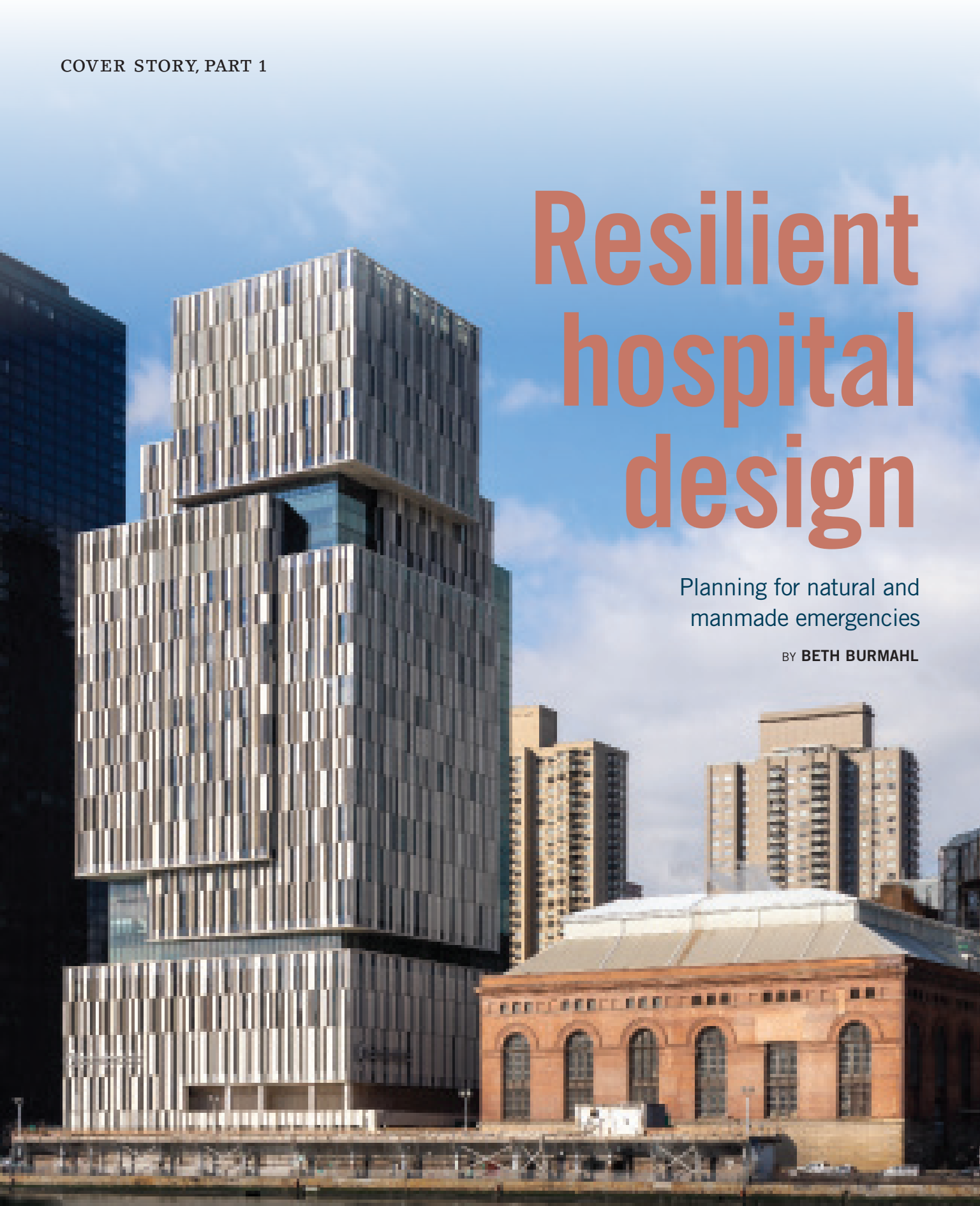
Resilient hospital design

Planning for natural and manmade emergencies

BY **BETH BURMAHL**



The Memorial Sloan Kettering David H. Koch Center for Cancer Care's waterfront location made floodproof design a top priority.

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In the aftermath of a disaster like a tornado, earthquake or the current COVID-19 pandemic, impacted hospitals quickly switch to recovery and after-action planning mode. What could they have done differently in the design to better prepare or mitigate the damage? How can they shore up their vulnerabilities?

For all hospitals, the answer lies largely in one place: resilient design. Resiliency, or the capacity to adapt to changing conditions and maintain or regain functionality in the event of an emergency, is becoming a fast-growing trend in hospital design — and for good reason.

From hurricanes and wildfires to terrorist and active shooter events, manmade and natural emergencies are increasing in frequency and scope throughout the world. Climate change is creating new design challenges across the board.

