority is delegated to eight Regional Entities shown in the NERC map (**Figure 1**). →

Figure 1: *NERC delegates for monitoring and enforcement of compliance (Source: NERC)*



If a utility fails to comply with the standard, Appendix 4B: Sanction Guidelines of the NERC, from the Rules of Procedures, is used to enforce the requirements and apply monetary or non-monetary sanctions. For the monetary sanctions, an initial value range for the base penalty amount is determined by considering the Violation Risk Factor (VRF) assigned to the requirement and the Violation Severity Level assessed for the violation. The intersection of the violation's VRF and VSL in the Base Penalty Amount Table defines the initial value range that could be applied for each day that a violation continues (**Figure 2**).

The required maintenance activities of the time-based program are divided according to the type of battery: Vented Lead Acid (Table 1-4a), Valve Regulated Lead Acid (Table 1-4b) and Nickel-Cadmium (Ni-Cd) (Table 1-4c). All of the activities of verification, inspection and testing should be documented and retained as evidence for audits. The time-based maintenance includes four-six, 18-month inspections and six- or three-year performance testing (**Figures 3, 4 and 5**).

Violation Risk Factor	Violation Severity Level							
	Low		Moderate		High		Severe	
	Range Limits		Range Limits		Range Limits		Range Limits	
	Low	High	Low	High	Low	High	Low	High
Low	$1,000	$3,000	$2,000	$7,500	$3,000	$15,000	$5,000	$25,000
Medium	$2,000	$30,000	$4,000	$100,000	$6,000	$200,000	$10,000	$335,000
High	$4,000	$125,000	$8,000	$300,000	$12,000	$625,000	$20,000	$1,000,000

Figure 2: Base Penalty Amount Table from NERC Rules of Procedure (Source: NERC)

Table 1 - 4 (a): Vented Lead Acid		
4 Calendar Months	18 Calendar Months	18 Calendar Months
Verify station DC supply voltage	Verify float voltage of battery charger	Verify that the station battery can perform as manufactured by evaluating cell / unit measurements indicative of battery performance (e.g. internal ohmic values or float current) against the station battery baseline. OR
Inspect electrolyte levels	Verify battery terminal connection resistance	
Inspect for un-intentional grounds	Verify battery continuity	
	Verify battery inter-cell or unit-to-unit connection resistance	6 Calendar Years
	Inspect the condition of all cells where visible OR Measure ohmic values when cells are not visible	Verify that the station battery can perform as manufactured by conducting a performance or modified performance capacity test of the entire bank.
	Inspect physical condition of battery rack	

Figure 3: Table 1-4(a): Vented Lead Acid from PRC-005

Table 1 - 4 (b): Valve Regulated Lead Acid			
4 Calendar Months	**6 Calendar Months**	**18 Calendar Months**	**6 Calendar Months**
Verify station DC supply voltage	Inspect condition of all individual units by measuring battery cell / unit internal ohmic values	Verify float voltage of battery charger	Verify that the station battery can perform as manufactured by evaluating cell / unit measurements indicative of battery performance (e.g. internal ohmic values or float current) against the station battery baseline. **OR**
Inspect for un-intentional grounds		Verify battery terminal connection resistance	
		Verify battery inter-cell or unit-to-unit connection resistance	
		Verify battery continuity	**3 Calendar Years**
		Inspect physical condition of battery rack	Verify that the battery can perform as manufactured by conducting a performance or modified performance tests.

Figure 4: Table 1-4(b) Valve Regulated Lead Acid from PRC-005

Table 1 - 4 (c): Nickel - Cadmium		
4 Calendar Months	**18 Calendar Months**	**6 Calendar Years**
Verify station DC supply voltage	Verify float voltage of battery charger	Performance or modified performance discharge test
Inspect electrolyte levels	Verify battery terminal connection resistance	
Inspect for un-intentional grounds	Verify battery inter-cell or unit-to-unit connection resistance	
	Verify battery continuity	
	Inspect the condition of all cells	
	Inspect physical condition of battery rack	

Figure 5: Table 1-4(c) Nickel-Cadmium from PRC-005

The two major tests that are indicated in the activities are the performance discharge test of the battery bank and the internal ohmic values for each cell. The ohmic value measurement in the VLA batteries is an option for when it is not possible to perform a visual inspection, and an option to determine if the battery can perform as manufactured. In the VRLA batteries, ohmic measurement is required every six months, mainly because it is not possible to do a visual inspection. It is also an option to determine if the battery can perform as manufactured instead of running a performance test.

For the Ni-Cd, the only major test that is required is the performance test. In Ni-Cd batteries, neither the nickel nor the cadmium readily dissolves in the alkaline electrolyte; hence, the ohmic value might not change in time. Instead, it mostly remains constant until the battery reaches the end of life, and it might not even change. Therefore, a Ni-Cd battery with an ohmic value different from the baseline is an indication of a problem; however, a value without a change in time does not necessarily mean a good battery.

When defining a PSMP for the battery system, the activities listed in Table 1-4 are the minimum to be included but additional activities can be added according to the needs or conditions of the system. IEEE and NETA have recommendations for battery maintenance that can be used as a reference when adding maintenance activities for batteries. →

Figure 6 shows a summary of all the activities listed among PRC-005 (P-blue), IEEE 450 (I-green) and NETA MTS (N-yellow) for VLA and VRLA batteries and their recommended periodicity. Further detailed tables for VLA, VRLA and Ni-Cd batteries can be obtained from http://bit.ly/2iXcdsN.

Activity	Monthly				Quarterly/ Tri-annual*				Yearly/18-months*					
	VLA		VRLA		VLA		VRLA		VLA			VRLA[1]		
Float voltage measured at the battery terminals	I		I		I	P	I		I	N	P	I	N	P
General appearance and cleanliness of the whole installation	I	N	I	N	I		I		I			I		
Charger output current and voltage	I		I		I		I	P	I			I		
Crack in cells (evidence of electrolyte leakage)	I		I		I		I		I			I		
Evidence of corrosion at terminals, connectors, racks or cabinets	I	N	I	N	I		I		I			I		
Ambient temperature and ventilation	I	N	I	N	I		I		I			I		
Pilot cells (if used) voltage and electrolyte temperature	I				I				I					
Battery float charging current or pilot cell specific gravity	I				I				I					
Unintentional battery grounds	I	N		N	I	P		P	I					
Electrolyte levels	I	N			I	P			I					
Voltage of each cell					I		I		I	N			N	
Specific gravity of 10% of the cells of the battery					I[2]				I					
Temperature of at least 10% of the cells					I				I					
Temperature of the negative terminal of each cell							I					I	N	
Specific gravity of all cells									I[2]					
Cell condition									I		P			
Cell / unit internal ohmic values							I	P[10]		N	P[4]	I	N	P
Cell-to-cell and terminal connection resistance		N[6]		N[6]					I	N	P[3]	I	N	P
Structural integrity of the battery rack		N		N					I		P			P
AC ripple current and/or voltage imposed on the battery												I		
Performance or modified performance capacity test of entire bank									I[8]	N[8]	P[4]	I[9]	N[9]	P[10]
Verify tightness of accessible bolted electrical connections[3]		N[6]		N[6]										
Perform a thermographic survey under load[4]		N[6]		N[6]										
Verify presence of flame arresters		N												
Verify existence of suitable eyewash equipment		N		N										
Verify equalizing voltage setting is in accordance to Battery Manufacturer's recommendations										N			N	
Verify all charger functions and alarms										N			N	

Notes:

***Tri-annual (4-month) time frames indicated in NERC-PRC-005-6**

1. **This inspection applies for the initial installation as well, according to IEEE Std. 1188**
2. **For lead-antimony batteries. For other technologies, only if float charging current is not used to monitor state of charge**
3. **Standard indicates to verify battery continuity, terminal connection resistance, intercell or unit-to-unit connection resistance**
4. **Standard indicates to evaluate battery performance by indicative measurements like internal ohmic values or float current every 18 months or perform a capacity test every 6 years**
5. **NETA MTS Table 100.12**
6. **Only one of the three actions is required**
7. **According to NETA MTS Section 9**
8. **Intervals and test procedure according to IEEE Std 450, every 25% of life expectancy or two years (whichever is less)**
9. **Intervals and test procedure according to IEEE Std 1188, every 25% of life expectancy or two years (whichever is less)**
10. **Measure internal ohmic values every 6 months or perform a capacity test every 3 years**

Figure 6: *Summary of battery maintenance requirements from PRC-005, IEEE 450 and NETA MTS*

Both the ohmic measurement and performance tests have their own specific procedures to obtain proper and reliable results.

Ohmic Measurements:

Pending construction type and health condition, lead acid battery cells will have a characteristic ohmic value. If this value is measured under consistent conditions and good testing practices, the battery can be characterized and trended to identify degradation. As a rule, if the internal resistance or impedance value increases, the capacity of the cell will be reduced; however, there is no direct correlation to apply for capacity calculation and the result is a relative value. Three different technologies are available to measure ohmic values: resistance, conductance and impedance.

For ohmic measurements, the battery should be in electrical, chemical, and thermal equilibrium. To obtain repeatable and reliable results it is recommended to perform the measurements when the battery is fully charged and 72 hours after adding water or charging the battery. Changing floating signal, such as the one influenced by ripple or noise from the charger or the loads will also affect repeatability.

In addition to the requirements above, a constant use of the same measurement technology (instrument type and leads) will guarantee reliable and consistent data for analysis.

Degradation of a cell can be defined based on trending and identifying cells for further investigation, based on a significant modification of the measurement. **Figure 7** shows four yearly results of a 60-cell bank.

Three different comparison methods can be used to determine if a cell or the string is deteriorating:

- Variation from each cell measurement when compared to the average value of the string. A high variation from the string average is not necessarily an indication of a bad cell; it may be poor connections causing inadequate charging or need of equalization. This method is for short-term analysis and at the beginning of measurements on a string.
- Change from the previous measurement for each cell. This helps to locate cells that may be about to fail in the mid-term period of the data trending.
- Deviation from a string baseline value established once the battery is installed and fully developed during the first year of life. This helps to identify how much the cells and the string have aged, especially in the long-term of the data trending. If multiple cells have a significant deviation from the baseline, it is an indication of capacity deterioration.

A significant modification is subject to the characteristics of each battery type and manufacturer, therefore it is recommended to trend results and establish specific warning values over time, with knowledge of the battery and consultation with the manufacturer.

