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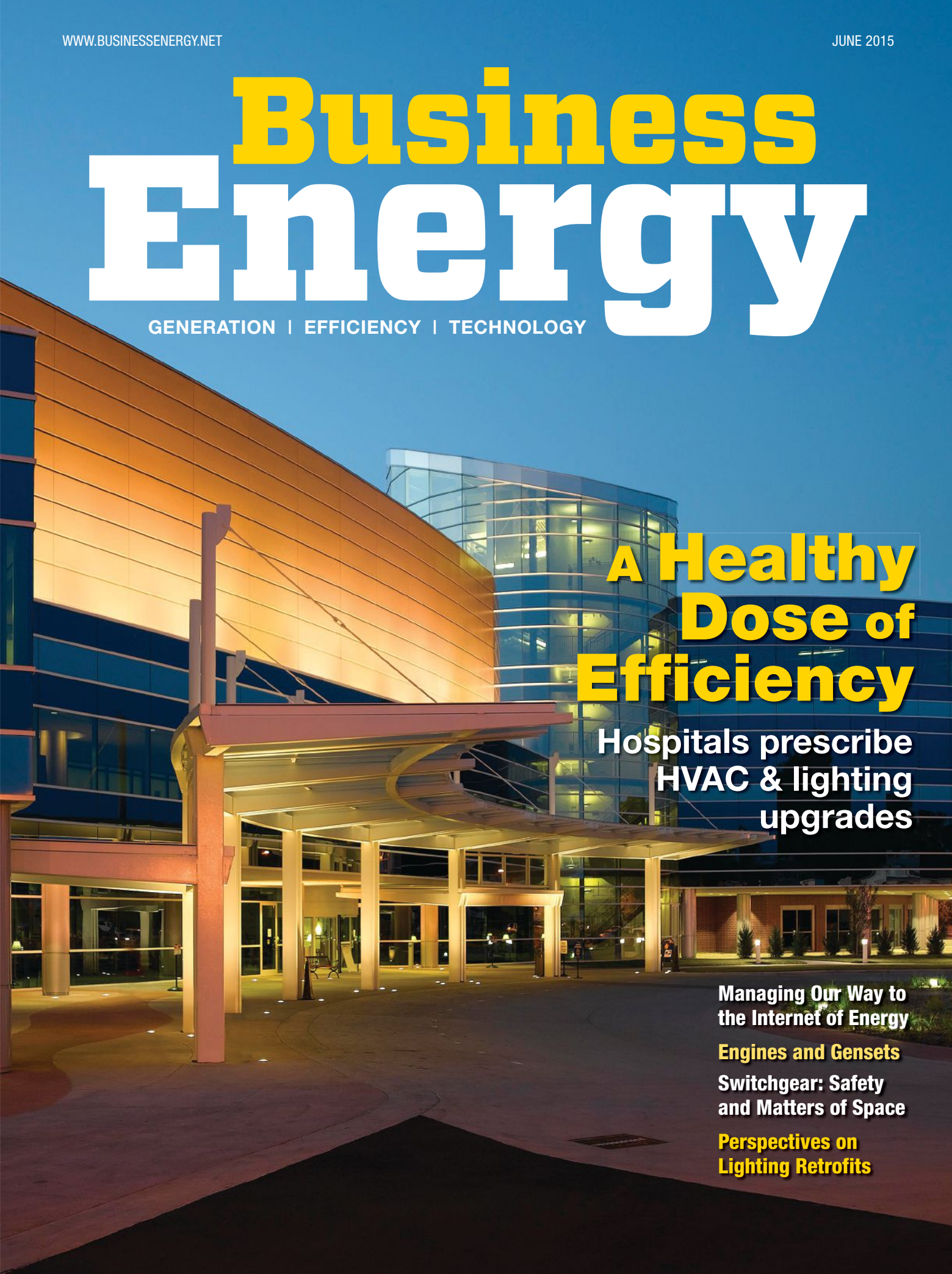

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Switchgear: Safety and Matters of Space

ARC FLASH PREVENTION, MOBILITY, AND REGULATORY COMPLIANCE

BY MATT M. CASEY

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In November 2014, a large North American utility experienced a quiet disaster. A month earlier, third-party contractors at the new power distribution center installed a cable improperly. When the utility energized the facility, the cable triggered an arc event. Uncontrolled, it could have severely damaged the building, its equipment, and the workers inside.

