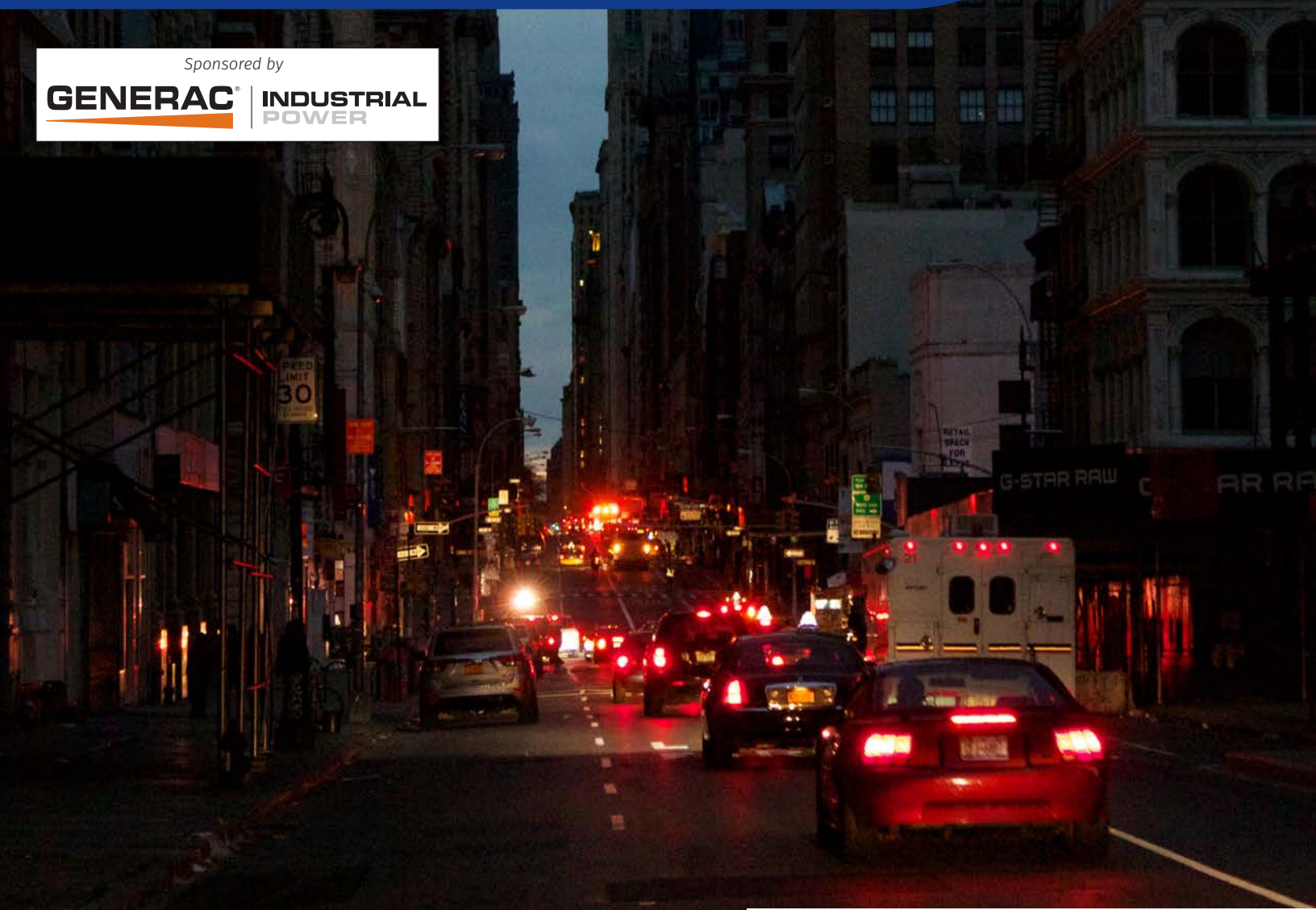
EMERGENCY POWER PREPAREDNESS

Will back-up power system design requirements change in the aftermath of recent hurricanes?



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Welcome

In recent years, we've witnessed the massive destruction of property and loss of life due to earthquakes, tsunamis, floods, tornadoes, and hurricanes. Each time one of these events occurs, we're all reminded of just how dependent we've become on communications and electrical systems. If I were a Doomsday Prepper, I'd tell all of you who live near the coastline to pack your bags and head for higher ground. I'd urge anyone living close to a fault line or in Tornado Alley to move to more stable lands. I'd also tell you to stockpile canned food and water and to start making plans to go off-grid. However, I'm not one to fall into this line of thinking. My personality and technical training lead me down a more methodical and practical path of analysis and action.

Some government officials and members of the media are beginning to wonder if the fundamental assumptions used to design and install back-up power systems are somehow flawed. Although I believe current rules and regulations are pretty sound, designing for natural disasters is where things can get tricky — especially when these so-called "once-in-a-lifetime" storms start hitting more frequently. The other obstacle to overcome is how to handle legacy equipment/systems and space restrictions in densely populated areas.

MIKE EBY
Senior Director of Content
EC&M

There's no doubt the 2017 hurricane season was devastating, after Hurricanes Harvey, Irma, Maria, and Nate swept through parts of the Gulf Coast and the Caribbean, causing unprecedented damage. Although these hurricanes may not be the deadliest on record, they wreaked havoc on their areas of impact nonetheless. In Florida, for example, eight nursing home residents died from excessive heat after Hurricane Irma knocked out power for days in the area, leaving the facility without air conditioning (see first article in this e-book, "**Taking Emergency Power by Storm**" on pg. 4).

After everything we've learned from Hurricane Sandy and Katrina, the looming question remains: Why are some facilities not better prepared to handle emergency/back-up power situations in the face of these natural disasters? This special report, which includes new material as well as popular evergreen content, will take a look at what previous

Welcome

hurricanes have taught us about back-up power system requirements on the state and federal level, what has changed since then, and what still needs to change in the face of these most recent deadly hurricanes.

I believe the people who have lived through these natural disasters and work on the front lines to bring normal and emergency power systems back online are the best resources we have when it comes to enacting change and ensuring reliability. Therefore, with their help, I'm confident that design guidelines and operational procedures will continue to evolve and improve.

IN THIS ISSUE

Taking Emergency Power by Storm

Wide power disruptions from latest round of hurricanes — and some deadly results — turn up the heat on addressing grid vulnerability and the reliability of standby power systems.

By Tom Zind, Freelance Writer

Thanks to their randomness — not to mention their ability to dish out equal-opportunity misery — natural disasters have a way of spurring action where there's been hesitation, forcing choices in the face of uncertainty and paralysis. That's what outbreaks of powerful hurricanes and superstorms over the last dozen years look to be bringing to serious discussions of back-up electrical power, including where it's needed, how much should be required, how to deliver it, and how to ensure it works.

Hurricane Sandy and three others in 2012 caused $75 billion in damage and exposed long-overlooked vulnerabilities in emergency power in the Northeastern United States, just as Hurricane Katrina and four others did in their $200 billion-plus Gulf Coast assaults in 2005. These clusters of storms, some with chart-busting size and power, knocked out grid power over large and, in some cases, densely populated areas, swamped on-site generators and fueling systems in low-lying areas, and exposed standby power systems that had not been maintained well enough to perform when needed.

A repeat performance came in 2017 when four more storms — Hurricanes Irma, Harvey, Jose, and Maria in quick succession — combined to cause another $200 billion in damage from Texas to the Caribbean. They wreaked similar havoc on the electrical grid and put a bold exclamation point on the emergency power issue, primarily because of one high-profile incident: the deaths of 14 residents of a Florida nursing home that lost power during Irma.

Like many nursing homes across the country, The Rehabilitation Center at Hollywood Hills,

in Hollywood, Fla., did not have standby power equipment to run air conditioning units, leaving elderly and frail residents to swelter for hours in rising heat and humidity. The failure to evacuate residents led to prolonged exposure to extreme temperatures, and 12 people ultimately died as a direct result, the country medical examiner ruled.