The bottom line is that all hospitals need to prepare for the possibility of an event that may or may not happen on a scale they have no way of predicting, says Jonathan Flannery, FASHE, FACHE, senior associate director of advocacy for the American Society for Health Care Engineering (ASHE) of the American Hospital Association.

"We are seeing significantly more impactful emergencies in all parts of the U.S., and hospitals have to be ready," Flannery says. "You can't start preparing for this the day it happens. It takes a lot of planning to incorporate resiliency into a hospital, but it's becoming more critical than ever."

For example, the COVID-19 crisis quickly became overwhelming for hospitals in hard-hit areas like New York, which quickly reached its bed-surge capacity. And while this pandemic is a rare event, hospitals can take steps to be prepared — or to be better prepared — for large-scale emergencies, says Brad Pollitt, AIA, vice president of facilities at University of Florida Health, Gainesville.

"This is the current disaster until a hurricane comes up or a tornado hits," Pollitt says. "It really speaks to the fact that when we talk about resiliency, it has to be a long-term issue. Emergencies won't stop happening."

Road to resiliency

Because resiliency is a relatively new concept — and one driven by the deepening severity of more recent events — hospitals still have work to do in preparing for disasters.

There are numerous challenges to resiliency, including cost factors, CEO buy-in, geographic location, and the sheer size and scope of planning required. And for existing structures, retrofitting hospitals for resiliency is a much bigger challenge than starting with a brand-new facility.

"It is easier to bring resiliency in from the beginning, but I've been able to accomplish a lot of resiliency in our projects as renovations," Pollitt says. "It can be done."

Most have been in the form of added utilities or more robust HVAC, Pollitt says. Additionally, his two newest buildings have hurricane-resistant windows and walls, flood protection, built-in surge capacity and an air system that can maximize fresh outdoor air quickly.

Flannery advises hospitals to start with a hazard-vulnerability assessment (HVA) to identify hazards or risks most likely to have an impact on a facility and the surrounding community.

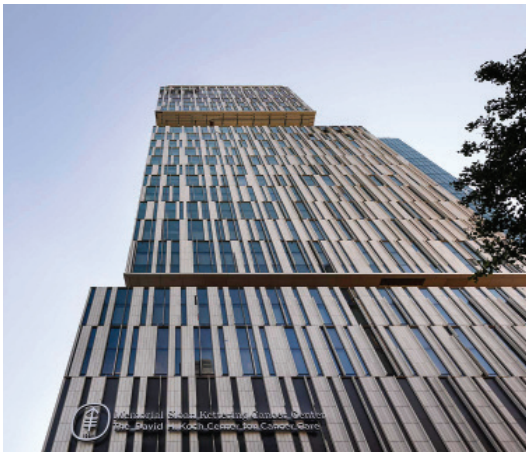
Ideally, resilient design should be integrated into the design plan from the beginning like any other component. "It should be part of the design just like the flow of patient care," he says.

The design resilience strategy is built on broader categories like building structure, utilities, and systems and operations, and customized based on the unique needs of each hospital. While resiliency encompasses a range of components, every plan should be focused on one area: flexibility.

"You don't know what's coming down the road in 10 years, but you have to be able to respond and change over time," Flannery says.

ASHE RESOURCE

American Society for Health Care Engineering members can download the monograph "Roadmap to Resiliency" at ashe.org/resiliency.



The David H. Koch Center for Cancer Care's property line and exterior walls were reinforced and waterproofed with floodgate technology to withstand storm surges, and part of its infrastructure includes a submarine-style waterproof entry door to the fuel tank room which serves its heating plant and emergency power systems.

PHOTOS ON THIS PAGE COURTESY OF MEMORIAL SLOAN KETTERING

Pandemic adds considerations for health care facility planning

While some hospitals are more prepared than others in terms of disaster planning, no one could have foreseen the magnitude of the COVID-19 crises when it hit the U.S. in early 2020.

"Hospitals were all over the board in terms of being prepared for the pandemic," says Jonathan Flannery, MHSA, FASHE, FACHE, senior associate director of advocacy for ASHE. "In a general sense, some were way ahead of the curve and had already been designing for a pandemic, while others were built in the 1950s and haven't made a major upgrade in years."

Media reports of hospitals on the front lines of the pandemic struggling to keep up with patient surge painted a sobering picture for other hospitals about the importance of designing for resiliency.

"People look to the hospital as a place of safety during a pandemic or any other crises. Hospitals have to be prepared as much as possible," says Brad Pollitt, AIA, vice president of facilities at University of Florida Health, Gainesville.

When the pandemic broke out, designers and architects across the U.S. stepped up to aid the hardest hit hospitals whose bed capacity had been pushed to the limit. Dallas-based HKS Inc. expedited a design plan to convert structures like hotels and convention centers into patient care areas.