Robert Kowalik, vice president of medium-voltage switchgear at ABB's Lake Mary, FL, facility, estimated that the damage caused by the arc could have cost the utility $1.5 million to repair, and it would have taken six months to get the Power Distribution Center (PDC) running again. That timeline would have created hardship for the utility, which had a January 1 operation deadline to receive tax incentives. In addition, the building held 14 workers, whose injuries—or deaths—could have compounded the financial, morale, and public relations cost of the disaster.

But the utility had purchased arc-resistant equipment from ABB. The switchgear contained the entire energy discharge inside of a 2B certified cubicle.

"Replacement of parts and re-energization of the equipment took only eight weeks with minimal costs to the utility [less than $50K]," says Kowalik. And, "Nothing happened to anyone. I don't think anybody lost a single hair."

He says that stories like this are why arc-resistant equipment makes up a significant—and growing—portion of ABB's sales. The company introduced some of the first arc-resistant equipment to the US in 1994. Now nearly all (95%) of the equipment the company sells in Europe is arc resistant. Kowalik expects the North American market to also migrate to the new, safer style of equipment.

Arc resistant switchgear may cost more to purchase, but it has enormous potential to save money over the long run. Fiber optics in the switchgear detect arc events, and ABB's earthing switches can interrupt an arc event in less than four milliseconds, Kowalik says. Once tripped, the earthing switches channel the bulk of the uncontrolled energy harmlessly into the ground.

That safety measure can prevent damage and injury on a huge scale. According to the Department of Labor, hundreds of workers suffer electrical injuries per year with more than 130 fatalities. But arc-resistant switchgear also offers another significant benefit: It improves reliability. When arc events remain contained to a single 2B cubicle, nearby equipment remains in working condition and often continues working, undisturbed.

While ABB may have been a leader, other companies have taken their own approaches to containing arc flash events. When Silicon Valley Power installed a new distribution substation serving an area that accounts for up to 20% of the utility's load—including a large sports entertainment complex and multiple data centers—they bought arc flash systems from Eaton that monitor cable and bus faults inside the switchgear. The system achieves a similar result to ABB's arc-resistant switchgear by shutting off the affected bus/breaker in the event of an arc flash. The system even allows the rest of the substation to continue running uninterrupted.

Eaton also introduced new low-voltage switchgear in March that helps safeguard workers from dangerous arcing faults when they access switchgear instrumentation and control compartments. The two-part design allows the circuit breaker panel door to remain closed while workers access control wires. This lets the gear retain its arc-resistant rating during use by protecting workers against potential internal arcing faults.

Taking a similar idea in a different direction, Anord Critical Power Inc. constructs substations and switchrooms for its customers that use compartmentalization to place physical barriers around gear. This keeps flashing gear from damaging other gear or injuring workers in the facility.

"Compartmentalization helps from the point of safety," says Rob Sweaney, vice president of operations and general manager for Anord Critical Power. "It keeps people from being exposed to arc flashes."

In some cases, the people the gear protects may also be the cause for those arc flashes. "IEEE has stated that 88% of faults are due to human error and 95% of those faults occur during routine maintenance," says John Day, vice president of Sales and Marketing at Anord Critical Power.

Sometimes, these mistakes occur when workers incorrectly assume that gear is de-energized when it's not. But sometimes workers drop wires or tools and cause a fault. In these cases, a physical barrier between the device the worker maintains, and other nearby gear can prevent the mistake from becoming an accident report.