Meanwhile, in Puerto Rico and other Caribbean islands, fall storms scored devastating direct hits, knocking out power so extensively that many areas are still without grid power as of this writing with not much hope for quick restoration. They exposed not only the special vulnerability of island electrical grids to Category 5-scale storms, but also the insufficiency of many emergency power systems, including those in critical facilities, such as hospitals, nursing homes, and assisted living facilities (ALFs).

"People in Puerto Rico are still on generators six months later," says Richard K. Ladroga, P.E., director of property loss consulting for DeSimone Consulting Engineers, who has assessed post-hurricane infrastructure damage across the Caribbean. "But many diesel generators are also still failing, many because they haven't been maintained like they should have been."

Deaths spur action. But it was the Florida nursing home deaths that has helped crystallize the issue of emergency power where it's perhaps most critical — in settings where it can mean life or death. That incident quickly resurrected a long-simmering debate over whether nursing homes and ALFs should be required to have much more robust standby power systems than ones most now must

Part of a 1MW diesel generator is lowered into position at Lutheran Towers Nursing Home in Orlando. The unit had to be placed below ground level, a design-build challenge.

maintain to operate elevators, fire suppression systems, and life support systems. The core concern: Should they be mandated to provide standby power equipment sufficient to operate air conditioning systems capable of maintaining safe temperature ranges for an extended period?

The quick answer from the Florida governor was "yes." Within days of the fatalities, Gov. Rick Scott issued an emergency order requiring nursing homes and ALFs to submit plans by Oct. 31, 2017, for installing emergency power systems that would be able to start immediately after a power failure and run air conditioning so ambient temperatures would stay at or below 81° F for at least 96 hours thereafter. Furthermore, plans had to be capable of implementation by Nov. 15, 2017.

That order, however, crumbled partly under pushback and formal challenges from interests representing care facilities concerned with the timing and cost-benefit considerations of the mandate. It was invalidated in late October by an administrative law judge, who said qualifying emergency conditions no longer existed and that the deadline for compliance was nonetheless "impossible" for most to meet.

"Our main concern was with the timeline — requiring plans in 60 days, which was unrealistic," says Kristen Knapp, director of communications for the Florida Health Care Association, which represents about 550 of the state's 680 nursing homes. "And we were looking at a cost of anywhere from $150,000 to $300,000 to put in generators of the size needed just to run air conditioning."

Nevertheless, the state's long-term care interests and the administration went back to the drawing board. A compromise was reached in January, mandating generators capable of powering air conditioning and maintaining 81° F temperatures in nursing homes and ALFs. The key difference: Generators don't have to be installed. Instead, portable generators would be allowed, but with a host of stipulations. Nursing homes would need to have 72 hours of

FLORIDA FACILITIES MULL BACK-UP PLANS AMIDST UNCERTAINTY

In the dark about a looming mandate for emergency power to run facility HVAC systems in a blackout, Florida nursing homes and assisted living facilities could have used some standby power in late February to light the way. As it was, clarity was in short supply. Would state lawmakers ratify a compromise allowing portable generators, or would generators have to be installed? Would alternatives or new specifics emerge? Might lawmakers even kill the mandate? No one knew for sure. Nevertheless, most facility owners plowed ahead, weighing options or making purchases as June 1 — the start of the hurricane season and the likely deadline for finalizing plans — approached.

John Knox Village of Central Florida, which lost power during hurricanes last fall, wasn't waiting; it will replace (but not until late 2018) aging generators not configured to power HVAC systems in two campus facilities with new, larger ones that will. The installed units will provide 105 hours of emergency power and replace spot-cooling using rented air conditioning units and fans during outages, says Joseph Trainor, executive director.

"It didn't make any difference to us what the legislature was going to do," he says. "By the time we get residents here they're sick, and the last thing you want to do is put stress on them."

Many facilities are making a similar calculation, says Tim Rebholz, director of new equipment sales for Genset Services, Inc., a Pompano Beach, Fla., distributor. Larger ones with ample resources are generally making the investment now, and most are going the installed route, he says. Some are interested in mobile generators as a cheaper alternative, he adds, but designs needed to meet tougher emissions requirements have made them costlier. Plus, they pose multiple on-site fuel storage issues, and availability isn't guaranteed.

"A week before a hurricane, those mobile units are usually gone, and they're picked up quickly by those with contracts," he says.

But up-front cost is a concern, and a reason many cash-strapped facilities are waiting for guidance on a rule — one that could provide funding, says Chris Hughes, P.E., president of Eau Gallie Electric, Inc., a Melbourne, Fla., company that has been consulting with facilities on design-build generator projects. Meantime, he's drawing up installed and portable options in varying configurations, "going as cheap as I can and looking for where corners can be cut, shorter copper runs, taking a closet and turning it into an electrical room, locating the generator in a parking spot."

Whether portable or installed, retrofitting facilities with generators poses design challenges. Many are older and not physically

FLORIDA FACILITIES MULL BACK-UP PLANS AMIDST UNCERTAINTY

or electrically configured to easily integrate units sized to run HVAC or all a building's load. Tying in a portable generator can be especially tricky.

"This is fairly easy to do in a new facility, but in an existing one that may be 40 years old it's harder," says Michael Dodane, president of MiGre Engineers, LLC, an MEP design firm in Longwood, Fla. "It can be hard to find AC systems that might be on 10 different panels."

To try to economize, Rebholz says, some owners have been wanting to explore establishing small cooling zones in facilities. That might translate to savings on generator capacity, he says, but facility wiring issues could be offsetting. On the flip side, some are interested in spending more to size generators capable of powering a facility's full load.

Another route to cheaper emergency power for such facilities is natural gas-powered generators. If permitted under the rules Florida is considering, they might be less expensive than diesel-powered units, up to a point, and could offer more assurances of uninterrupted fuel.

"A 100kW natural gas unit is about the same price as a diesel, but above that natural gas is a bit more," Rebholz says. "Once you map everything, though, natural gas might make more sense."

fuel on site and the ability to tap into another 24 hours' worth in a declared emergency. ALFs would need either 48 or 72 hours of fuel on site, depending on their number of beds.

The January agreement left facilities facing a tight timeline to come into compliance; agencies overseeing the rules were giving them until June 1 — the official start of the hurricane season — to begin implementing standby generator projects.

The wild card, though, is the Florida Legislature. In the push to ratify the rules by the March 9 session end, as state law requires, the body was contending with numerous freshly drafted care facility generator bills containing different prescriptions for reducing the chances of a repeat of the Hollywood Hills debacle. Much of the debate centered on costs the facilities would incur under the rules, which was spawning some proposals to address the issue by some means other than standby generators.

Mandates spreading. In the absence of ratification or passage of new legislation, the state's proposed generator mandate could die. That would hardly make Florida an outlier, as such mandates appear to be far from the rule. But some states do have laws addressing the maintenance of air conditioning — and

A utility crew repairs lines damaged by Hurricane Irma on Sept. 12, 2017, in Hastings, Fla. The storm brought flooding to areas not seen in generations.

even heat specifically — in care facilities after power outages, and storm events around the country may be moving some states to action. Ohio, for instance, was reportedly considering legislation because of Irma.

Beyond the states, the federal government is getting involved. As of last November, hospitals and other types of facilities that serve Medicare and Medicaid patients had to begin implementing a host of new emergency preparedness procedures. One requirement of the Centers for Medicare & Medicaid Services (CMS) rule, which grew out of care facility incidents during Hurricane Katrina, is that licensees provide "alternate sources of energy to maintain temperatures to protect patient health and safety and for the safe and sanitary storage of provisions."

Eric Cote, project director for Powered for Patients, a Washington, D.C., group formed in the wake of Hurricane Sandy to address power issues facing critical health care facilities, says the new CMS rules intentionally leave the door open to a variety of emergency power solutions.

"It doesn't require the use of generators because there are other emergency power systems out there, but generators are used in 90% of these cases," he says. "There are more obscure technologies that could meet that need, such as battery storage, microgrids, and

People created signs following Hurricane Irma in Key Largo, Fla. Irma made landfall in the Florida Keys as a Category 4 storm, swelling waterways an estimated 10 to 15 feet, according to published reports.

combined heat-power (CHP) systems."