For impedance measurements, the following are the recommended evaluation criteria for VLA and VRLA batteries (**Table 1**). These are a starting point; they can vary depending on the battery or environment and should be adjusted as successive testing and investigation is performed. →

FIGURE 7

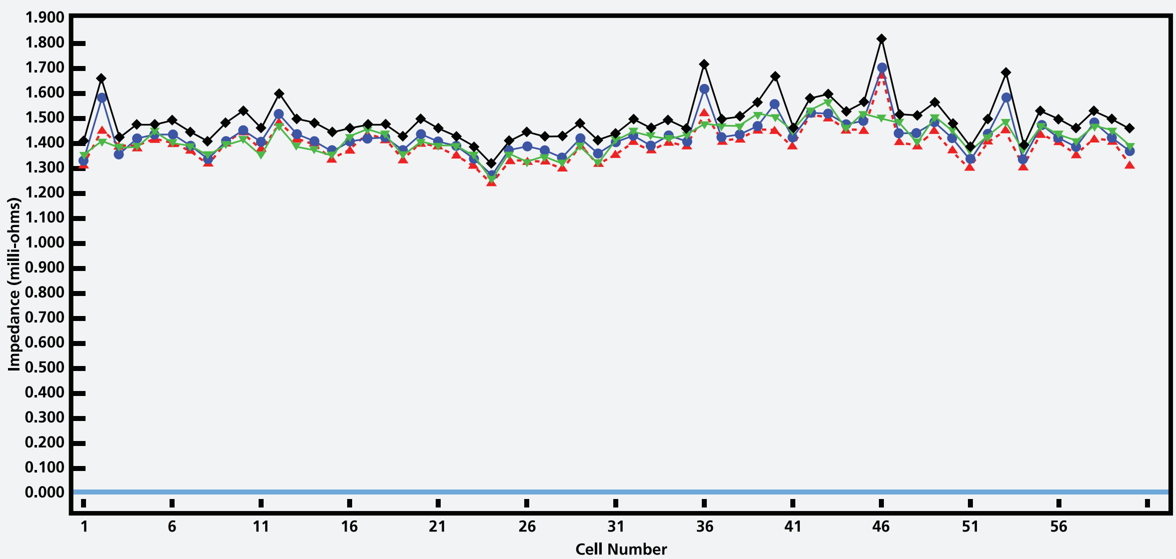


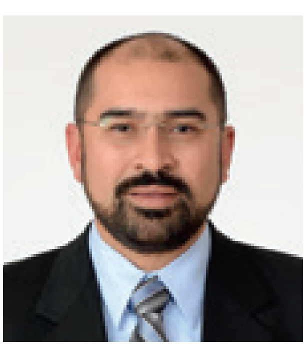
Figure 7: *Impedance results of a 60-cell bank. Four consecutive years of testing.*

-- Baseline ◆ 1/24/2005 ● 2/17/2004 ▲ 2/22/2003 ▲ 2/16/2002

Type of Battery	Single Test	Single Test	
Lead Acid	% variation from average	% change from last test	% Deviation
	30	5 – 10	30 - 50

Table 1: *Impedance evaluation criteria*

An impedance tester provides the voltage of each cell, float and ripple current, and strap resistances in addition to the ohmic value. All of these measurements are included in the monthly, quarterly or yearly requirements, so it makes sense to use one single instrument to perform all the measurements in one single operation for each cell.



ABOUT THE AUTHOR:

Volney Naranjo is senior applications engineer at Megger. He has more than 16 years of experience working in the power engineering industry, providing professional services for design, and testing and commissioning of power systems as field engineer and project manager. Volney has been working with Megger for more than six years as an application engineer focusing on power transformer, high voltage circuit breaker, battery and power quality testing. He graduated in 2001 from the University of Valle in Cali, Colombia with a Bachelor of Science in electrical engineering and is a member of IEEE-PES.

Discharge and Performance Test

A discharge test is that in which the battery delivers a current to a load to determine its ability to meet specific criteria such as duty cycle, service or a determined capacity before or at reaching its end of discharge voltage. The voltage of each cell should be monitored throughout the discharge to identify weak cells. The test result will determine if the battery needs to be maintained, or replaced either totally or partially.

The performance test included in the PRC-005 requirements is, in essence, a test to determine the percentage capacity of the battery. The modified performance in addition to the percentage capacity also helps to determine if the battery can meet a specific duty cycle. To run a performance test, the following is required:

- Battery fully charged, in equilibrium, and maintained as per monthly/quarterly requirements
- Record the temperature at the beginning of the test
- Desired discharge time (typically longer than one hour)
- Manufacturer specified constant current or constant power for the desired discharge time at a specified temperature
- End of discharge voltage
- Load bank capable to draw a constant current or power from the battery with the ability to stop the test when the overall voltage reaches the end of discharge level
- Means to measure individual cell voltages throughout the test

The purpose of the test is to determine the true capacity of the battery by finding the time that it takes the battery to reach the end of discharge voltage and compare it to the expected time from the battery specifications. The ratio between the resulting time and the expected time defines the capacity of the battery in percentages. If the temperature of the battery is different from 25 °C (in some cases 20 °C), a correction factor should be applied: $\%C=(T_a/(T_s*K_T))*100$. Temperature correction factors are provided in IEEE 450 for lead acid and IEEE 1106 for Ni-Cd batteries.

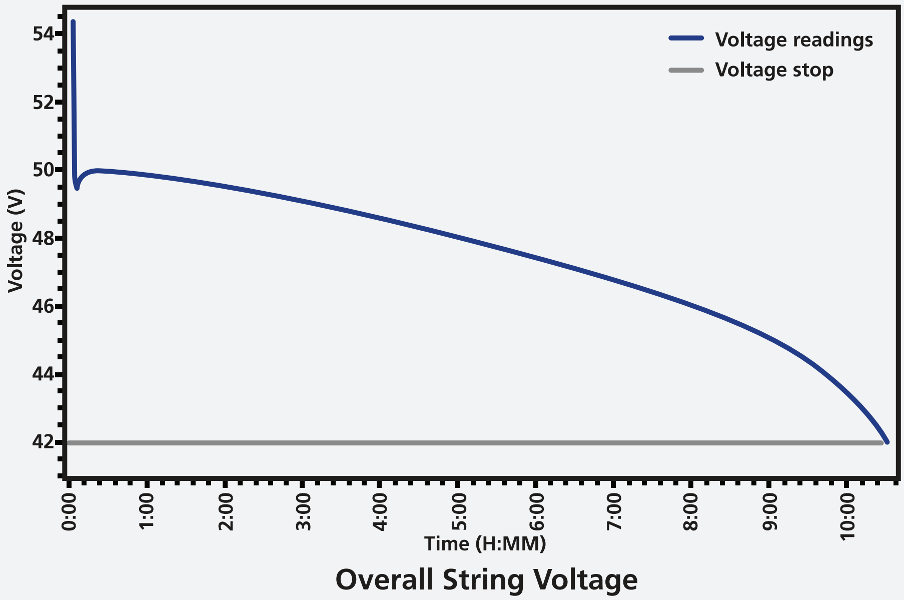
When defining the desired duration of the test, it is recommended to select a time close or equal to the duty cycle of the battery, to confirm the ability of the battery bank to meet the expected duty cycle, in addition to the capacity.

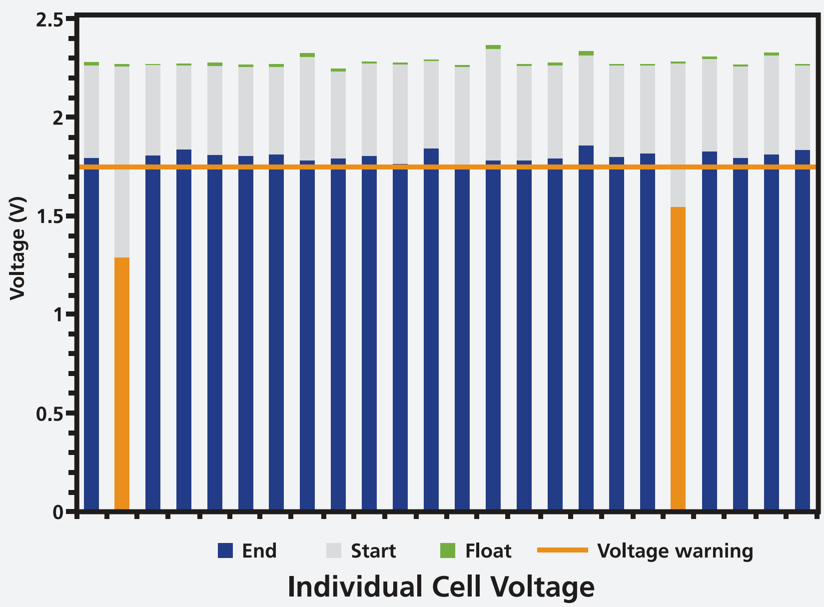
Furthermore, when performing the test periodically, it is recommended to use always the same duration in order to trend historic results.

The standardized IEEE passing criteria for Lead Acid and Nickel Cadmium batteries are 80 percent capacity. At the beginning of the life of the battery is very common to measure capacities ranging from 90 - to - 110 percent or above. Below 80 percent of capacity, provisions should be taken to replace the battery within a year.

Cell voltages should be recorded throughout the test, but a minimum of three instances is required at the beginning, the middle and at the end of the test. The purpose is to identify weak cells that could be affecting the overall capacity of the bank, or if it is a generalized string deterioration. In lead acid batteries, when a cell reaches the minimum voltage before 90 percent of →

FIGURE 8





Torkel

Measured Capacity (Ah)	Corrected Capacity (Ah)	Percent Capacity	Discharge Time (HH:MM:SS)	Pause Time (HH:MM:SS)
135.4	137.3	133.364	10:31:11	00:00:00

Float Voltage	Open Total Voltage	Start Voltage	End Voltage
54.6	54.34	52.55	41.98

Figure 8: *Battery performance test result*

the completion of the test, it should be bypassed to avoid polarity reversal, which is the moment in which the cell will become a load for the bank.

If a cell or cells are identified as weak or are bypassed, depending on the age of the battery and the final capacity result, it might be applicable to replace these cells to improve the capacity of the string. If the cells are just removed, not replaced, the charger floating voltages should be recalculated to the appropriate level to avoid overcharging or overvoltage that can lead to permanent gassing and dry-out of the cells.

Considering that the battery might operate with weak cells, or even without them, the question arises of the maximum number of cells to be bypassed. The recommended criterion to define this is by determining the minimum voltage required by the system being supplied by the battery to avoid reaching under-voltage limits.

Bypassing a cell should be done in a maximum of six minutes, which requires preparation and appropriate practices to avoid accidents. Hence, the decision should be based on the proper amount of data from the cells. Measuring the cell voltage in prolonged intervals might lead to a late identification of a weak cell risking a polarity reversal in lead acid batteries. Technology now allows monitoring the voltage of each cell throughout the test and identifying weak cells accurately and in a timely manner.

The typical result of a performance test includes the overall voltage curve during the discharge and the capacity calculation. This is complemented with overall and individual float voltage before turning off the charger, open circuit voltage before starting the test, as well as the start and end voltage. If there is any pause during the test, it is also important to document it to show that the time limit was not exceeded. Figure 8 presents a simplified example of a performance test result.

A performance test provides an absolute result and is the only way to determine exactly the state of health (SOH) of the battery. However, it is a test that can be resource-demanding and might require having available a backup during the test and the recharge of the battery to avoid unavailability of the equipment backed up by the battery.

On the other hand, ohmic measurements, like the impedance method, provide a relative measurement. When performed under consistent and good testing practices provides a simple and comprehensive online method to assess the condition of the string and each cell. This can be used to determine further investigation or to decide the replacement of a cell or the entire string. It also provides extra measurements that are required by the standards and regulations on regular maintenance testing.

Proper PSMP implementation requires considering the type of batteries, the standards and regulations, available resources and specific conditions or needs. Reviewing the standards provides the necessary references, but it is very important to understand and know what testing equipment can do, so it is selected properly to meet the testing needs and assure efficiency and accuracy during the maintenance activities.

TRACKING WORKERS, BORROWED CREWS

AND CONTRACTORS DURING A HURRICANE

CAROL JOHNSTON

Hurricane Harvey hit Texas in August 2017, the first hurricane to make landfall in the United States in 12 years. Over a four-day period, many areas received more than 40 inches of rain, which caused catastrophic flooding and required extensive power restoration.

The devastation from Hurricane Harvey prompted an application developer to offer its worker location app for utilities in the path of the upcoming Hurricane Irma, which was expected to make landfall in Florida in early September and then continue as a tropical storm north towards Atlanta.