Day puts it like this: "Compartmentalization improves personal safety by reducing the potential for human error while performing maintenance."

Tighter Spaces

In addition to arc flash monitoring and mitigation systems, the Silicon Valley Power project faced a space challenge. The lot itself presented an awkward footprint that was made tighter by necessary safety clearances from the edge of the property and between pieces of equipment. The site also had to comply with California's environmental and landscaping regulations, which further reduced available space.

As national power demands grow, utilities and other large electricity producers face a space crunch. Utilities or facilities managers are often confined to the electrical rooms and vacant property they already have. Even when they can acquire more space, real estate prices in cities like San Francisco and New York make that prospect prohibitively expensive.

"We see a lot of pressure from customers both in the industrial and utility sectors to reduce size of their electrical equipment," says Kowalik. "Many companies are adding new equipment to the existing rooms and buildings or are replacing existing equipment with more voltage or current density."

As a result, ABB has worked to make smaller equipment that can handle larger loads. The company's ReliaGear ND, for example, offers a two-high breaker design for 15-kV switchgear applications up to 2,000 amperes (A) of the continuous current and 31.5 kilo-amperes (kA) of the interrupting current. All of this fits in a 26-inch-wide frame.

Anord Critical Power Inc. has also taken a tighter-space approach to its switchgear, but the company focuses narrowly on the data center business. By using compartmentalization instead of air gaps to separate switches from each other, they've compressed the space required for gear in their data center substations and switchrooms. "It reduces the depth a lot in the switchgear," says Sweaney.

Typically, Anord's switchgear setups—which can use breakers from all major manufacturers—are 12 inches shallower

than they would be with air gaps, he says. Depending on the customer's needs, this can make it easier for Anord to fit new gear into an existing electrical room, leave space for future expansion, or leave space for employees to enter and work in the room comfortably.

For Pioneer Power Solutions, their approach to tight spaces has more to do with installation than equipment. "We're pretty flexible; we don't have a standardized product," says Vince Visconti, general manager of Pioneer's strategic sales group.

The company recently completed a project for the Federal Emergency Management Agency, he says, in which they had to fit a 4,000-A, 480-V emergency switchboard into a particularly awkward equipment room. The agency built the room on eight parking spaces in a garage. In addition to its L-shaped footprint, the second section had clearance of just 80 inches due to overhead pipes.

The challenge of cramming more equipment into the same (or less) space has grown, Visconti says, because new codes have made the new equipment physically larger. New UL standards, for example, require more gutter space on switchgear. (See the section later in this article, titled "Regulatory Environment.")

Pioneer Power Solutions, Visconti says, generally gets around these problems by building custom busses and cabinets for off-the-shelf breakers from Eaton, GE, Siemens, or Square-D. "You can basically configure the custom gear any way you want," he explains. "Within physical limitations, obviously."

But Pioneer doesn't work magic. "You're talking about cutting inches," he says, "not taking 20 feet worth of equipment and stuffing it into a 10-foot space."

And custom work isn't for everyone, Visconti adds. Pioneer charges less for custom work than other companies do, but custom work still comes at a premium. If a utility or facility manager needs standard indoor switchgear and switchboards, he says, "the majors can do that pretty well."

Photos: ESL Power Systems

Mobility and Mirrored Design

In addition to working in tight spaces, Kowalik says his customers increasingly need substations that can physically move on short notice.

Customers working in fracking or in the natural gas industry often need substations quickly. But their use at a particular site might be short-lived, making a traditional install inconvenient—especially when they may suddenly be needed on another field. So, ABB and other switchgear suppliers can now deliver their equipment that fits in pre-fabricated buildings known as "E-Houses."

A manual transfer switch

"It takes days or a few hours to install this on the site," says Kowalik. "You can [also] have it on a skid, and you can move it around."