Shortly after the CMS rules took effect, Florida U.S. Congresswoman Debbie Wasserman-Schultz introduced the Nursing Home Comfortable Air Ready for Emergencies Act bill. As a condition for Medicare and Medicaid participation, long-term care facilities nationwide would need to have emergency power sufficient to run facility air conditioning systems. It also would create a federal loan program to help facilities fund installations.

The Hollywood Hills incident has also renewed study of whether hospitals need to ensure air conditioning stays on in a power outage. While they must have and regularly test standby power equipment for critical building functions and patient safety, they're not required to ensure air conditioning systems stay operating.

But a Powered for Patients report issued in 2017 on the resiliency of critical health care systems stated that proposals to require hospital emergency power systems to run air conditioning "are advancing on multiple fronts."

Hardening facilities. While 2017 storms precipitated scrutiny of residential care facilities' ability to cope with power outages, they also helped refocus attention on the vulnerability of the nation's power infrastructure generally, and especially elements of it that service other facilities with priority needs for uninterrupted power.

Cutting huge swaths, powerful hurricanes like Sandy, Katrina, and others of the past

decade took some vital health care facilities, heavily populated public housing projects, data centers, gas stations and wastewater treatment facilities off grid power, forcing many to turn to emergency systems, some of which proved unreliable. Many institutions, industries, and jurisdictions responded with efforts to improve power reliability. Generators and fueling systems have been added, upgraded, and moved to higher ground; islanded microgrids using traditional generators and off-grid clean energy assets have been constructed; and closer monitoring of standby systems has been instituted.

In the New York City area, hard hit by Sandy, the hardening of emergency power systems has progressed steadily. By law or choice, many structures in vulnerable areas are being built or improved with generators and fuel sources securely isolated from the most remote flooding scenarios.

Installation of a 300kW natural gas generator for the Boca Raton, Fla., Housing Authority required two 600A transfer switches, gas plumbing work, and custom painting for aesthetics.

While 2017 storms precipitated scrutiny of residential care facilities' ability to cope with power outages, they also helped refocus attention on the vulnerability of the nation's power infrastructure generally, and especially elements of it that service other facilities with priority needs for uninterrupted power.

For instance, many public housing facilities in New York were left without power following Sandy after diesel generators and their fueling tanks flooded. Long-term plans were quickly laid to improve their resiliency, but actual progress has been slow in some quarters. In August 2017, the first of nearly 300 natural gas-powered generators specified for some three dozen properties operated by the New York City Housing Authority began to be installed. At NYU Langone Health, a New York hospital that experienced high-profile generator problems during Sandy, a new Energy Building was only recently completed in 2016. Its new generators, boilers, and CHP plant are designed to power the hospital's entire campus in the event of

an extended grid power outage.

Beyond a push for new and improved emergency power systems, there's a growing focus on improving their functionality and reliability. A primary mission of Powered for Patients is raising health care institutions' awareness of the critical need to regularly test, service, and maintain systems.

"There are various levels of readiness across the health care spectrum," Cote says. "Most hospitals have emergency power installed and ready to go, but those systems can run into problems from time to time."

To better ensure system performance, Cote says institutions should also be open to new standby power technologies, such as battery storage; emerging methods of status checking and utility communication using remote monitoring technologies; and potentially more reliable and economical generator fueling options, such as natural gas.

There's evidence that generator reliability could be in question. A National Public Radio report that aired in the wake of the Hollywood Hills incident stated that one-third of U.S. nursing homes have been cited for failing to inspect their generators each week or to test them monthly; 1,373 facilities were cited more than once.

That's an eye-catching statistic in the wake of a year in which another rash of powerful storms again served deadly notice that the power grid is vulnerable — and that reliable emergency power is anything but a luxury. Expanding its reach, improving its affordability, and ensuring its reliability will be central themes in the growing conversation about power continuity in an era of growing dangers and expanding risks.

In touring the Caribbean after the 2017 deluge of storms, Ladroga thinks he may have seen a vision of the future, one that will elevate attention to power infrastructure hardening, preparedness, and fail-safe systems to new levels. The grid is more vulnerable than ever, he says, and the last decade has brought that into sharper focus.

"To some degree, last year was a wake-up call," he says. "The strength of these storms is getting people's attention, especially when outages last as long as they have in Puerto Rico, for instance. There's going to be a need for greater self-sufficiency and room for more visionaries to develop new ways of achieving grid independency through battery storage systems, green power, and traditional generators."

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Hurricane Sandy: A Turning Point for Emergency Power?

Hurricane Sandy and its aftermath raise questions about the sufficiency of flooding protections for back-up power systems.

By Tom Zind, Freelance Writer

In a span of less than 24 hours in October 2012, residents of metro New York City were rudely reminded of how very close they live to the water — maybe, it now seems, a little too close for comfort.

Hurricane Sandy, dubbed a "superstorm" for its sheer size and reach in punishing the Northeast, took dead aim on the New York/New Jersey metropolis, merging torrential rains with waters of the Atlantic to flood low-lying boroughs and a broad stretch of coastline on a scale not seen in decades.

Among the many victims in the water's path were emergency back-up power systems in a range of environments — from health care facilities and data centers to office buildings and residential structures. In the worst cases, some systems were swamped, rendering gen-sets useless or too unpredictable to rely on in a critical hour of need. In others, they were temporarily disabled, leading to mere inconvenience.

Regardless of the venue, the inability of some systems to answer the call — and the problems that followed — sounded some alarm bells in the industry. New concerns are sprouting that perhaps fundamental assumptions used to design and install back-up power in some applications and locations may be fundamentally flawed.

Challenging assumptions. Fearing that Sandy may foreshadow new weather patterns that could spawn more surprise and possibly unprecedented flooding events, building owners, engineers, gen-set manufacturers, systems designers, government officials, and code

authorities may be poised to start revisiting best practices and requirements for back-up power systems.

For Bill Burke, division manager for the National Fire Protection Association (NFPA), the storm's fury and its impact on the electrical power infrastructure was crystallized in a dramatic newsmagazine cover photo showing a largely blacked-out Lower Manhattan in the storm's wake. Remarking on it with colleague Don Bliss, chairman of National Electrical Code (NEC) Code-Making Panel 13, which establishes emergency power system provisions in the NEC, they both agreed it was a stark and telling image.

"Being electrical people, we were struck by the same things in that cover showing a darkened skyline, especially the realization that every one of those buildings probably had some kind of requirement or provision for back-up power, yet many of them apparently hadn't worked," Burke says.

While that photo was revealing, likely hundreds of facilities across the metro area did indeed have emergency power that ultimately worked as designed, even after experiencing temporary glitches in some cases. So, in that sense, the image may have overstated the extent and impact of the actual blackout and its duration.

Nevertheless, Sandy's floodwaters did find vulnerable systems in places that could least afford power interruptions of any duration. Looking back, those failures stand as fresh proof that back-up power is ultimately only as good as its ability to stand up to the most extreme circumstances, particularly in mission-critical environments.

Uncommon darkness settled on the eerily empty, blacked-out streets of Lower Manhattan in New York on Oct. 31, 2012.

Vulnerable venues. Understandably, the Sandy-induced back-up power system failures that captured the most attention for both their real and potential impact were those that plagued a few important hospitals in low-lying parts of New York City.

Problems like those faced at facilities like New York University Langone Medical

HOSPITAL SYSTEM DESIGN DEBATE

Emergency power reliability at health care facilities has long been a topic of debate. After Hurricane Sandy, that conversation may be heating up even more.

Hospital back-up power is governed by an array of rules, regulations, and guidelines, many rooted in parts of the National Electrical Code (NEC). Location-specific design, testing, and maintenance are addressed in NFPA 99 – Healthcare Facilities; broad guidelines are covered in NFPA 110 – Emergency and Standby Power Systems. The chief hospital accrediting body, The Joint Commission, references both in its requirements for back-up power.

As comprehensive and detailed as these are, there may be gaps. Proclaimed skeptics of hospital readiness point to the flooding of back-up systems in Sandy as evidence. One, Arthur Kellerman, the policy chair at Rand Corp., was quoted by ProPublica as saying it was "remarkable" that the major hospitals still have critical back-up systems located in basements prone to flooding.