Hurricane Irma was expected to be the most intense Atlantic hurricane to strike the United States since Katrina in 2005, and getting this technology to utilities ahead of the event would speed restorations and ensure workers were kept safe.

Fast Deployment – No Learning Curve

Adding new technology so close to a major event could have been overwhelming to office and field staff, but the worker location app is instantly installed and used with no learning curve. Incoming crews, provided through mutual aid programs are set up as part of the foreign crew onboarding process and are instantly tracked on the borrowing utility's workforce or outage management maps.

The app is loaded to the worker's own smartphone or tablet, eliminating the need to provide and train on new hardware. And when a worker is not on the clock a simple suspend button ensures their privacy is maintained.

Partnering with a solutions provider in the telecommunications space, the app developer was able to contact affected utilities the weeks leading up to Hurricane Irma with an offer to provide the worker location app at no cost to track their workers, crews and contractors during the event – including those provided through mutual aid assistance.

Excelsior Electric Membership Corporation (EEMC) accepted the offer, and within a day they were on site to assist. The automated worker location app was then set up at EEMC in less than 24 hours. →

Real-time GPS Tracking of Vehicles and Workers

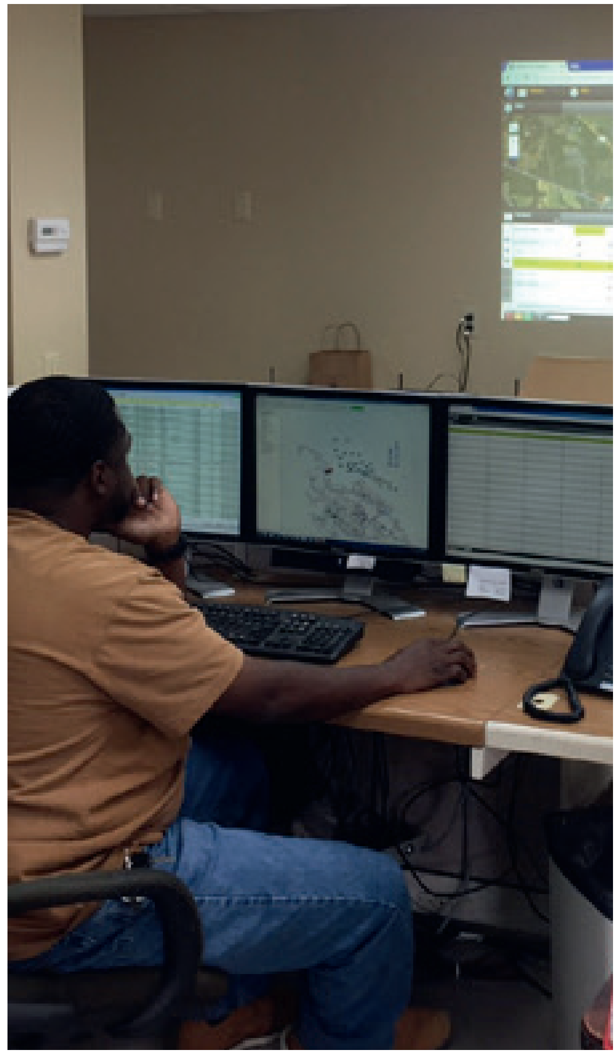
The utility was well prepared for bringing in foreign crews, having learned valuable lessons from their response to Hurricane Mathew in 2016. As the president of EEMC stated in a letter to their members after the event, "the odds of having two major outage events in consecutive years doesn't seem likely, but Mother Nature is anything but predictable."

EEMC had nine dispatch workstations prepared, and divided the crews among them. With assistance from the solutions provider, they loaded the donated app to their own workers' devices and then to the mutual aid workers that were arriving from neighboring states. On average, it took just 15 minutes per worker to get the app installed, the worker trained, and the worker's location to start appearing on the utility's OMS map.

"During emergencies, a modem in a truck is not accurate enough as a truck might be down the street or a significant distance due to terrain conditions," stated Bill Walden, Manager of Data and Technical Services at EEMC. "This is why we had our own crews using the app as well as contractors and borrowed crews. We greatly improved worker safety while crews were energizing lines, and the app made easy work of getting materials, equipment and food out to crews in the field without chasing them down."

More Than 150 Workers from Six States Quickly Restored Power

In total there were 150 workers restoring power to the EEMC territory after Hurricane Irma, including mutual aid crews from Oklahoma, Kentucky, Virginia, Arkansas and Washington. More than 85 percent — over 18,000 meters — of the territory was affected but in 72 hours the utility had 100 percent restoration.

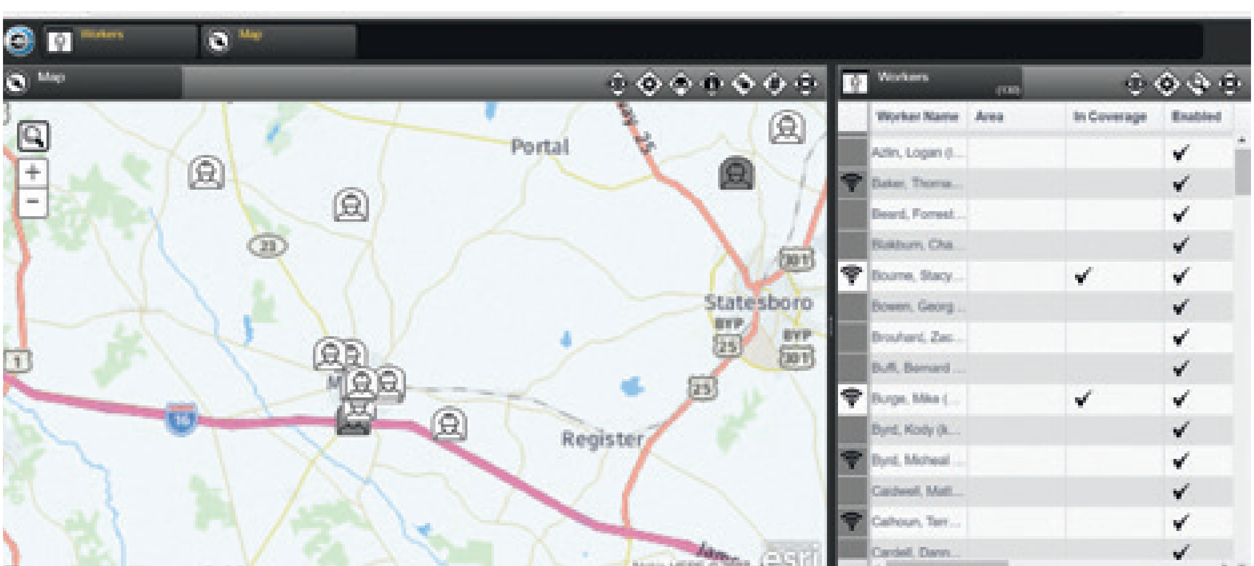


The use of the automated worker location app during a major event was considered a success by EEMC. The deployment of the app was quick and easy, and the consistent performance of the app led the utility to keep it operational until all meters that could safely receive power were restored.

ABOUT THE AUTHOR:

Carol Johnston has more than 15 years of experience working in the mobile workforce management and other related technology industries. Prior to Clevest, she was VP of product and strategic partnerships for Bazinga Technologies, solutions manager for ABB Software (formerly Ventyx), and product line manager for Itron, where she managed their product and go-to-market strategies.


Worker Location
Suspend
Log Out
You are currently reporting your location. Click the Suspend button to temporarily suspend reporting.


Map
Workers
Portal
Statesboro
Register
Worker Name
Area
In Coverage
Enabled

BYLINE

POWERING THROUGH

SEVERE WEATHER OUTAGES

DON LEICK

Larger utilities typically spend significant dollars to contract with professional weather services, especially to be better prepared to restore power after storms. Why, with all the good free weather available from the National Weather Service and free (ad-based) weather, is that still the case? If you're a small to medium sized co-op or municipality using free weather, what are you missing? What's the value of a weather service geared to serve utility needs? Is free weather actually costing you?

In this article, we'll focus on the benefits of working with a service to improve your storm response. A professional weather service can have value for day-to-day operational planning, and more value on the load/generation side of things, but the greatest return on investment is around better staffing decisions before storms. It's not just basic forecasts of wind or thunderstorms. How severe will the weather really be? Timing is critical for making potentially costly decisions about holding crews over, putting crews on call overnight or over the weekend. Make the wrong decision and you can waste a lot of money in unused crews, or have a real PR disaster in a poor storm response because you weren't adequately prepared.

For utilities, there are three reasons why a professional weather service is extremely valuable over free weather:

1. Lightning data
2. Meteorological consulting
3. Specialized services and products designed for utilities

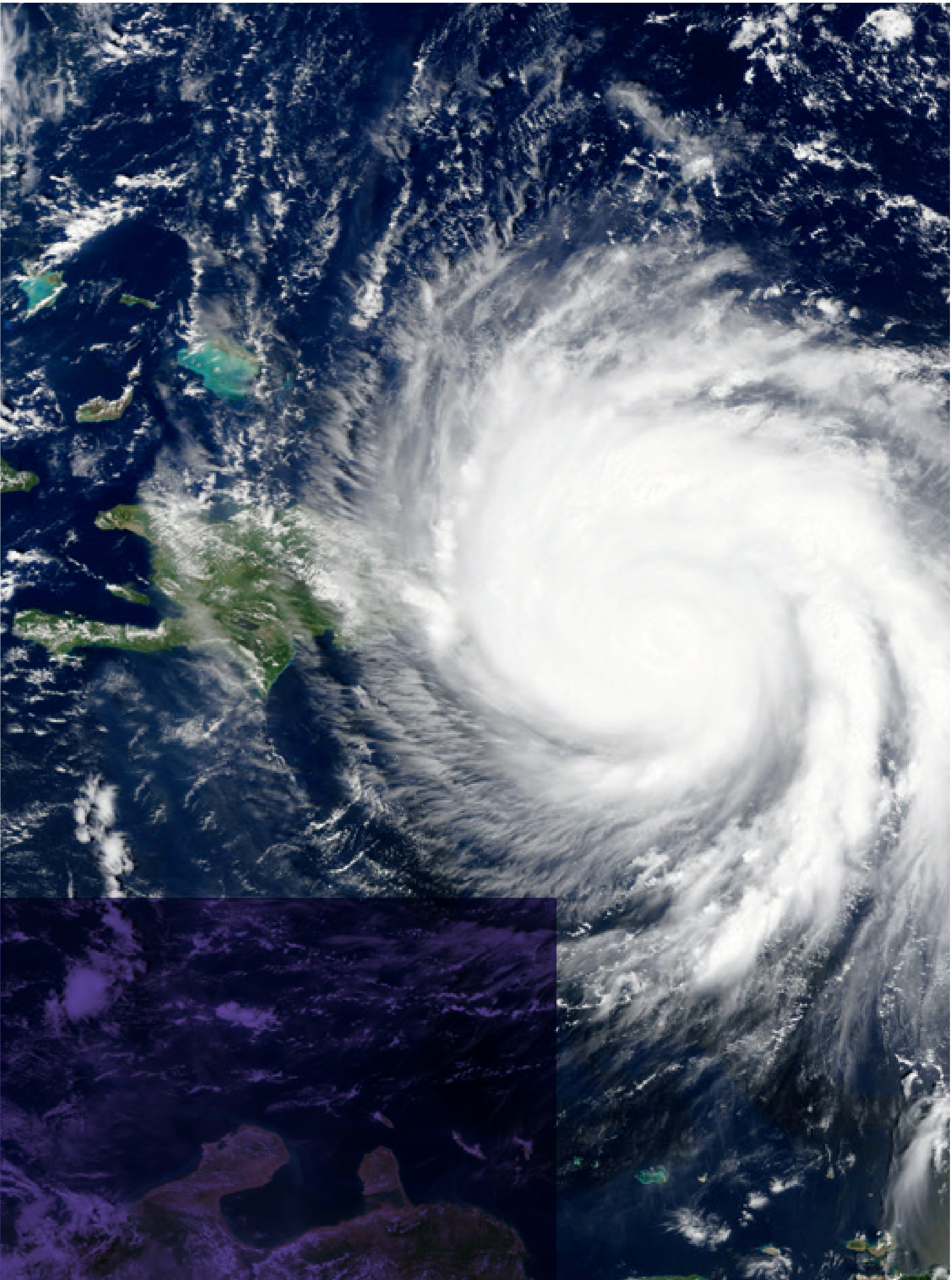
We'll look at each of these, and then put it all together.