These pre-fab buildings, Kowalik says, add extra pressure for manufacturers to shrink the size of their standard switchgear, but also have side benefits. The predesigned buildings can include "sheltered aisles" for improved safety for workers and equipment. They're also modular, allowing customers to tailor their design to their individual needs.

While they can be mobile, e-houses can also be simply convenient. When Skyonic Corporation took on the task of retrofitting a cement facility with carbon dioxide (CO_2) capturing equipment, they hired Eaton to fill their switchgear needs. Eaton delivered Skyonic's switchgear in a pre-assembled and pre-tested E-house that was immediately ready for installation outside the cement plant.

ESL Power Systems focuses on a different angle of mobility—the

connection between mobile generators and the facilities they power. The company works with banks, hospitals, cell phone tower sites, shipyards, and other businesses where it's important to give workers quick, easy, and safe power connection equipment. In place of using lug nuts to pinch raw wire endings, ESL provides cam-style connectors that resemble microphone cords. This lets workers pop connections in and out without cranking lug nuts or fraying wire ends.

ESL brings these same technologies to businesses that sometimes need temporary generators to perform load-bank testing, or to keep the shop running in the event of a power outage. Businesses "have the option of installing just the manual transfer switch and get[ting] a portable generator for emergencies, which is considerably more affordable than purchasing and installing an automatic transfer switch and a permanent generator," says Lesleyanne Daniels, marketing manager for ESL.

Daniels notes that this isn't an option for critical facilities like hospitals, but it can save money for less-critical installations like retail stores or wastewater treatment plants. This approach can be particularly worthwhile, she says, for businesses in places that sometimes suffer power outages from predictable, seasonal weather events.

"The southeast has hurricanes and heavy storms," she says. "The northeast has heavy snow, and the Midwest has tornadoes. Those areas are constantly preparing for power outages due to weather."

Non-critical businesses could secure emergency generators even without cam-style connectors, she explains, but they would expose themselves to certain hassles. "When a crisis occurs, it may be difficult to find a qualified electrician because everyone else is doing the same thing."

US newcomer Anord Critical Power Inc. uses its outsider status an advantage. The Ireland-based company has been in business for 45 years, but has only recently crossed the Atlantic Ocean. At the time of this writing, the company had just moved into a new, 50,000 square foot manufacturing facility in Sandston, VA, on the outskirts of Richmond.

Because the company focuses on work with data centers, their clients often have similar installations all over the world. By ensuring that its equipment has earned UL certification in addition to IEC standards, Anord can install the same gear for the same company at all of their sites—whether that's an US company expanding overseas or a foreign company venturing into the US.

"They can take basically one setup and put it anywhere they want to in the world because we have the accreditation," says Sweaney.

The data center may have to make a few minor changes based on the local power grid, Sweaney says, but those are peripheral and have no impact on the heart of the switchroom. Such consistency appeals to data center companies because it allows them to install nearly identical, standardized facilities everywhere that they need them.

Maintenance . . . Or Lack Thereof

When switchgear fails, so does the business or utility it serves—making proper maintenance not just important, but critical. Fortunately, switchgear providers continue to improve the maintenance environment.

ESL's transfer switches, for example, streamline the process of connecting electrical gear during the load-bank testing. According to marketing material from ESL, one of the company's end-users needed up to 20 man-hours to perform a load-bank test with its existing equipment. With ESL's TripleSwitch, a single employee could complete the same task in as little as four hours—though Daniels cautioned that not all businesses would see that drastic of a time reduction.

"Each business is different, but the time saved in making the connections can be quite significant," says Daniels.

According to one businesses case evaluation summary, she adds, the labor savings from ESL's TripleSwitch would help the equipment pay for its own installation in just two to five years.

ABB has also deployed its engineers to simplify the process of maintaining switchgear itself. A traditional breaker, says Kowalik, contains between 200 and 400 moving parts. With such complex innards, these traditional breakers need to be inspected and serviced at least once per year. Hinges need to be lubricated. Springs need to be checked for tension.