George Mills, director of engineering for the Joint Commission, says hospitals have some discretion in how they configure and place back-up systems, though some code wording does opaquely reference flood protection. They must rigorously and routinely test their systems for reliability, but a detailed hazard vulnerability analysis (HVA) typically governs system design and installation.

"Each organization needs to look at the HVA and see how to manage their systems through that," he says. "Hospitals generally have to identify the risks they perceive to the public and then work to mitigate that risk."

Designing for natural disasters, however, can be tricky. Threats vary based on geography, climate, and weather history, Mills says. But unprecedented events, similar to Sandy, can alter risk assessments. Following Hurricane Katrina, the Joint Commission issued an alert of sorts that advised locating back-up systems above expected flooding levels. But hospitals, he says, have to consider risk-benefit scenarios and weigh the costs of relocating systems or designing new ones that may be more costly to install. Post-Sandy, Mills says, some New York-area hospitals did engage in some second-guessing.

"Some said they wished they had maybe done a more thorough job looking at HVA assumptions," he says. "But the theorem we go by here is that organizations appear to pay attention to the most recent events. If they haven't experienced flooding, that's low on their radar."

Center (NYU Langone), Bellevue Hospital Center, and Coney Island Hospital, as well as other buildings scattered across several boroughs, largely shared a common theme. Where back-up power systems failed, most, if not all, apparently succumbed because floodwaters

overwhelmed fuel pumps, transfer switches, or other essential equipment housed on lower levels. The problem was many of these units needed to power generators that were sitting on upper floors. Many of the 6,000-patient evacuations from metro area hospitals likely stemmed from power interruptions or losses (see **Hospital System Design Debate** on pg. 16).

Storm surges of 11 feet in most areas of the city and up to 14 feet in others sent water cascading into the lower levels of buildings. Many were constructed to withstand some water inundation, but generally not at the levels Sandy delivered. Some reports put peak water volumes in some basements upward of 15 million gallons.

Of all the New York-area facilities that suffered back-up power problems, NYU Langone may have received the most attention. Located on the banks of the East River in Manhattan, parts of the NYU Langone medical complex (consisting of four hospitals) experienced flooding, and parts of some buildings lost emergency power provided by on-site generators.

According to one published report quoting the hospital's vice president of facilities operations, in places floodwaters under extremely high pressure overwhelmed protective barriers surrounding pumps that shuttle fuel to multiple emergency generators, causing them to shut down. With fuel supplies cut — and critical power distribution circuits also compromised by exposure to water — some generators were rendered ineffective or operationally suspect, leaving or threatening to leave multiple areas of the complex powerless as the storm bore down.

Some pump operations were quickly restored, but hospital officials decided to take the precautionary step of evacuating patients. Because of flooding in the basement level that made the elevators unsafe to operate, the hospital brought patients down stairwells. Outside, where the storm raged, ambulances queued up to ferry them to other facilities. In all, more than 300 patients were safely evacuated.

Seeking answers. Responding in late January 2013 to these early published reports and specific questions from *EC&M*, NYU Langone appeared to distinguish between generator failure and the failure of pumps and other related components, but did not address the latter.

Specifically, the hospital said in written responses that only one of its eight campus generators actually failed. That unit, the only one below ground level (which provides less than 5% of the campus' generator capacity) did sustain water damage. But since it did not serve any patient care or critical research areas, the hospital said its failure "did not result in significant power outages and did not lead to the evacuation of patients."

Addressing only the center's Tisch Hospital for acute care patients, and no others, NYU Langone said generators serving that facility did not fail and supplied power to "several hospital floors" during the storm.

Anton Oparin/Shutterstock.com

Flooded building entrance, caused by Hurricane Sandy, seen on Oct. 29, 2012, at the corner of Bragg St. and Shore Pkwy. in Brooklyn, N.Y.

"Our investigation into the cause of the power outage at Tisch Hospital is ongoing, and it is too early to speculate as to what caused certain floors within the hospital to experience the power outage," the statement read.

While details of what happened at NYU Langone remain unclear, it is certain that on some level the hospital's back-up power system did not perform optimally — and the failures that occurred did so even after work had apparently begun to re-engineer the system to better handle potential flooding.

Fixes weren't enough. Following Hurricane Irene in 2011, the hospital reportedly scaled back and hardened the back-up power system's street-level components. Generators were moved to the rooftop, fuel tanks were repositioned, and ground-level pumps connected to an underground fuel tank were cordoned off in a flood-resistant structure. According to reports, Sandy struck as the hospital was trying to secure funding for the next phase of system improvements aimed at further hardening it against storm-related threats, exposing the inadequacy of the patchwork improvements to the system and its continued vulnerability to flooding.

When questioned about efforts to ensure there would not be a repeat of back-up power problems, NYU Langone told *EC&M* that a $250-million co-generation natural gas power

The Casino Pier Star Jet roller coaster submerged in the sea on Jan. 13, 2013, in Seaside Heights, N.J.

plant is under construction, and that flood barriers for that building and others are being considered.

That structure, the hospital said, will provide 8MW of additional power generation, enough to "mitigate potential outages and damages sustained from future storms." As an additional precaution, back-up generators and components will operate 20 feet above code requirements.

Factoring floods into future designs. In Sandy, back-up systems failed across the metropolis for various reasons and to varying degrees. But their apparent vulnerability to flooding events, because of either location, design, or both, is worrisome to those who study emergency power systems. Studies, hearings, and investigations into why will likely loom. But the sheer number of apparent failures, combined with the venues in which they occurred, leaves some wondering if a fundamental rethinking is in order for applications where flooding is a risk.

With early indications that emergency power failures were rooted in failures of pumps and other systems that deliver fuel, generators themselves aren't likely to emerge as the culprit. Provided they're maintained, tested, kept in good operational condition, and located on higher ground — shielded from all but the most catastrophic water incursion — gen-sets should perform in typical storm scenarios.

The concern, says Michael Pope, current president of the Electrical Generating

Systems Association (EGSA), an organization that represents gen-set manufacturers, now likely centers on the design and location of enabling components of back-up power systems.

"The positioning of pumps and fuel supplies has to be reconsidered, and part of the problem in New York may be that the building codes don't permit fuel storage on building roofs," Pope figures. "If that's the case, then every installation where fuel is stored below grade probably needs to be reviewed and looked at to determine if water can get in there and, if so, what precautions can be taken to prevent that from happening."

With Sandy, and Irene before it, amping up the debate over climate change and the prospect of more powerful and more frequent storms, reasonable gauges of future high water marks might be ratcheted up.

While such an assessment may be an important first step, the looming question is whether Sandy may have been a game-changer. If the flooding it spawned resets the calculation of expected future high-water levels in lower-lying areas, remedial fixes may not be possible for many systems located at street level or lower.

Re-design challenges. With Sandy, and Irene before it, amping up the debate over climate change and the prospect of more powerful and more frequent storms, reasonable gauges of future high water marks might be ratcheted up. If so, as NYU Langone learned with its system improvements, it may not be realistic to think about protecting systems already in place from flooding that could accompany stronger storms.

Consequently, some, like engineers in the New York-based consulting engineering firm Syska-Hennessy Group, Inc., anticipate a fair amount of hand-wringing over how to configure back-up power systems in Sandy's aftermath. In surveying the post-Sandy landscape and working with some clients in the city, among them health care institutions, vice presidents Keith Fitzpatrick and Marina Dishel see a litany of concerns.

For one, if an expected new flood map of the city raises the 100-year flood mark by three or four feet, Fitzpatrick says, many existing back-up systems will be situated too low for comfort. But, as always is the case in disaster planning, it will come down to a question of how much risk to shoulder.

"Some landlords are replacing systems right where they were destroyed as if nothing happened, and others are thinking about moving everything up, at great cost, a floor or two higher," says Fitzpatrick. "Clients who can't afford that are thinking about constructing bathtubs of sorts around components to seal them off and rely on sump pumps in hopes of minimizing the risk. But for some of the buildings on the

waterfront, there's no way that pumps could have pumped as much water out as came in."