Lightning Data is Key

Mapping of real-time lightning strikes is very valuable for making near-term decisions about the impact an approaching storm may have and the number of crews that may be needed. There is a strong correlation between the amount of lightning and the winds that can be expected. So, not only does display of each lightning strike show if you may have outages due to lightning itself but it also helps indicate the severity of wind damage you can expect. Free weather services either have no lightning data, delay the lightning, or use backyard hobbyist sensors that can't be relied upon.

Professional services can issue lightning alerts. This is valuable if you're a small utility without 24/7 weather monitoring. And during restoration, for safety when thunderstorms re-develop, lightning alerts can even be sent directly to the phones of crews, using their GPS position, so dispatchers don't have to monitor weather for the crews.

Historical lightning data is also valuable. Some professional services allow you to overlay lightning strike position against your infrastructure – such as your substations – on the map too. While other services even generate automated reports for inspections. This provides a list of substations to inspect after a storm if a strike occurred in close proximity. The strike may have caused damage but not an outage and this enables you to detect and fix the issue before an unexpected major failure occurs. The exact time of strike is included and that can be correlated to faults or other outage or SCADA data. Professional services include amplitude and polarity to help you identify strikes that are more likely to cause damage. →



Professional Meteorological Consulting is Especially Helpful to Utilities

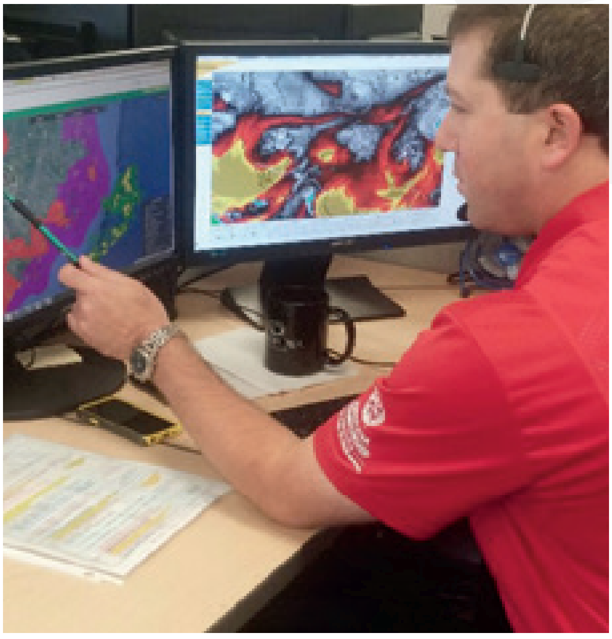
Even as weather models and resulting forecasts continuously improve, a human being still adds much value to a utility. First, weather models do a great job with temperature and are getting better with precipitation probability. But severe weather, especially high winds, not so much. Weather models tend to under-forecast high winds. This is especially the case several days out. An experienced meteorologist adds significant value when you most need it. They can adjust the forecast or give you other guidance about what to really expect.

Meteorological consulting is especially helpful in understanding your risk. What's the likelihood of the event being significantly worse than what's forecasted? How much worse? Usually it is prudent to staff for not just the most likely scenario, which is what a weather forecast is. So what is the realistic worst case for this event? Tricky and particularly concerning events like ice storms are another example of the value of consulting with a meteorologist. Very small changes in the forecast can mean the difference between rain and ice. You have a lot riding on your decisions and the support of a weather professional who really understands not only the weather but also the decisions you need to make is invaluable.

Consulting or meteorological input can take many forms. It can be a forecast specially prepared for you. It can be phone consulting when you need it. It can be question and answer consulting online. It can be a storm briefing or briefings before a storm. Forecasts can be aligned to your service territory divisions (how you geographically organize your work). And they can take into account operational considerations such as various actions you take at forecasted wind speed thresholds.

Experienced meteorologists who work with utilities understand these things and factors such as leaves on trees results in a more severe impact. Or that soil saturation can come into play and make a major wind event even more major.

Free weather gives you none of these benefits. Utilities that use high quality meteorological consulting come to trust and deeply rely upon these people. They're like an extension of your staff, 24/7.



Products Geared to Power Utilities

We've just talked about people – professional meteorological support. Now let's talk product. Professional weather service products offer many features useful to utilities including features specifically designed for utilities.

Some professional products can display utility service territory boundaries, transmission lines, substations, and other infrastructure, so you can see weather in the context of your utility. You may also be able to import custom layers.

Tools to gage distance and time of arrival of a storm, help you with more precise crew callouts. Some products provide indicators of impending severe weather in addition to radar and lightning – indicators like severe storm cells or corridors. And local storm reports from weather spotters or other on-the-ground observers.

Automated alerts can watch the weather for you – and give alerts for way more than just NWS bulletins. Alerts can give you a heads up on forecasted or current weather conditions of concern to you, based on your specific thresholds.

After the storm, professional tools can provide various types of historical data for post-storm analysis and reporting to management.

Some weather services have features specifically for display on a large monitor in your operations center or control room, continuously cycling through various saved views.

And in the mobile world of your crews, you should also be able to get these professional features on apps on your phone.

So Much More than Just Getting a Forecast

Yes, free weather keeps getting better – but the paid weather services keep getting better too. So whether it's lightning data, meteorological consulting, or specialized product features, a professional weather service brings enormous value to the operations side of the utility business. If you're trying to get by using free weather, now you know what you're missing. With so much riding on preparing for power restoration – expensive crews, your reputation with customers, executive management's expectations around time of restoration and more – a professional weather service is an excellent investment.

ABOUT THE AUTHOR:

Don Leick is the senior product manager for DTN's weather business. He leads the future direction and enhancement of online, mobile and alerting products. He's been the product manager for the WeatherSentry product for most of his 13 years with the company. Leick has extensive experience working with many of DTN's customer segments including utilities, wind farms, sports and winter road maintenance.

EDITORIAL

POWERING PATIENT CARE WITH INTELLIGENT POWER DISTRIBUTION

JACK MCCAULEY

Power is the beating heart of a healthcare facility. Without it, the hospital, surgical center or aging facility cannot function. The challenge of delivering reliable power is compounded by aging infrastructure, inefficient power distribution systems and thin operating margins. Given the critical nature of reliable power in delivering a safe, healthy, clinical environment, healthcare facilities must embrace modern, connected technologies to improve efficiency and financial health without compromising patient care.

IoT-enabled Care

Advanced technologies, in particular, the Internet of Things (IoT), can help healthcare facilities meet their power needs. Beyond the more obvious trends in wearables and machine-to-machine (M2M) communication, IoT is gaining adoption as a means for improving facility management and operation. Connected devices feed data to building, IT, power, security and clinical management systems to create intelligent hospital systems.

Within a healthcare infrastructure environment, IoT-enabled devices can take many forms: temperature sensors, power meters, circuit breaker panels, uninterruptible power supply (UPS) devices, building automation controllers and more. When integrated with software and analytics as part of an intelligent solution, these devices provide the means by which healthcare facilities can monitor energy use, reduce energy costs, monitor equipment performance, improve predictive maintenance, ensure available backup power and much more.

Trends in healthcare IoT

An important trend in healthcare IoT is the convergence of information technology (IT) – the computer systems and networks that store and manage business data →

– and operational technology (OT) – the hardware and software required to manage staff, resources, equipment and facilities. This convergence can promote greater efficiencies and productivity and reduces costs across industries.

This trend is significant as it is leading to greater use and ROI of connected infrastructure devices. These IoT-enabled devices provide embedded intelligence and control, can often be controlled and monitored via cloud, and with the help of software, can provide advanced data analytics.

In new facilities, this convergence will be built into the design plans, allowing for optimal technology interoperability. In aging facilities, a technology layer will update legacy infrastructure, making it future-ready. In both cases, IoT-enabled solutions can be leveraged to deliver real-time visibility into the facilities' power distribution systems to ensure the reliable power necessary for facility processes, patient and staff safety, energy efficiency and financial health.

Intelligent power distribution and management for healthcare

IT/OT convergence relies on a secure, open, scalable, and flexible IoT platform that connects three core layers of technology—connected products, monitoring and control software, and apps and analytics. These technologies combine to create intelligent power distribution that delivers power quality and reliability.

In a healthcare environment, this may include:

- Electrical distribution through smart panels
- Metering to measure power consumption and power quality
- Monitoring using a system that offers real-time data on power use and quality
- Fault detection including automatic alerts of electrical faults
- Automatic generator or emergency power supply system (EPSS) testing, which is mandatory for health facilities in many countries
- Operating theater environment monitoring where loss of power can have life or death consequence

Because of the critical nature of hospital power, an IoT-enabled power monitoring system can be used to provide automated testing of a facility's emergency power supply. An EPSS test can collect data from and control key assets in the systems – generators and automatic transfer switches (ATS) – and test these assets regularly to confirm optimal operation and a reliable backup power system for the hospital and patients. This not only increases reliability due to the accurate monitoring and recording of test parameters, it greatly reduces the burden on staff to conduct such tests.

Smart panels provide another means of intelligent power management. Essentially a circuit breaker and meter in one, smart panels make it possible for electrical equipment to communicate about power usage quality and asset status from a digital screen within the panel or a remotely connected device. Facility managers can monitor energy information, as well as physical properties, including trip status, cycle count, and contact wear indicators. Smart panels enable remote management of electrical distribution assets in different locations across a hospital campus or a distributed health system.

Powering Facility Processes

Since even a momentary power failure can have serious consequences for patients, secure power is fundamental to a healthcare facility's processes – both medical and nonmedical. Critical medical processes within a healthcare facility carry the highest risk in terms of a power outage. Operating rooms, emergency departments, and intensive care units rely on commercial loads (computers and servers) and industrial loads (medical gas systems and scanners), all of which require continuous power quality.

Critical nonmedical processes involve management of patient data systems, electronic medical records, physical and data security, IT management software and more. Medical staff must have consistent, quick access to the IT system and reliable power for backup procedures and archiving making critical power and cooling fundamental to supporting nonmedical processes.

Safety First and Always

Patient safety is of paramount concern for every healthcare facility. Uninterrupted access to power can mean the difference between life and death. Hospitals and surgical centers need constant, reliable power to feed medical instruments, life support machines, and diagnostic equipment. Reliable power is critical to ensure these functions run smoothly in order to provide adequate care and ensure patient satisfaction.

IoT-enabled solutions can monitor the power status of critical loads and provide system data to staff via easy-to-read dashboards. For example, operating theater environment monitoring provides real-time information on power status, room temperature and more, from one screen. In the event that a power fault occurs, nurses and surgeons can quickly assess the electrical health within the operating room and determine if they have enough power to continue the surgery. Additionally, insulation monitoring system information helps protect patients from electrical shocks. With these tools, healthcare professionals have the information they need to prevent operating room downtime and ensure patient and staff safety.