But ABB now offers magnetic actuators with just one moving part.

"We call it the iPhone of the breaker," he says.

With starkly fewer parts and less friction, these magnetic breakers only need to be inspected once every five years. That

can save utilities a lot of man-hours and payroll. In addition, Kowalik says, the field failure rate for the magnetic switchgear is just 0.08% versus a 0.4% failure rate for traditional spring charged breakers.

"If you switch the breakers, you can save $3 to 4 million over 40 years," he explains. "Those are big numbers. It gets a lot of attention from the senior executives."

In addition to its low-maintenance breakers, ABB also sells a variety of gas-insulated switchgear. This gear allows businesses or utilities install gear with higher voltage ratings on a smaller footprint and improved reliability.

Photos: ABB

ABB IS-Limiter

ABB's AMVAC magnetically actuated breaker

AMVAC

Gas-insulated switchgear, Kowalik says, also saves time and money on maintenance costs. It only needs to be serviced ¼ to ⅓ as often as air-insulated switchgear—though it does come with a bit of a catch.

"I would say it is maybe more complex than air insulated switchgear," says Kowalik. "You would normally like to use ABB for any maintenance on the gas insulated switchgear."

That has served to be only a minor barrier, though. The company introduced outdoor gas-insulated switchgear about 10 years ago, and it has been growing in popularity ever since.

Regulatory Environment

While meeting utilities' and businesses' needs shape how providers design their switchgear, the regulatory environment nudges what businesses demand. In recent years, regulatory groups have issued several rulings that impact switchgear—if only tangentially.

In 2008, UL introduced new standards for wireways, auxiliary gutters, and associated fittings that demanded more space for wire-bending. This put pressure on switchgear providers to make their gear smaller—especially when the American National Standards Institute adopted the same standards in 2013. UL has also published new requirements for remote racking devices for switchgear and controlgear (2014), and switchboards (UL 205, ANSI 2012).

The Occupational Safety & Health Administration (OSHA) also instituted new switchgear-related rules in July 2014 that became fully effective in February 2015. The new rules cover a wide variety of situations common to utility workers, including potential exposure to arc-flashes. The rules, which hadn't been updated in four decades, bring OHSA's guidelines in line with industry standards. Among other prescriptions, the new rules broadly require employers to accurately estimate the intensity of arc-flashes employees may be exposed to. Then, they must equip their workers with adequate protections from those arc flashes.

While this doesn't directly impact the manufacture of switchgear, OSHA suggests that choosing more modern switchgear could minimize danger.

"Employers may institute measures (such as selecting circuit breakers designed to keep the probability of restrikes extremely low...) to reduce the probability of restrike to a negligible level. Employers may then ignore the potential for restrike in calculating maximum transient overvoltages as long as those measures are in place."

This also means that employers who institute safety measures directly on their switchgear—such as using arc-resistant switchgear or earthing switches—can relax the intensity of their employee's safety equipment.

Altogether, OSHA projected that the new rules—which also include guidelines for fall-protection equipment and safety distances from exposed energized parts—would prevent approximately 118 serious injuries and 20 fatalities each year.

And it's likely that the existing installations of the kind of gear the new regulations encourage has already saved dozens—if not hundreds—of lives. As the anecdote at the beginning of this article shows, a North American utility could have added 14 casualties to 2014's injury statistics when they energized their power distribution center in November. Instead, the utility chose to disaster-proof its switchgear. Ultimately, that choice saved both money and human well-being.

But modern switchgear improves on traditional equipment in many ways. As existing gear reaches the end of its useful life, utilities and facilities managers have plenty of reason to upgrade. New gear saves time and money on maintenance. It fits into increasingly tight spaces. And it improves uptime and reliability—all of which are tremendous bonuses on top of new gear's potential to save lives. **BE**

Journalist **Matt M. Casey** *writes about science and technology.*

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