Then there's the problem of existing city building codes that dictate rules on emergency power system integration and, more relevantly, where and how much diesel fuel can be stored on site, says Dishel.

"A lot of buildings will probably be looking to at least elevate pumps above flood level, if possible, but depending on the architecture of the system and the building that can be costly," she says. "We're working on redesigns like that for some clients, and we've also looked into submersible pumps, which don't now look to be an option. Another solution could be dual-fuel (natural gas/oil) generators, but we're not sure if the industry now provides the type of generator that would be needed."

In search of best practices. Indeed, a broad slate of options for improving the reliance of back-up systems will likely be on the table as the Sandy experience is further analyzed. Bliss, the NEC Code-Making Panel 13 chairman and a professional emergency management expert, says revised calculations about flooding risk should probably be factored into assessments of the readiness of systems in flood-prone areas.

"There are some lessons to be learned here about preparedness, and there will be multiple components to study, including code compliance, the performance design/risk assessment process, how systems are designed and installed, specific needs for back-up power, and operational and human factors," says Bliss.

Information on those and other elements of the back-up power experience in Sandy are due to be gathered by NFPA. Panels like Bliss' and others who oversee parts of the NEC covering emergency power systems are keenly interested in understanding just how well such systems in Sandy's path performed.

The mission, according to NFPA's Burke, will be to draft a formal study that could inform efforts to update or change the many parts of the Code addressing back-up power. It's too early to say whether changes to requirements are needed, but Burke says anecdotal information about failures suggest a need to study revisions. If critical systems are deemed more vulnerable to water because of where they're housed or because geography conveys a heightened risk of more frequent and more powerful storms, remedies must be explored, he says.

"There may be better ways to install systems to protect against this sort of thing," says Burke. "We need to find out why so many appear to have failed, try to categorize our findings into some very specific areas, and then take a logical look at maybe doing something better to prevent something like this from happening again."

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Hurricane Sandy Restoration Efforts

New York electrical contractors continue to get the city back online after Hurricane Sandy.

By Beck Ireland, Staff Writer

In anticipation of the destruction the winds of Hurricane Sandy would bring to the East Coast in late October 2012, electrical contracting firms around the country hired additional hands and dispatched teams to prepare to work alongside electric utility workers in order to bring power back to the area. Parker City, Ind.-based Townsend Corp. sent 510 employees in 194 crews from branch offices in Pennsylvania, Kentucky, Indiana, Michigan, Missouri, Louisiana, the Carolinas, and Georgia to support line clearance and construction work. John Pequet, a member of electrical workers' union Local 17 in Southfield, Mich., said that when he dispatched his crew on October 28, he was told to "keep going until you get to the ocean."

In addition, despite having to manage their own disaster preparedness, several New York-based firms pitched in with the effort (**Disaster Planning Works for New York Electrical Firm** on pg. 27). For example, Victor, N.Y.-based O'Connell Electric Co. dispatched 116 workers and 68 pieces of equipment and vehicles to help in Long Island and Brewster, N.Y. According to CEO Victor E. Salerno, the firm's linemen first focused on getting customers back online, which, because of the extent of the damage, took much time and resources.

E-J Electric Installation Co., Long Island, N.Y., began mobilizing union electrical workers, most coming from IBEW Local 3 and 42, and equipment as the threat of Sandy increased. In all, it hired an additional 200 workers. With divisions that include transmission and distribution (T&D) and electrical construction, the firm was in a unique position to offer its services to the New York City area. The firm deployed around 40 linemen to help with power restoration efforts in Long Island, along with First Call, its emergency response team. Its field staff — from project management to

engineering — worked around the clock, even through the weekends.

Fortunately, the firm's headquarters were untouched by the rising waters, and the building never lost power. "Our entire neighborhood was flooded, literally right up to 10 feet from our steps," says Anthony E. Mann, president and CEO, E-J Electric Installation Co., Long Island City, N.Y. "We were lucky, and that enabled us to respond very quickly."

Still, the company wasn't completely unaffected. Its warehouse, located two blocks from headquarters, had 10 inches of water in it. Furthermore, many of the company's employees lost their homes. "A lot of our employees had challenges," says Mann.

Some had to take time off to relocate or rebuild. Still, the firm responded to the emergency situation. "We've had situations where we needed up to 25 electricians in the facility for an emergency, and they've come and worked through the night," says Mann. "A lot of them have their own problems, but were working around the clock to help other people. It was amazing to see how everybody stepped up with the whole organization working 24/7."

Up and running. In the immediate aftermath of the storm, ongoing construction projects were postponed in order to respond to emergency situations. "The clients had to be back up and running," says Mann. "Critical care, housing, even commercial facilities, had to have power restored."

E-J Electric worked to restore equipment at a 27-story office building in the financial district of New York. All electrical service and distribution equipment was damaged by water from Hurricane Sandy.

For instance, E-J Electric responded to an emergency call by New York City Housing Authority (NYCHA) to survey and repair 29 public housing buildings on Coney Island. All locations experienced some type of damage due to flooding from Hurricane Sandy, including some of the switchgear rooms being submerged by ocean water that left the buildings without power. Through a coordinated effort with multidisciplined construction management, engineering, and architecture firms, the LiRo Group and HAKS, as well as NYCHA, Army Corp of Engineers, and E-J Electric, generators were located to get the buildings on temporary power and re-energize the resident

Trees and electric poles came down in the Sheapsheadbay neighborhood of Brooklyn, N.Y., due to strong winds from Hurricane Sandy.

apartments, boilers, elevators, trash compactors, and other life safety systems.

"These people couldn't afford to leave or go to a hotel," says Mann. "They didn't have any place to go. So we needed to get the power back up because these people were really dependent on living there."

In the time before the storm, E-J Electric had been working for Turner Construction to build a new energy building at NYU Langone Medical Center, a private hospital. Turner Construction was able to use that relationship to quickly hire E-J Electric for the post-storm recovery. Under the design/build process, E-J Electric brought power up in three weeks, with the cooperation of a national electrical manufacturer, which produced switchgear in six days instead of the normal 12- to 18-week turnaround time.

At the entertainment and sports facility Chelsea Piers, the entire first floor, which contained the electrical infrastructure, was under water. E-J Electric Installation Co. crews were able to get the place opened in three weeks — in time for its busy holiday season.

In order to do that, the firm cleaned and put back in service two 4,000A service switchboards, while simultaneously evaluating and ordering replacement electrical equipment for four major electrical distribution rooms throughout the complex. Three of these rooms were completely rebuilt, including the

complete relocation of one electric room to the second floor to limit the facility's exposure in the event of another flood event in the future.

In a second location, a replacement 500kVA transformer was installed on a 16-foot-high steel platform, and the remaining equipment was raised by 12 inches. In addition, E-J Electric helped determine a location for a replacement main service switchgear room on the second floor that was in design by the consulting engineers.

Some owners are considering more long-term changes. According to Mann, the market for commercial buildings will drive the changes. Power independence has now become a necessary quality for attracting tenants. Co-generation will power buildings independently in case of emergency.

"Short-term, there was a lot of activity," says Mann. "But most of the work finished rather quickly. New construction is ongoing again. It was a short-term postponement, and everybody's back to the normal processes."

Additionally, such as in the next phase for Wall Street commercial buildings, there are opportunities for further projects in the future to meet revised building codes. "There will be some long-term infrastructure work that comes out of it," continues Mann. "Also, the people building new buildings are already making changes to what they're doing. They're moving their switchgear upstairs. They're putting in retaining walls to keep water out."

Toward resilience. Flooding in lower levels where mechanical and electrical infrastructure were located destroyed fuel pumps, transfer switches, and other systems. "The water ran right through the parking lots and took out the switchgear in the basements," says Mann, who explains that many commercial buildings in the area have moved their electrical and mechanical infrastructure to an upper floor. "They're looking at relocating their infrastructure to be ready if there's another big storm. That's a second phase. The upper floors were all fine. It wasn't wind, and there was very little rain. It was all water damage from flooding."