Protect Equipment and Financial Health

In addition to patient and staff safety, the primary concern for facility and operations managers is resiliency and availability of power equipment. And for good reason. If a 200-bed hospital experiences a power outage and its backup generator solution fails, the cost is $1 million, and that costs increases to $5 million for a 500-bed hospital[1].

Power equipment is costly and is not easily replaceable, especially in older facilities. IoT technology helps these facilities keep legacy systems, while identifying new opportunities for cost reduction. Retrofitting old transformers with sensing technology can help prevent failures in the future. IoT-enabled devices can monitor power equipment for power quality, asset status and more and automatically provide notifications if an irregularity is detected, enabling maintenance staff to address problems before a failure can occur.

A power monitoring system can reduce potential financial risk by maximizing power availability and performance. It can help reduce electrical maintenance costs and optimize power distribution and availability to help support operational efficiency and minimize the impact of power events on a facility's function, reputation and finances.

With an asset performance management solution in place, hospitals can expect to reduce maintenance costs by 25-30 percent, eliminate equipment breakdown by 70-75 percent, and reduce equipment downtime due to failure by 35-45 percent[2] .

Improve Energy Efficiency

Hospitals consume large amounts of energy because they operate 24/7, use energy-intensive equipment and have specialized HVAC needs. Beyond medical services, these facilities engage in other energy-intensive work like food service and refrigeration, computer and server use, and laundry.

For healthcare organizations already operating on razor thin margins, energy efficiency is a clear area of focus for cost reduction. With the right technology in place, even the most sustainably-minded organization can uncover energy efficiencies within its power distribution system.

For example, 30 to 40 percent of all unscheduled downtime today is related to power quality issues, including harmonics, voltage dips, flicker, sags, and so on. For power-intensive organizations, such as hospitals, poor power quality forces equipment to work harder, affecting its energy consumption and efficiency. Implementing a power monitoring system can provide visibility into the quality and availability of facility power, enabling facility managers to gain higher efficiency, fewer process interruptions, less wear and tear to equipment, and improved safety. A power management solution translates power quality and equipment data into actionable intelligence. Facility managers can gain visibility into energy consumption trends and real-time data to find sources of power loss or poor power factor. Healthcare facilities are able to improve power reliability while reducing energy-related capital and operational expenses.

Powering Care Now and in the Future

Today's healthcare providers are under mounting pressure to do more with less, while also complying with strict regulations and health and safety measures. With dated infrastructure and an aging population, the world's health facilities will strain under the pressure.

IoT-enabled power management solutions, such as smart electrical panels, connected p ower metering devices and power monitoring software can ensure reliable electrical power to critical areas, identify potential issues before a power failure occurs, reduce operating theater downtime and automatically test emergency power supply systems. Through IoT, there will be new opportunities to improve patient care and satisfaction, which ultimately leads to better patient outcomes.

ABOUT THE AUTHOR:

Jack McCauley is the vice president of Strategic Customers & Segments for Schneider Electric. In his current role, McCauley is responsible for leading the overall business development and growth strategies in the US for the Healthcare, Federal, Hospitality, General Contractor and Real Estate segments and customers. With more than 15 years in the industry, McCauley brings leadership and sales experience in energy management, smart building technologies, power distribution and IT infrastructure solutions. McCauley holds a BA in business management from Washington College and currently lives in Boonsboro, MD with his wife and daughter.

[1] Schneider Electric. How Unreliable Power Affects the Business Value of a Hospital. (2010)

[2] Schneider Electric. How IoT Delivers Better Patient Care and Optimizes Healthcare Facility Operation. (2016)

EDITORIAL

TRANSITIONING TO TRANSACTIVE COST OF SERVICE

DAN GARVEY

WHY UTILITIES WILL NEED MORE GRANULAR FINANCIAL ANALYSES TO SUPPORT 21ST CENTURY BUSINESS MODELS

The proliferation of DERs and the emerging "prosumer" are rapidly changing the way electricity is generated, distributed and consumed. This transformational shift in physical power delivery is beginning to turn the utility business model of the past century on its head. For investor-owned utilities (IOUs), the historical, and, for the most part, successful business model has revolved around a cycle of capital spending on system resources supported by a regulated rate of return through rate-based revenues. This model has been the de-facto standard of the distribution utility since the introduction of "Bonbright's Rate Design Principles" a half-century ago.

Regulatory rate setting produced predictable revenue streams. This, in turn, provided utilities access to low-cost capital secured by bonds to fund the development of the largest interconnected machine in the world – the North American electric grid. →

Locational Resource Planning with Granular Data

For the past 50 years, utility corporate planning has revolved around regulatory approved capital spending plans and the resulting rate-based revenue recovery over the life of capital assets. Investments in system expansion, upgrades and other capital-intensive projects were designed to service the system peak capacity requirements. Until recently, these requirements were determined through the extrapolation of sampling data per rate class and aggregated up to the asset level by a combination of service-point profiles, as well as some actual interval data from commercial accounts with interval-data recorders. This statistical exercise was based largely on estimations and assumptions but did not accurately aggregate load to reflect system constraints on assets hour-by-hour, for example.

System planners currently design system requirements to meet peak load requirements on upstream system assets (e.g., substations, feeders and associated lines). Using the extrapolated statistical approach previously mentioned, these peak load requirements are based upon the system load at certain hours of the year. Reliability is "job one" for utilities, so, in many cases, this approach has led engineers to err on the side of caution and oversize assets and/or prematurely upgrade them. Needless to say, this has led to inefficient capacity utilization.

As AMI replaces scalar meters across the distribution system, hourly (or even sub-hourly) data will become the standard measurement interval for all service point measurements. This granular spatial and temporal data will provide utility system planners with aggregate asset level data that more accurately reflects the flows on every system asset for every measurement period. Service point-by-service point, hour-by-hour, minute-by-minute and second-by-second analysis of this granular data will reveal where and when power flow is approaching or violating a system asset limit. The capability to forecast the net power consumption or generation at each service point will provide system planners with asset constraint forecasts for every hour of the year — from tomorrow to 20 years out.

With granular forecasted data, system engineers can conduct locational resource planning to more accurately evaluate upgrades and size equipment to improve capacity utilization. By better understanding granular power flows on assets, and identifying when and for how long generation or loading creates a constraint on an asset, utilities will be able to target investments or incentivize customers to shift load and defer costly system upgrades. These non-wires alternatives (NWA) have been implemented as pilot projects across the country. Many utility regulators are requiring utilities to consider this design approach in lieu of, or at least as an analytical alternative, for long-term rate base capital improvement.

Transactive Cost of Service Driven by the New Prosumer

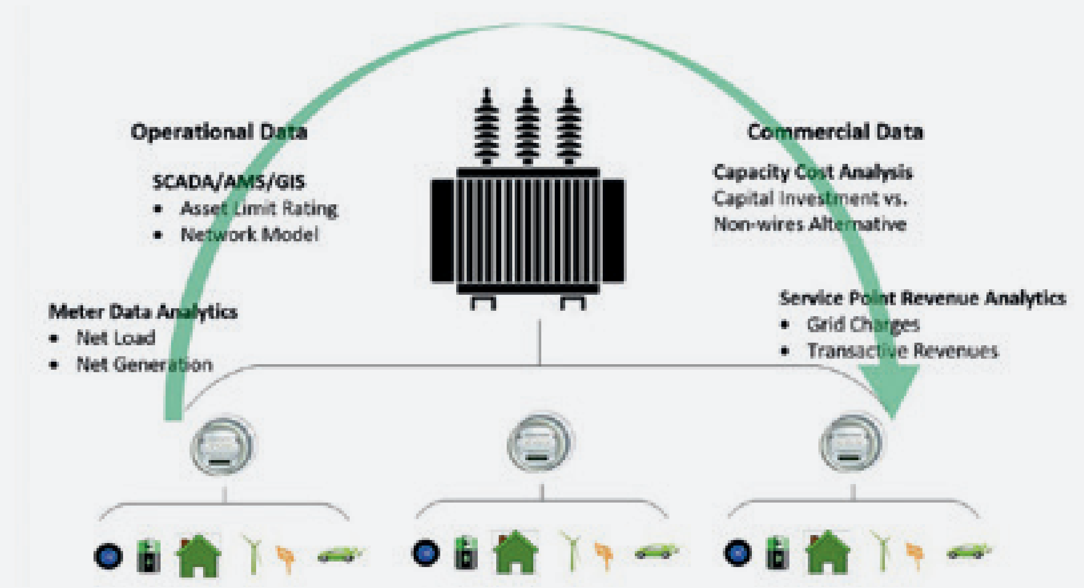
The transformation underway in the electric utility industry is truly a consumer-driven sea change. It may not yet be affecting every utility in every state. However, as more homes are built or retrofitted with solar panels, energy storage, home energy management systems, and garages equipped for electric vehicles, the emergence of the prosumer will change the utility business model. To better understand the changing needs of the prosumer and effectively and equitably serve their needs, utilities will need to develop new cost-of-service models that reflect the true value of the grid as a platform.

The prosumer cost of service model will be a blend of transactional service charges and fixed charges associated with grid services. Grid services will include costs associated with reliability, interconnection, restoration, metering and settlement. The cost of service associated with transactive charges and their associated costs and value to the distribution grid are flexible and dependent upon spatial and temporal variables. As discussed previously, capacity utilization is locational; therefore, it is dependent on spatial and temporal variables. This means the value of a transaction will vary greatly from circuit to circuit, hour-to-hour, etc. As part of the emerging transactive service model, utilities will be charged with transparently determining the value of every transaction at any point and time on the system. This will ensure prosumer performance and all transaction settlement while maintaining grid reliability. Calculating the cost of service associated with providing these platform services will require the convergence of Operational Technology (OT) data and Information Technology (IT) data to align commercial cost and value with the physical delivery of energy to every service point on the distribution system.

Platform Technology & Services

Transitioning to this new business paradigm will require utilities to analyze revenues vs. costs on a more localized and temporal basis. Ultimately, understanding the profit/loss and grid value (load, generation or ancillary service) at each asset per hour will be necessary to support transactive costs of service analysis. In turn, this detailed granular data will support more frequent and in-depth regulatory rate-case development.

FIGURE 1
LOCATIONAL RESOURCE PLANNING IN THE 21ST CENTURY GRID

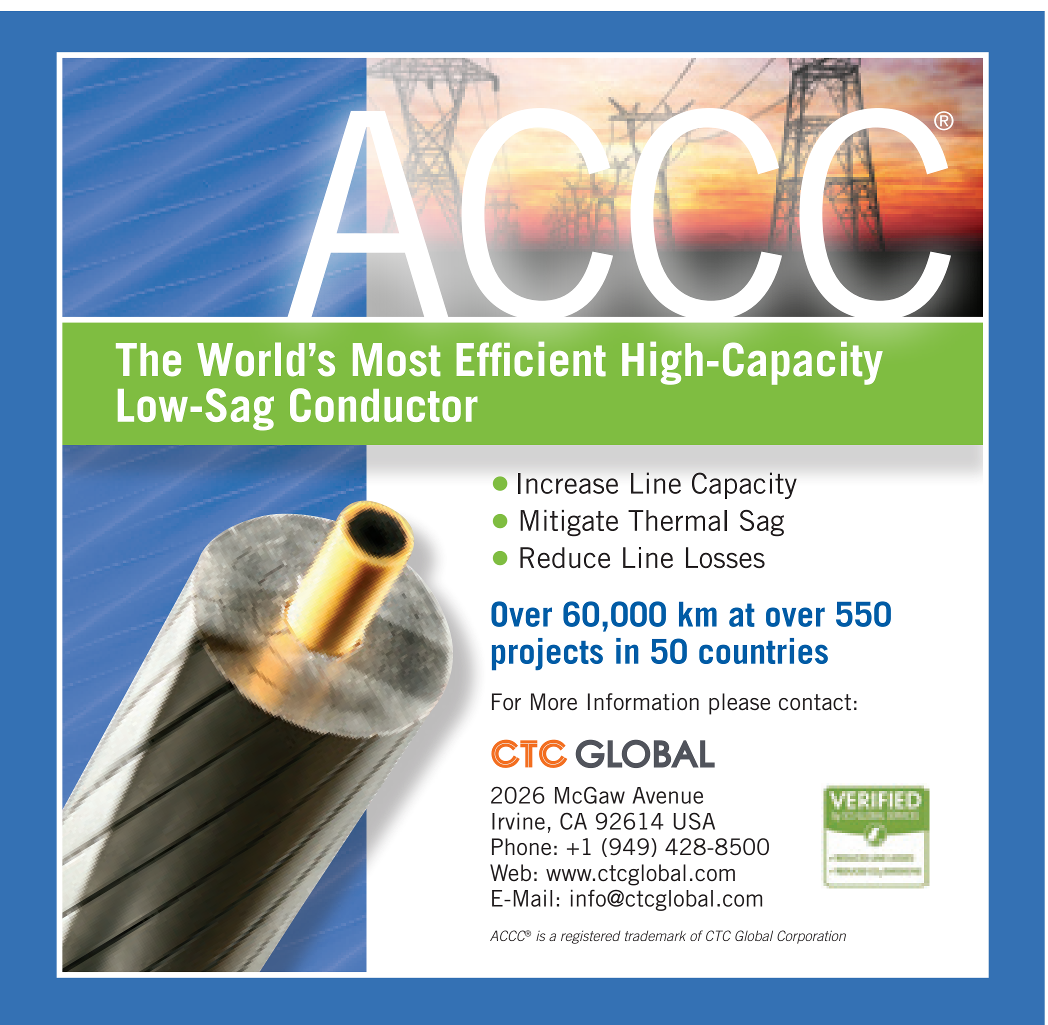


Through the convergence and analysis of granular operational and commercial data on a spatial and temporal basis, utilities will perform revenue analyses to determine the appropriate capital requirements needed to support physical system investments and properly compensate DER grid value.

The role of the utility as a transactive platform service will require new skill sets, services and technologies to serve the evolving prosumer marketplace. The core function of a platform service is to ensure transparent price discovery, transaction delivery and financial settlement. The utility Transactive Energy Platform (TEP) will provide the following services:

1. **Transparent Pricing – Value of DERs (Load, Generation, Ancillary Services)**
   As a first step in the creation of a transactive energy platform, utilities need to determine the locational and temporal value of DER assets on the system. This value can be calculated by determining the current and future constraint on system assets such as transformers. Downstream historical service point level hourly load and generation data will be analysed for each system asset to determine if and when loading on an upstream asset exceeds the equipment rating of that asset. An avoided capacity cost can be calculated from this constraint analysis to determine the hourly value for every DER on the system. Asset constraint analysis is a vital step in determining the temporal capacity value of a DER asset. Micro forecasting at each service point can be rolled up to asset forecasts in order to predict future hourly constraints on system assets. Spatial and temporal DER valuation will allow utilities to accurately determine the value of DER assets in a transparent manner and develop equitable compensation rates for the value these assets provide to the grid without unduly shifting the cost to ordinary consumers.

2. **Grid Fidelity – Ensuring that All Transactions are Physically Stable**
   Reliability will continue to be job one for utilities. This will become increasingly difficult on a system design to manage unidirectional power flow as thousands of bi-directional DER assets are introduced to the grid. Ensuring grid fidelity will require dynamic modelling that can adjust to daily changes in asset configuration and sub-hourly changes in forecast model variables like cloud cover. System operators need micro forecasting systems that can dynamically model the introduction of new assets and respond to changes in granular spatial and temporal variables to create next-hour asset forecasts that feed localized system power flow programs. →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3. **Transactive Settlement - Financial Settlement for Every Transaction at Every Asset**
   Transactive settlement will require detailed operational data (load, generation, voltage, etc.) and commercial pricing data to determine the temporal performance of every asset on the system. This convergence of OT/IT will feed a settlement system that will settle millions of transactions for any defined interval and for multiple products at every service point/asset. This next generation settlement system will require utilities to overhaul their existing settlement processes and invest in Graphics Processing Unit (GPU) technology-driven solutions that can handle the massive data requirements associated with this new functional requirement.

These expanded services are functions that are currently beyond typical distribution utility services. To support these new services, utilities will need to make investments in the people, processes and technologies required to support a transactive energy platform. Transitioning to a transactive cost of service revenue model to support these services require a detailed analysis of the platform services value and operational costs.

The 21st Century Utility Business Model

The model of the past century has to evolve. The introduction of the prosumer has forever changed utility revenue and business models. Volumetric rate structures will no longer provide utilities with the revenues required to cover their return on equity (ROE). As distributed generation, electric vehicles, energy storage and declining load growth continue to eat away at volumetric sales; utilities will have to establish different cost-recovery mechanisms that support the services needed to ensure grid fidelity and every individual energy transaction.

The ROE-centric business model of the past century will have to shift as large capital spending projects are displaced by smaller localized projects that combine limited or no capital spending with customer energy efficiency programs and DER incentives to reduce demand and improve capacity utilization. This NWA approach towards system planning will have a dual impact on the utility business model. Not only will utility program spending and DER incentives further erode volumetric sales, it also will reduce capital spending, which, in turn, will reduce the rate base and resulting return on equity. The continued decline in volumetric based revenues will have to be replaced with other revenues or spread across all rate classes through higher customer or grid charges.

The 21st century utility is evolving into a platform service provider. Transitioning this industry towards this new paradigm is akin to turning an ocean liner. It will be a slow and steady turn, requiring new skill sets, processes and technologies. This shift from a long-term capital-intensive industry with predictable ROE, to a nimble transactive platform that is responsive to shifts in behind-the-meter consumer behaviour, peer-to-peer transactions and third-party market participants, requires a TEP that is capable of producing transparent pricing, dynamic system modelling and financial settlement for every transaction.

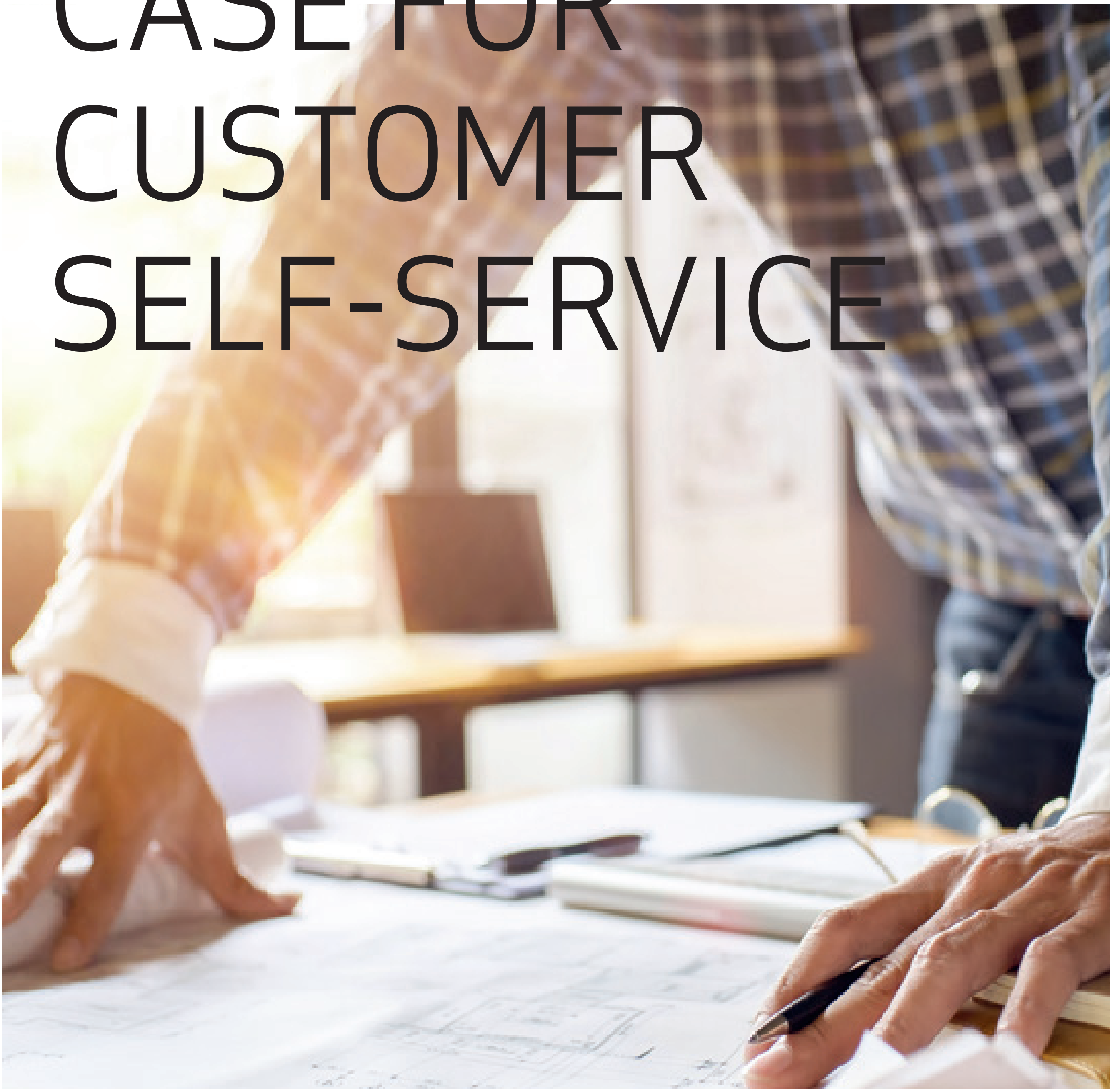
Determining the value of TEP services is paramount to the 21st century business model. Volumetric rate structures are failing to recover the revenues needed to sustain the current utility business model. Utilities, regulators and other stakeholders have to examine how the 21st century business model will evolve. The success of the 20th-century utility model has been the backbone to American industrial strength, economic growth and the overall quality of life in North America. Cheap and reliable power has fuelled the American way of life. It is essential that we ensure that the 21st century utility has the appropriate revenue and sustainable business model to continue to support American industry and the American consumers with reliable, inexpensive and clean energy.

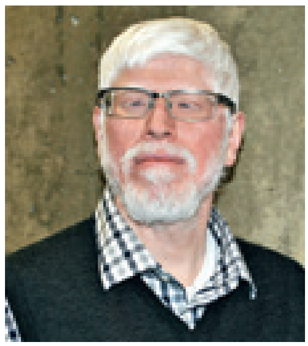
ABOUT THE AUTHOR:

Dan Garvey is director of business development at PowerRunner, LLC. He has more than 25 years of diverse energy industry experience that include engineering, sales, and account management positions with NStar, United States Navy, Southern Company Energy Marketing, Siemens, and Oracle (LODESTAR). Garvey graduated from Merrimack College with a bachelor's degree in electrical engineering

EDITORIAL

THE BUSINESS CASE FOR CUSTOMER SELF-SERVICE





VIKAS MUKHI

Have you taken a flight recently? Chances are you found your flight, picked out your seat, checked in, and added your boarding pass to your smartphone. You did it by yourself and online, right? At the airport, you may even have printed your own luggage claim ticket before boarding.