Moreover, some owners are considering more long-term changes. According to Mann, the market for commercial buildings will drive the changes. Power independence has now become a necessary quality for attracting tenants. Co-generation will power buildings independently in case of emergency. "Class A buildings are going to take measures that their tenants are going to want them to take," says Mann. "If you're a tenant in a Class A building, you're going to want to make sure your

critical systems are above where any water would come. So that will naturally happen for those types of buildings."

Nonetheless, New York intends to make some of these changes official. On Nov. 15, 2012, New York Governor Andrew Cuomo convened the NYS 2100 Commission in response to the recent severe weather events like Superstorm Sandy, Hurricane Irene, and Tropical Storm Lee. The commission was asked to recommend actions to be taken to prepare New York to more effectively respond to, and bounce back from, future storms and other disasters. On January 11, 2013, the Commission issued its first report, "Building Resilience in New York."

The recommendations are categorized by transportation, energy, land use, insurance, and infrastructure finance. The report also highlights nine major cross-cutting recommendations that are relevant to multiple sectors and systems: protect, upgrade, and strengthen existing systems; rebuild smarter; ensure replacement with better options and alternatives; encourage the use of green and natural infrastructure; create shared equipment and resource reserves; promote integrated planning and develop criteria for integrated decision-making for capital investments; enhance institutional coordination; improve data, mapping, visualization, and communication systems; create new incentive programs to encourage resilient behaviors and reduce vulnerabilities; and expand education, job training, and workforce development opportunities.

"We're looking at what the city needs to do for buildings," says Mann, who was appointed co-chair of the electrical and IT working group on the New York City Building Resiliency Task Force, convened by Mayor Michael Bloomberg and City Council Speaker Christine Quinn. "We're right in the middle and hope to conclude by May, coming out with new regulations on what needs to be done to prevent what happened with Sandy. Each building type is different, each location is different, and it's something that the city is looking at closely."

Economic impact. Estimates put the damage caused by Hurricane Sandy at $50 billion. On January 29, President Obama signed into law the Hurricane Sandy Supplemental bill, which appropriates roughly $50.5 billion to various agencies for Hurricane Sandy relief and recovery efforts. The bill provides funding to the Federal Transit Administration for transportation-related projects, the Army Corps of Engineers for flood control and construction projects, and the Department of Housing and Urban Development for community development programs. In addition, the bill provides more than $11 billion to the Federal Emergency Management Agency (FEMA) to replenish and expand the Disaster Relief Fund. Combined with the $9.7 billion in aid President Obama signed into law January 6, federal aid for recovery from Hurricane Sandy now totals $60.4 billion.

This funding has led some observers to believe the recovery work from the storm's

DISASTER PLANNING WORKS FOR NEW YORK ELECTRICAL FIRM

MTA/NYCT, the largest U.S. public-transit service, suffered $5 billion in damage and lost revenue as a result of Hurricane Sandy.

N.J. Transit, the United States' second largest transit system, sustained $400 million in damage. RailWorks, North America's leading provider of track and transit and systems construction/maintenance services, weathered Hurricane Sandy with minimal disruption due to contingency plans in place along with the extraordinary response by its employees, and was able to help get New York's transportation services running again. This is the timeline of the company's proactive action and responses:

Three days before Sandy made landfall, RailWorks' Information Technology (IT) Department, led by Chief Information Officer Bob Cummings, verified that contingency plans developed more than a year ago were in place. The department began the first of 10 consecutive daily morning and evening calls to monitor the storm, its impact on critical business functions, and related IT support activities. Field and project offices in Sewell, N.J.; Worcester, Mass.; and throughout the Greater New York area, secured equipment in their yards, repositioned equipment and materials out of low-lying areas, and confirmed access to generators.

On October 27, Salvatore DeMatteo, general superintendent for RailWorks subsidiary L.K. Comstock, monitored flood zones and began sending alerts to project managers and general foremen on the status of project operations over the next five days.

On October 28 — a Sunday — Payroll Manager Fabi Mayor, Finance Manager/Payroll Controller Tom Lealand, and Controller Judy DelGizzo decided to begin running payroll early using available data. Mayor contacted Assistant Payroll Manager Linda Horan and Payroll Associates Kathy Calvente, Michelle King, Louanne Wilson, and Susana Wong, who immediately started processing payroll from their homes.

On October 29, the corporate and Farmingdale offices were without power and Internet. Services were out or intermittent over the next few days. MTA/NYCT construction managers advised N.Y. Transit that all project sites were shut down. N.Y. Transit leadership initiated ongoing communications with field personnel to coordinate Farmingdale office and project startup activities. The IT department maintained contact with departments throughout the week to support essential activities and to help coordinate getting employees set up to work from home. Telecommunications Manager John Barry and Director of Infrastructure Services Bob Hickey monitored and addressed infrastructure, network, and power problems and worked with the IT team to resolve them throughout the week.

DISASTER PLANNING WORKS FOR NEW YORK ELECTRICAL FIRM

Payroll employees continued processing payroll from their homes. Power outages began hitting one payroll employee after another throughout the afternoon. They used landlines and cell phones to notify each other when the power went out or was restored. Using a tag-team approach, they kept work progressing wherever they could find power. This effort continued the next day. Payroll Operations Analyst Fred Omar charged his mobile phone in his car so he could respond to calls from the field about the automated time-collection system.

On October 30, winds, rains, and flooding pounded New Jersey and New York throughout the night and through three cycles of tides, crippling transportation networks, downing overhead power lines, and flooding eight NYCT subway tunnels, as well as the Hugh L. Carey and the Queens Midtown tunnels. The Metro-North Railroad lost power in sections, and the Long Island Rail Road sustained flooding. As the day progressed, Sandy weakened as it moved inland over Pennsylvania.

N.Y. Transit personnel resumed limited work at some project sites. With all mass transit still shut down in New York, Staff Accountant Kevin Evangelista caught a ride from his apartment in Queens into the Manhattan office so he could get his computer. He returned home where he used his Wi-Fi to transmit the file of electronic ACH payments to vendors. He continued this effort throughout the week.

Corporate Cash Manager Trisha O'Donohue maintained banking throughout the storm by working off available hot spots in Westchester County, N.Y.

On October 31, the payroll department met at the Farmingdale, N.Y., office. They traveled with John Barry to an emergency back-up office on Long Island, where the IT and payroll departments had power and Internet connections to perform their work.

Work resumed at all N.Y. Transit project sites, including CBTC Flushing and the No. 7 Line Extension, which were flooded and had the most damage. The CBTC Flushing project office in Long Island City ran with a back-up generator for the next two weeks.

On November 1, the IT and payroll departments resumed operations in the Farmingdale office, even though most employees' homes were without power and some were taking on water.

On November 2, Accounts Payable Manager Melissa Quinones used Wi-Fi at her home to transmit the file for check runs.

During the week of November 5, N.Y. Transit began restoration services for NYCT at South Ferry, to clean up and restore the station, and at Coney Island Yard, to overhaul water-damaged switch and stop machines. Work continued into December.

damage will create a surge in construction spending. But according to the Associated General Contractors of America (AGC), the overall impact is likely to be negative. The funding to replace these structures in many cases will be taken from other construction budgets, says the AGC. Meanwhile, businesses that had planned to build, or to occupy new space that developers put up, will defer or cancel those projects. State and local governments will experience lower income, sales, and property tax receipts, forcing further budget cuts.

Stephen Sandherr, CEO for the construction trade association, urged Congress and the administration to make infrastructure investment a top priority in 2013. "Congress and the president have provided some tax certainty that provides a foundation for economic growth," Sandherr said. "But their jobs are far from completed. It is vital that the states devastated by Hurricane Sandy receive funding immediately for recovery work. In addition, lawmakers should not target construction spending for further cuts when they turn to spending decisions in the next two months."

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On-Site Power: Out of Sight, Out of Mind, Out of Operation

Did Hurricane Sandy expose a flaw in standby power systems design that now may be too big to ignore?

By Tom Zind, Freelance Writer

Now soaking wet, the "elephant in the room" is perhaps easier to see. With its floodwaters swamping generators, switchgear, and fueling components for back-up power systems serving scores of facilities in and around New York City in October 2012, Hurricane Sandy exposed a flaw in back-up power that now may be too big to ignore. The fact is many systems still may be housed in highly vulnerable areas that could compromise their reliability.

Sandy, rated a 100-year storm at minimum, glaringly exposed the vulnerability of some back-up power systems, particularly those installed at or below ground level in low-lying, flood-prone areas. Back-up power was lost when water from a storm surge and rainfall poured into basements and street-level areas. Office buildings, hospitals, retirement homes, and data centers were among the victims. Widespread loss of power left the sick and vulnerable, communications networks, critical infrastructure, public services, and a host of functions dependent on electricity grimly exposed across a wide swath of coastal New York and New Jersey.

Following the storm, reserve power, especially that serving high-risk areas and mission-critical applications, received closer scrutiny. Flooding scenarios that could render

Anton Oparin/Shutterstock.com

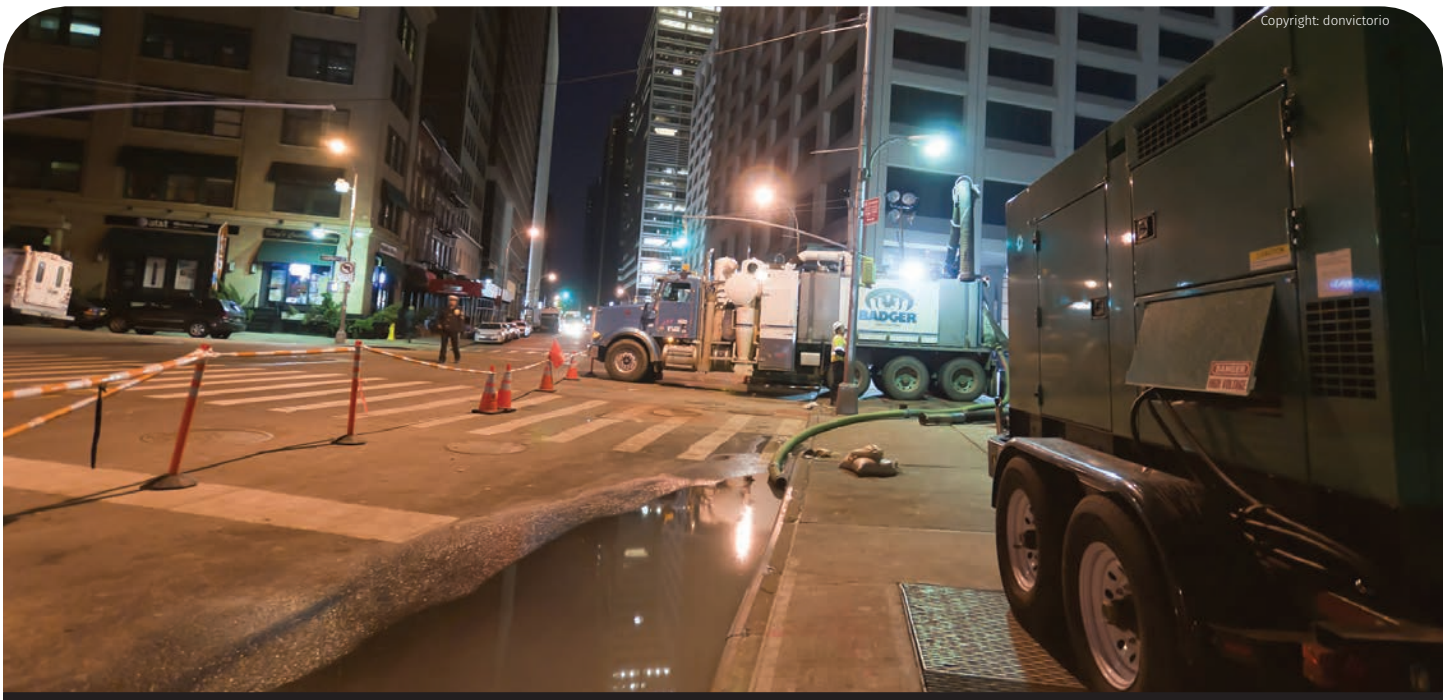
Work crews pumped water out of a flooded building in New York City's Lower Manhattan following Superstorm Sandy.

such power inoperable suddenly looked a lot more plausible.

Assessing risk. Predictably, concern with the adequacy of back-up systems was now most acute in areas directly affected by Sandy. Consulting engineers in the region who specialize in emergency and legally required power systems have a front-row seat — and a window — to new business opportunities, watching these new concerns/fixes play out. They're fielding more requests for help in assessing and hardening systems either damaged by Sandy floodwaters or now deemed more at risk.

Following the storm, reserve power, especially that serving high-risk areas and mission-critical applications, received closer scrutiny. Flooding scenarios that could render such power inoperable suddenly looked a lot more plausible.

Engineering firms like John-Winston Engineers and Consultants, a utility and power consultancy in Allenhurst, N.J., stepped in. Company president Richard Bernhardt sees evidence that Sandy has changed how entities responsible for buildings and facilities in the region think about back-up power. The heightened



Portable generators were brought in to power critical loads.

level of concern may prove fleeting as memories of Sandy recede, but for now it's palpable.

"There's a new awareness of what the risk is," he says. "More and more people are becoming conversant in this language of resiliency and attempting to actually consider the implications of flood lines on a FEMA map, the potential for sea level rise, and a pre-purchasing of that reality by preparing a facility for something like that."

After Sandy's floodwaters easily breached numerous sewage pumping stations along the New Jersey coast, ruining back-up generators and associated electrical equipment with brackish water, several regional sewerage authorities turned to Bernhardt's firm for help in designing a fix that would better insulate back-up power from water. Ruling out a wholesale elevation of the pumping facility, Bernhardt advised lifting the back-up power equipment and building berms and ship doors around it to keep water at bay.

"When those original systems were built 35 years ago, the areas never experienced the kind of flooding we saw with Sandy," says Bernhardt. "Now we have an experience where generators were ruined and equipment was shorted out. If we get a 100-year storm that brings water 10 feet high, this is built to withstand 3 feet above that."

Fuel factors. One element of the old systems that's being retained is natural gas-powered generators. Where on-site generators continued to work during Sandy, many were ultimately foiled when fuel resupply problems

In the aftermath of Superstorm Sandy, a Con Edison work crew fixes power lines in Brooklyn, N.Y.

emerged. As numerous diesel-powered back-up generators quickly ran out of fuel when storage tanks sized for limited duty ran dry, widespread street flooding slowed the pace of diesel deliveries. Bernhardt says that experience is a good argument for installing natural gas-powered generators.

"As the technology matures, a dual-fuel solution that offers the fuel security of some amount of time for diesel, and, in the event that runs out, the ability to run on natural gas will be the best of both worlds," says Bernhardt.

Natural gas, however, isn't a perfect solution. While closer to the mark as an uninterruptible fuel source, it's not the most efficient way to power an on-site generator. Generator sizing is one barrier to widespread adoption, and it's a factor that comes quickly into play in designing high-capacity back-up systems that often have to be wedged into small spaces in city buildings.

"Natural gas is one of the topics that's come up as a preference for critical systems where there's an interest in eliminating another potential point of failure in the supply chain," says Angelo Bufaino, principal engineer with Hatch Mott MacDonald, a Metro Park., N.J., consulting engineering firm that in Sandy's wake has done some back-up power redesign work for clients. "But natural gas gen-sets are typically much larger than diesel, so it's difficult to get your head around the idea of natural gas as a fuel source when you're considering very large

generators. It's hard to actually find anything above 1MW that's powered by natural gas."

Fuel storage is another obstacle, notes Bufaino. Where strict rules address the readiness of on-site power, mandates are often clear on the amount needed to power the generators for a set period of time. To guard against an interruption of natural gas, on-site storage rules might still apply. But storing natural gas — perhaps in compressed or liquid form — could pose another design hurdle.

"Having 48 hours of uninterruptible storage might work for small gen-set applications," maintains Bufaino. "But when you approach the 1MW size, it might not be feasible."