If you're like most people these days, your travel planning and flight purchase get done at your choice of timing, not just when some airline call center or travel office is open. Your seating matches your preferences, not the airline's. And it all gets done without requiring any other person to be involved.

This is the new customer experience model and, increasingly, it is a model that has customers doing everything they want themselves.

One 2015 study found that nearly 75 percent of consumers preferred to solve customer service issues without a customer service representative (CSR). The same study found that 65 percent of all consumers and 69 percent in the millennial age group report feeling good about themselves and the company they're dealing with when they can resolve a problem without CSR intervention. In fact, nearly a third of survey respondents said they'd rather clean a toilet than talk to a CSR.[1]

Statistics like these – and there are plenty of them – demonstrate the business need for robust customer self-service channels. That's a big part of the business case. Following are some other ways to profit from self-service solutions. →

[1] https://www.aspect.com/uk/company/news-and-events/press-releases/customer-serve-thy-self-new-study-reveals-millennials-desire-for-self-service-digital-interaction-to-change-customer-service-forever

Analyze Your Data

The big costs involved in a self-service portal accrue when you first get it up and running. Because a large portion of your business justification comes from cost savings, it's wise to focus on the most common service requests that now hit your call center. The goal is to drive usage of your self-service technology quickly and defray upfront costs.

To do that, begin your customer portal project with analysis of company data that is already available. Examine why customers call in, what business they're conducting, how long the average call keeps a CSR on the line and what might speed up the interaction.

At a large, Canadian municipal utility serving some 730,000+ customers, one organization did this and quickly prioritized the requests CSRs managed that could easily be transferred to a self-service channel. One was related to account changes: move-in/move-out calls or changes in contact information. Other common requests that were well suited to self-service included bill payment, account history questions and how to sign up for automated payments.

Such issues guided the design of the company's customer self-service portal. Now that this portal is complete and online, the end result is a website that's highly personalized and enables users to manage their accounts from any device. Account details, such as current balances, payments, payment history and due dates, are accessible at a glance. All account information can be downloaded or printed for manageability. Billing features include pre-authorized disbursement using a highly secure and robust payment engine.

Within one year of launching the portal, the utility had exceeded its portal-registration goals by 110 percent and had seen an increase of approximately 20 percent in self-service use. The call center, which previously received approximately 614,000 calls per year, saw a 65-percent reduction in call center traffic, resulting in operational savings.

Numbers like this come from taking an outside-in approach and clearly meeting customer requirements as identified by customer behavior.

Turn Outages into Opportunities

After an initial launch aimed at meeting top reasons for customer calls, the utility noted above began to enhance functionality. One project involved a mobile-first outage reporting solution that was built in 2.5 months.

The solution gave customers the ability to report an outage on any device from any location, which minimized the number of calls coming into the call center. It also helped customers report outages even when the power was out at their premises. Finally, the solution enabled automated messaging for customers who signed up to receive alerts about outages in their areas.

Benefits from a solution like this extend far beyond call-center savings. For instance, if your utility doesn't have advanced metering infrastructure in place, every call or online outage report helps you restore power more quickly. That's because each customer contact becomes another data point your outage management system can use to triangulate the fault location on your distribution system.

Rapid outage restoration has been correlated with higher customer satisfaction scores, according to researchers at The Brattle Group, a firm that provides consulting services and expert testimony in economics and finance to many utility regulatory agencies.

What's more, results from the most recent J.D. Power and Company survey of residential electric-utility customers indicates that proactive outage communications can be a powerful satisfaction builder. The survey found that increasing numbers of utility customers are getting information about outages – such as the cause, number of customers affected and estimated restoration time– via alerts. Fifty-nine percent of customers got such information 2016, and that number jumped to 66 percent in 2017.

Overall satisfaction among customers who receive such information is much higher than among those who do not receive those outage details. Customers in the know gave their utilities an average score of 716 out of 1,000 possible points versus 683 for customers who didn't get any outage insights.

And, here's another reason making an outage reporting solution mobile-first is a good call. The 2017 J.D. Powers survey also found that 35 percent of utility customers are now accessing their utility's website either by a mobile phone or by a tablet. That's a 15 percent increase over 2016 figures.[2]

Given all these J.D. Powers results, it's little wonder that an outage reporting self-service option can pay off well in call-center savings. Before implementing its outage-reporting mechanism, the utility mentioned above received about 96,000 calls annually from customers reporting outages or wires down. Despite an increase in outage events and numbers of people impacted by them, the utility still saw a 25-percent reduction in call-center volume in the year after implementing its self-service outage reporting tool.

Let Customers Solve a Problem

Another utility has justified self-service with a simple customer-related problem: the cost of mailing out bills.

Around the time this utility was looking at increasing its paperless billing adoption, a benchmarking study on e-billing was conducted by a consulting firm specializing in strategic research for financial services organizations, utilities and other large billers. That study found that utilities averaged only 12 percent adoption of paperless billing.[3] This utility's adoption was in that range, and the company decided to target a 20 percent adoption rate.

The utility reached that goal and more in the first year after launching a comprehensive self-service portal that gave customers the ability to view their account histories, update account information, request services, set up e-billing and more.

The utility also saw a 20 percent reduction in call-center volume. All told, managers estimated some $10 million in savings annually.

Implementing self-service portals can be even more cost effective when you follow best practices. Here are a few to remember:

Hire the Whole Package:

A customer self-service portal isn't a marketing project, although you'll want to have your marketing people involved to maintain brand integrity. Still, while it's tempting to look at website developers, you really need to hire portal experts, companies that understand how to take back-end activities and bring them into the front-end where customers can interact with them.

Put another way, self-service portal projects typically require deep integration knowledge across multiple types of legacy systems, including Microsoft, IBM, Oracle, SAP, home-grown software and more. The average call center agent has to access 19 different systems to complete a customer interaction. A portal requires customers to complete tasks using those same disparate systems, which means that this software must be seamlessly connected. There won't be a representative on the phone to fill the wait with chitchat while the computers do their processing.

Manage Your Data:

Research from Microsoft indicates that the quality of customer data hinders 48 percent of company managers who want to better adapt customer care to customer needs. Nearly one in three chief marketing officers cite technology capabilities as a major challenge to delivering the experiences their customers expect.

When you look for a portal-project consultant, look for an organization with data cleansing expertise and understanding of source or master data best practices. The quality of your customer portal experience will only be as good as the data supporting the functionality.

Build, Measure, Learn, Improve:

Usage volume is what pays off in portal deployments, so you need to do everything you can to drive adoption. One way to do that is to work in an agile, incremental way, delivering applications in phases and validating them every step of the way with users to make sure the portal will serve customers well.

Once you launch your new applications, monitor user and system behavior to drive continuous improvement. After all, your customers are constantly evolving. You need to keep up with them. And, today that doesn't mean more service. It means self-service that puts customers in control.

ABOUT THE AUTHOR:

Vikas Mukhi is an enterprise architect at Navantis, a Datavail company with 15+ years of successful leadership and experience in business processes, complex applications and secure enterprise-class solutions necessary for 24/7 business operations. His responsibilities include solution strategy and implementation for business operations and has been recognized as a customer-trusted advisor throughout the project life cycle.

[2] Ibid.

[3] https://www.fiserv.com/resources/wp-state-of-paperless-billing-2011.pdf

POWHERFUL FORCES

SHARON ALLAN

CHIEF INNOVATION OFFICER OF SEPA

FOR THIS INAUGURAL COLUMN OF POWHERFUL FORCES, WE ARE PLEASED TO FEATURE SHARON ALLAN, CHIEF INNOVATION OFFICER FOR SEPA.

Years ago, after Sharon Allan was named one of the 50 Key Women in Energy by *Now* magazine, that honor was referenced by a man who introduced her to conference attendees she was about to address. The audience was impressed. Allan told them they needn't be. *"There are only about 50 women in Energy,"* she quipped.

Allan can make such jokes because she's been an industry player for decades, and she recalls the days when fewer women chose to major in engineering, as she did.

Despite being a rarity in the industry, Allan also has been a leader. She was president of a large advanced metering infrastructure (AMI) vendor, headed the smart grid group for Accenture and was CEO for the Smart Grid Interoperability Panel (SGIP). Under Allan's leadership, SGIP merged with the Smart Electric Power Alliance (SEPA), and she now serves as that organization's chief innovation officer.

It's a fitting role because Allan has seen much change in the power sector over the years. Interestingly, she points out that the most significant advancements have taken place fairly recently. *"It's been stated, that the electric grid is the largest interconnected machine on earth and the greatest achievement of the 20th Century, but it is really the emergence of IoT, which began around 2000, that has led to increased connectivity in the utility space,"* she says.

Today, IoT has a tremendous impact on grid operations and resilience. But before there was IoT, there was AMI, which Allan sees as a foundational technology because it made two-way communications and control a widespread capability. According to Allan, *"Had AMI not been rolled out a little more than 10 years ago, we would not have the proliferation and rise in popularity of solar. We would not have the technology in place to support net metering or management of microgrids."*

Allan also points to mobile apps as a technological advancement that has completely changed the way utilities interact with their customers. Today's consumers want to be in greater control of how and when they use energy. *"Customers are now buying their own appliances and automating their home needs, including remotely controlling their energy consumption," says Allan. "This unprecedented consumer involvement is shaping our industry from the proliferation of DERs to innovative technologies of the future."*

One area where Allan sees there remains a great need for improvement is within the grid itself. With what appears to be an increasing number of major storms we've seen in North America, Allan believes it is critical that more effort is made to shore up the grid so it can survive and quickly recover from such devastation in the future.

While technological advances will continue to shape the future of utilities, humans will be the ones managing the industry transformation. Recognizing the importance of bringing together stakeholders whose collective intelligence can come up with the best solutions to the most complex problems, Allan established working groups while she was the CEO for SGIP. These working groups now exist under the SEPA, and they are considered core to the organization.

"*We are there on the ground with utility engineers and managers, helping them shape their strategy, guiding them along the way as they work to achieve their vision,*" Allan says.

She strives to engender collaboration among the utilities, the business community, and government entities. This collaboration is something about which Allan is passionate, and she sees SEPA as a platform that allows that collaboration to happen.

Specifically, there are now 13 working groups, and each aligns around a particular topic like grid architecture, grid management, EV's, energy storage, and cybersecurity. Each group averages at least 50 members, but some have more than 100.

The exchange of ideas and collaboration among working group members benefits the organizations each member represents, but their activities extend beyond case studies. Often, such groups generate outputs that influence the industry. For example, at DistribuTECH 2016, SEPA's utility-only Grid Management Working Group held a meeting to discuss requirements for distributed energy resources management systems (DERMS). The effort to create a requirements document for DERMS grew out of a joint effort between the utilities-only working group, Southern California Edison, Duke Energy and ComEd.

Now available for industry comment at www.dermsterms.com, SEPA's Distributed Energy Resources Management Systems (DERMS) Requirements document was crafted to help utilities reduce risks of procuring systems that failed to deliver all needed capabilities and to inform and guide industry vendors in their own product development efforts.

Another working group (Distributed Resources Generation Storage – DRGS) generated the requirements that went into what today is IEEE 1547, the standard that defines how distributed energy resources connect to the grid. This was done under the organization's priority action plan process and the work is known as PAP (priority action plan).

Allan's role will continue to evolve as she works with SEPA to support its stakeholders and help them navigate the ever-changing industry landscape — especially concerning DERs. "*This industry, like all industries, will continue to change,*" says Allan.

ABOUT SHARON ALLAN:

Sharon Allan has more than 30 years of experience and is an executive known for business transformation and growth. She was CEO of SGIP, which merged with SEPA in 2017. She is also on the advisory board of Enertech Capital. Previously, she was managing director of Accenture's Smart Grid Practice. Other industry roles include president of Elster Integrated Solutions, chief knowledge officer of Elster Electricity, as well as executive roles at ABB, and IBM. Allan has been recognized throughout the years as a Pioneer by Smart Grid Today, Mover and Shaker by GTM (Greentech Media), Top 3 by Smart Grid News, Technology Leader by NCCBI, Platts Energy, and a "*Class of 2007 and Alumni*" leader by World Generation. Allan is an honors graduate of the University of Florida with a Bachelor's of Science in electrical engineering and holds an MBA from Duke's Fuqua Business School.

"*Our centralized grids have existed for a number of years, yet we face a lot of change and evolution as we see new distributed energy resources get integrated. And this change is really where SEPA is focused. My role at SEPA will help accelerate that innovation curve, whether it's innovation of technology, of policy, of tools and models, or of business processes, in order to ensure a smooth transition into the next stage of our industry.*"

SECURITY SESSIONS

THE NATIONAL RENEWABLE ENERGY LABORATORY'S CYBERSECURITY RESEARCH PLATFORM

ERFAN IBRAHIM, PH.D.

Introduction

Today's highly internetworked business applications are exposed to a variety of threats—both internal and external. The external threats include natural disasters, amateur hackers and advanced persistent threats from nation states or non-state entities. Internal threats include disgruntled employees, industrial espionage rings, and other nefarious groups that have infiltrated legitimate enterprises. System errors can also cascade into large-scale disruptions to business applications. All verticals of the economy that are dependent on information systems for day-to-day operations and business transactions are susceptible to internal and external cyber threats. Since information systems control the functions of many tangible devices at data centers and in the field, the threats can also be physical in nature. The cyber-physical interface has to be protected in both directions to ensure business continuity.

Possible Solution:

The complex cyber-physical environment in modern enterprises described above cannot be secured with traditional cybersecurity technologies such as firewalls, anti-virus servers, access control lists and username/password alone. A layered approach is needed to secure all seven logical layers of the OSI Basic Reference Model (ISO standard), as well as the semantic and business process layers that ride above them. Typically, security controls are inserted into the protocols only at the application and network layers. Not enough consideration is given to systemic security through intrusion detection technologies that combine in-line blocking with passive observation of network traffic and determine anomalous behavior by comparing actual commands between legitimate nodes with the desired commands between them for each protocol/business application of interest. →

At the U.S. Department of Energy National Renewable Energy Laboratory, researchers have designed, built, and validated a cybersecurity research platform that incorporates a 9-layer security model. This testbed consists of electric utility distribution grid management hardware and includes an enterprise station and two substations protected by multiple layers of security. This security architecture is applicable to any multi-site information system in any industry vertical that has real-time transactions between different end-users, end-systems or a hybrid of the two.

Network Description

The research platform consists of an enterprise site with a Cisco ASA 5512x firewall facing the internet and a Cisco 3850 Layer 2/3 switch. The Cisco 3850 switch has three Virtual Local Area Networks (VLANs) configured on it, such as information technology (IT), operational technology (OT), and management VLAN. The IT VLAN contains the DNS server, the SMTP server, the FTP Server and the Syslog server. The OT VLAN contains distribution management system (DMS) and devices commonly found in the control center of a typical distribution utility. The management VLAN contains the management ports of the cybersecurity technologies, with a logical separation from the production network to limit access to only authorized network administrator staff.

The research platform connects the enterprise site with two substation sites through a mock Internet Service Provider (ISP) network represented by an ISP switch. Each substation has a Cisco ASA 5512x firewall facing the ISP switch and a Cisco 3850 Layer 2/3 switch behind it representing the bus network and containing the Advanced Substation Platform (substation logic in a box). Each bus switch is connected to another Cisco 3850 Layer 2/3 switch, representing the field network by connecting the field equipment electric vehicle charger, electric storage, and photovoltaic simulator, which represents a solar array) to the two substations. The testbed uses the Open Shortest Path First routing protocol.

Power Systems Use Case Description:

The research platform supports distribution grid management use cases, such as Auto-Sectionalizing and Restoration, volt/VAR optimization, electric vehicle charging with demand response, photovoltaic smoothing with electric storage, and frequency regulation with electric storage. These use cases are supported by the Advanced Substation Platform in each substation via built-in software modules communicating with field equipment via the Modbus TCP protocol. The Advanced Substation Platform in each substation communicates with the enterprise information system via a proprietary protocol. The enterprise information system communicates with the DMS via the Distributed Network Protocol version 3 (DNP3). With these power system use cases, this testbed represents the complete ecosystem of a typical distribution utility's IT, OT and management system.

Cyber-Security Architecture Description:

The testbed is secured by the following controls:

1. The enterprise firewall is configured for VPN access through role-based access control, requiring unique login credentials for each user, and restricting access to specific nodes of the testbed based on their specific role.
2. Reflexive access control lists are set up to allow OT nodes to send notifications and files to the IT VLAN and receive acknowledgments. But no unilateral communication is allowed from the IT VLAN to the OT VLAN or management VLAN under any circumstances. This allows IT/OT convergence to occur to support the distribution grid management application, but without compromising the OT VLAN nodes by IT VLAN traffic that may contain inside threats, or viruses and other malware from the internet.
3. Bi-directional data can be transmitted between the enterprise station and each substation in the IT VLAN, between the enterprise station and each substation in the OT VLAN, and between the enterprise station and each substation in the management VLAN. However, no data can be sent or received between the two substations.
4. All Cisco Layer 2/3 switches (bus and field) are configured with "sticky" specification, which locks the media access control (MAC) address of legitimate nodes to unique interfaces of the switch. If the device is removed from the interface, it cannot be re-attached unless the switch interface is re-enabled. Unauthorized MAC addresses cannot connect to any enabled interface. All unused interfaces on each switch are disabled by configuration to minimize unauthorized access by insider threat.
5. The most recent security patches and software upgrades have been applied on each server, to minimize software vulnerabilities that can be exploited by hackers.
6. Strong authentication—which is difficult to break with password cracking tools—has been enforced on each testbed node.

The research platform uses BlackRidge TACS to provide in-line blocking to protect the enterprise information system and the two Advanced Substation Platforms. This technology inserts tokens (four-second life) in each TCP segment header of data at the point of origin using an in-line appliance and authenticates it on another in-line appliance next to the target node for the data to ensure that only data from authorized nodes are exchanged in the supervisory control and data acquisition (SCADA) system. This limits the possibility of unauthorized access by third party users or systems and provides an effective block against distributed denial of service attacks of any magnitude (can scale up to 10 GB throughput verification of data traffic).

In-line blocking is also provided by the SecLab Denelis platform to prevent unauthorized access to field equipment on the Modbus TCP server. The SecLab device is a hardware layer filter that strips all header information from each data packet and verifies that the payload consists of only authentic commands from a legitimate source before forwarding it to the Modbus TCP Server, and vice versa. The SecLab device ensures the physical segregation of the network and will block network layer attacks through packet dis-assembly and assembly.

Three situational awareness tools are connected via taps located on the enterprise and substation racks.

- The first is Albeado PRISM, which provides business process layer security by comparing data at the enterprise and the substation to ensure consistency across multiple data protocols. Data fuzzing would be easily detected with this tool.
- The second is N-Dimension's N-Sentinel, which is an enhanced form of the open source Snort Intrusion Detection System, which can decipher power systems protocols—such as DNP3, Modbus TCP and International Electrotechnical Commission standard 61850—and identify anomalies in them caused by malware, hacker attack, data fuzzing schemes and system errors. The N-Sentinel appliances are connected via the internet to the cloud where malware signatures and other there at information is available from the classified side for continuous threat monitoring capability.
- The third is NexDefense Integrity, which provides network anomaly detection capability by tracking all the simultaneous TCP sessions that are active in the research platform and providing a visualization capability on a computer screen to allow quick and effective identification of unnecessary or unauthorized communications and application layer protocols.

Additionally, there is a hardware-based file filter provided by SecLab that checks all files from peripheral devices before allowing them to be saved on the testbed server. This is an effective type of mitigation for Stuxnet type virus proliferation across the air gap. The SecLab filter can be kept as a standalone device in the lab or inserted discreetly in the server chassis with a regular USB interface exposed to the outside. Any peripheral device attached to the USB port of the SecLab filter will be scanned for malware-ridden software before permitting the server to copy any files from it. This is critically important to protect high-value digital assets from insider threats or negligent employees introducing malware into the IT or OT environment with malware-ridden peripheral devices such as thumb drives, laptops and mobile devices.

Codenomicon/Synopsys has a "Static Code Analyzer" tool that inspects software code as it is being developed to identify vulnerabilities resulting from poor coding techniques. Codenomicon/Synopsys also has Protecode SCM, which performs the same function as Static Code Analyzer on third party software and also verifies that there are no "back door" routines in the software that can be exploited in a production environment. Finally, Codenomicon/Synopsys also has "Defensics" which is a powerful data-fuzzing tool to test how resilient applications are to dealing with adulterated data.

Conclusion:

Two months open research platform from inside and outside the research platform did not result in a successful exploit or compromise of any system. The NREL cyber-physical systems security and resilience research platform has therefore demonstrated the value of layered security in protecting against a variety of thre at vectors (internal and external to an organization) and proven that "off the shelf" cybersecurity technologies today, combined with sound cybersecurity management principles, can successfully protect the enterprise from these threats. The assistance that enterprises need today is in developing a sound cybersecurity architecture based on business applications running across multiple sites, and on profiles of end-users, to minimize vulnerabilities that can be exploited. NREL's Cyber-Physical Systems Security & Resilience Center is uniquely qualified to provide this support, given its experience with the distribution grid management research platform, and years of practical experience in the electric utility industry.

ABOUT THE AUTHOR:

Dr. Erfan Ibrahim is a research advisor and acting director for Cyber-Physical Systems Security & Resilience R&D at the National Renewable Energy Laboratory n Golden, Colorado. Ibrahim works with the public and private sector to identify security requirements, evaluate cybersecurity standards, test cybersecurity controls and determine residual risk in smart networks in electric, water, and oil and gas. He serves as the liaison from NREL to the Office of Electricity Delivery and Energy Reliability (OE) at Cybersecurity for Energy Delivery Systems (CEDS). He also serves on the cybersecurity and resilience team within the Grid Modernization Lab Consortium for the Energy Department.

Ibrahim led the industry consensus building exercise in the National Institute of Standards Technology (NIST Smart Grid Interoperability Roadmap project in 2009 and also led the National Electric Sector Cybersecurity Organization Resources (NESCOR) project for the Energy Department during 2010-2011, while serving as a Technical Executive in the Intelligrid Program at Electric Power Research Institute (EPRI). Ibrahim has a bachelor's degree in physics from Syracuse University, a master's degree in mechanical engineering from the University of Texas Austin, and a Ph.D. in nuclear engineering from the University of California Berkeley.

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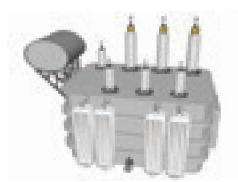

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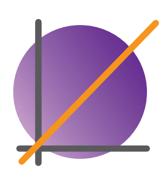

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