Storage solutions. While refueling issues caused many systems to shut down during Sandy, the culprit in other system failures was the fouling of diesel storage tanks and fuel-pumping systems with floodwaters. In the most vulnerable facilities, tanks and pumps at ground level or below were often quickly overwhelmed, rendered unable to deliver fuel to generators — some out of harm's way at higher elevations.

In addition to exploring new fueling options, Bufaino's work with clients affected by Sandy has spanned consulting on reworkings of fuel storage tank vents and fill ports to insulate them from water; moving and reconstruction of fuel and gen-sets to higher areas; and the addition of oil and coolant makeup systems for generators to allow for longer periods of safe operation and maintenance, as needed during extended outages like those seen during Sandy.

"Sandy was a unique event. We had facilities down in excess of 10 days," says Bufaino. "Back-up power systems aren't meant to run that long — 100 hours a year is standard. So makeup systems are being recommended more for systems that might be expected to run outside of their published capabilities."

Given the inherent problems with fixed on-site power generation that Sandy amply exposed, interest may also be running higher in solutions incorporating portable power generation. Regional supplies of rental generators were quickly snapped up in the wake of Sandy, and since then solutions involving generators that can be easily connected and disconnected via cam lock connectors/boxes as conditions warrant has grown.

"We've seen some interest from municipalities in mobile sets that could be carted away to a high and dry area, and then brought back and reconnected," says Bufaino.

Mobile power may not be a feasible solution for the majority of buildings and facilities looking to protect back-up power systems from flooding, but elevation stands as a primary controllable element in re-design work. The single best remediation, while costly and challenging, may be bringing system components higher up, out of the way of higher water levels that might be expected to accompany future storms like Sandy.

But building codes in cities like New York that have restricted generator fuel and other system components to ground level or below

NEW YORK INITIATES BUILDING CODE CHANGES

New York City lawmakers have taken actions aimed at better ensuring the reliability of future back-up power systems installed in city buildings. Acting on a raft of proposals to improve the flood resiliency of facilities in the wake of Hurricane Sandy, the New York City Council gave the green light to several that appear to dictate where systems are housed.

Under revisions to the New York City Building Code, new buildings — or those being extensively renovated and located within the 500-year flood plain — will have to locate back-up power systems (including fuel storage components) above the design flood elevation. Specifically, hospitals won't be able to install such systems just to the 100-year flood elevation, but instead to the 500-year flood line. Those facilities will also be explicitly required to comply with broader requirements for flood-resistant construction.

Revised city codes also address the generator-fueling issue that was the source of so many problems in Sandy. According to a New York City Buildings Department recap of new legislation enacted in response to Sandy, natural gas will be permitted as a generator fuel for emergency systems serving certain classes of residential buildings and in standby power systems serving all building types. A long-standing requirement for on-site fuel storage is waived for systems using natural gas.

City codes also have been rewritten to make it easier for buildings to install systems that meet the specific requirements of "standby" power. A separate category of "legally required standby power systems" is defined and addressed in Sec. 701 of the NEC. Its requirements are somewhat less stringent than those for systems classified as "emergency" in nature, making it potentially less costly to install and maintain, according to a review of the new legislation released by New York's Urban Green Council. By relaxing requirements on the types of buildings that must power elevators with emergency power, more resources may be freed up to install back-up power meeting the definition of standby.

With its code revisions, New York seems to be clearly acknowledging that the city's back-up power infrastructure as it now exists is not ready for a "new normal" that Sandy may have ushered in. Richard Bernhardt, president of John-Winston Engineers and Consultants, a utility and power consulting firm in Allenhurst, N.J., who participated in the task force that reviewed Sandy's impact and advised the mayor's office on initiatives that could help the city avoid a repeat scenario, sees a good foundation for change.

"The post-Sandy review showed that there are things allowed in legacy systems that are really not going to withstand the threats we may be facing," he says. "As we consider low probability-high impact events like this, we have to look at the true consequences of failure and the options for making what's in place more robust and resilient."

for safety reasons, and the high value of prime real estate in areas like Manhattan, have effectively consigned critical parts of most systems to underground locations or other areas at risk of flooding.

Proactive measures. After Sandy's floodwaters disabled fuel pumps for back-up generators in its basement, New York's Bellevue Hospital embarked on an ambitious plan to reduce the chance of a repeat scenario where power was lost and some 300 patients had to be evacuated. In 2013, as part of an effort to rebuild electrical switchgear damaged in the storm, contractors relocated the Manhattan hospital's electrical components, including a 12,000-pound transformer, from the basement to the ground floor.

The project, coordinated by construction manager Parsons Brinckerhoff, involved extensive structural steel framing and support work to handle the weight of relocated equipment. Undertaken with the assistance of Gross Electric, Inc., Queensbury, N.Y., the work also involved installation of a new 1.5MW back-up generator and other efforts to shield the hospital campus' electrical system from water.

A careful reading of electrical and building codes — and a crystal ball that may have foretold Hurricane Sandy's arrival — could have helped Bellevue and facilities like it better locate back-up power long ago. Back-up power design and location considerations reflecting possible threats to their operation are referenced in places like NFPA 110 (Emergency and Standby Power Systems); NFPA 99 (Health Care Facilities); NFPA 5000 (Building Construction and Safety Code); NEC Article 708 [Critical Operations Power Systems] and various parts of Article 700 [Emergency Systems]; Joint Commission rules governing member hospitals' safety protocols; and the International Building Code.

Code quandaries. Yet codes geared to ensuring electrical safety could be seen as less detailed and rigid about ways to ensure back-up system reliability. But given the different nature of threats that exist geographically — and the different risk-benefit analyses that result — language about location and threats to design for, in particular, is intentionally somewhat vague. Even Sandy's toll on the power infrastructure may not change that.

"The Code is explicit about how to install, but it doesn't say exactly where to install it, and it's absolutely a problem," says Bill Burke, NFPA's division manager for electrical engineering. "It says you need to consider floods, emissions, and many other factors before you locate it, but it doesn't get into specifics."

What might emerge in Sandy's wake is a heightened appreciation for the risks of natural disasters and the need to better design back-up power solutions so they're not imperiled by the likeliest threats. Flooding is the threat with arguably the greatest potential to knock out back-up power, but any system design hardened against water may consequentially be more vulnerable to other risks.

Fire and explosion risk, for instance, could increase by moving fuel storage tanks and supply lines to higher levels. Tornadoes and other disasters that carry high winds could leave those systems more exposed as well. Even putting waterproof enclosures around generators and related equipment might raise the risk of fire or heat-related damage that could put a back-up system out of commission.

And moving generators to a building's roof or higher floors can lead to other concerns that are unrelated to generator reliability but are equally worrisome, cautions Ken Lovorn, president of Lovorn Engineering Associates, a Pittsburgh consulting engineering firm. Sonic issues related to generator operation — noise and vibration — can be managed in a basement location, but higher up they can pose problems. In certain structures, that might have to be addressed with structural designs that muffle and disperse sonic energy.

"In a basement area, you can put block walls around a generator and channel the noise out through louvers. But if you're on the roof, you can't take the chance of having vibration get down into the structure," he says. "A structural slab with an inertia pad design can help contain that."

That's an example of special considerations building and electrical codes might not be able to account for in laying out guidelines for locating back-up power systems. Ultimately, the dramatic Hurricane Sandy experience could well lead to a closer examination of whether codes can be more emphatic and prescriptive about designing for reliability. But it will be up to those supplying and installing back-up power to understand the specific risks, figure the odds, weigh the costs, and design accordingly.

Tom Divine, senior engineer and project manager with Smith Seckman Reid, a Houston engineering firm, recalls that flooding from coastal Texas hurricanes over the years has claimed its share of back-up systems. The company participated in the restoration and improvement of several systems, and some were rebuilt to standards at least partly dictated by FEMA. But more than any code dictates, it was the harsh lessons of firsthand experience that probably led many to move components further out of harm's way.

"The codes say you shall consider various kinds of disasters in the placement and design of systems, but many owners had consigned their systems to the least valuable space in the facility, which meant a lot of systems ended up in the basements," Divine says. "Codes don't make specific requirements about a lot of things that may need to be addressed in certain localities and environments. So, ultimately, many decisions have to be left to design teams."

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