For example, HKS partnered with the U.S. Army Corps of Engineers to convert the convention center in Detroit to a 1,000-bed temporary field hospital in Novi, Mich., among other projects. The project was completed in just 15 days.

"Design firms began to react to COVID-19 right away," says Norman Morgan, AIA, principal and regional director of Dallas and Fort Worth at HKS, in mid-April. "And through this experience we are coming away with strategies preparing for the next pandemic."

Post-COVID-19, hospitals preparing for the next pandemic will be focusing primarily on flexibility and capacity in patient rooms and having the ability to convert a room into an intensive care unit if necessary, Morgan says. Certain areas of the hospital should be isolated with separate air handler units and air filtration systems to mitigate cross-contamination, he says.

New strategies are already emerging. In response to the COVID-19 epidemic, the American Institute of Architects (AIA) moved quickly to organize a task force that developed a COVID-19 alternate care sites assessment tool to facilitate information sharing and developing of best practices for responding to COVID-19 and future pandemics, according to the AIA website at www.aia.org.

"This tool is geared toward flexible and rapid decision making during a public health pandemic," says task force chair Molly Scanlon, Ph.D., FAIA, FACHA, who is an environmental health scientist at Phigenics, Warrenville, Ill.

"Our goal was to synthesize decades of health care knowledge and experience into a checklist reflecting the key essential elements of health care operations to reduce risk and increase safety at an alternate care site," she says. ■

COVID-19 RESOURCES

American Society for Health Care Engineering members can locate facilities-related pandemic resources at ashe.org/COVID19resources, and Association for the Health Care Environment members can locate environmental services-related resources at ahe.org/covid-19-resources-evs-professionals-2020.

He cites the five-story Rush Tower, part of the Rush University Medical Center, Chicago, as an example of a new health care facility that factored flexibility into every inch of the design.

"Rush designed with the capability of creating negative pressure in the new tower from the get-go," Flannery says. "They can convert traditional patient rooms to negative pressure rooms with just a couple of operational changes."

Opened in 2012, the 840,000-square-foot Rush Tower has 40 negative-pressure rooms to prevent cross-contamination. The emergency department (ED) is divided into three 20-bed units, which can each be isolated with separate air handling. Each patient room is fitted with a double set of gas and electrical outlets. In the event of a mass casualty situation, two patients can be placed in each room.

The ED can be rapidly converted to enable high-volume screening. And the tower's lobby can also serve as a shelter in case of a biochemical attack. The Rush Tower is a green hospital, designed to conserve energy and water, reduce waste and use sustainable building materials. The tower demonstrates how sustainability strategies often tie in or overlap with resiliency design.

Avoiding dependence

Resilient design was uppermost in the minds of designers charged with rebuilding Mercy Hospital Joplin, Mo., which took a direct hit from an EF5 tornado in 2011. Architects sizing up the damage weren't left with much to work with in terms of salvaging the structure.

"The tornado pretty much knocked out the whole hospital," says Norman Morgan, AIA, principal and regional director of HKS Inc., a Dallas-based architectural firm. "The infrastructure, emergency power and windows were blown out. Part of the roof was torn off, and equipment was picked up and thrown everywhere."

HKS began work on a brand-new replacement facility in 2012 and fast-tracked the project in time to meet the planned opening in 2015. Lessons learned for 2011 guided the design that factored in resiliency from the very beginning.

Strategically investing in materials was part of the plan. Designers installed laminated glass windows designed to withstand 250-miles-per-hour winds and hardening components, which was a central focus of the design.

"We spent $8 million on just hardening alone," Morgan says.

The team also focused on redundancy — the intentional duplication of system components in order to increase a system's dependability. For example, the new facility has multiple

Mercy Hospital Joplin was completely rebuilt after taking a direct hit from an EF5 tornado and its new patient rooms have windows rated for 140 miles per hour.

points for bringing in power, water and communications.

"The hospital used to have only one communication hub; now they have two," Morgan says. "We also laid redundant fiber and added backup lighting in addition to the required emergency lighting."

Because the hospital's energy source was on the outside of the building, the structure lost all power during the storm. In the rebuild, designers added a 30,000-square-foot central utility plant containing all mechanical, electrical and plumbing (MEP) systems connected to the hospital by a 450-foot underground tunnel. Two power systems and a generator system will enable the hospital to operate independently for a minimum of 96 hours.

Power sources

As demonstrated at Mercy, redundancy is particularly important when it comes to powering the facility, since hospitals obviously cannot afford to lose a sole source of power during a crisis.

"It doesn't matter how good a structure you have if you don't have electricity," Flannery says. "Utilities play a vital role in design, and I believe the codes and standards we have today do a good job of helping us meeting resiliency requirements for utilities."

Fast-rising energy costs and tightening regulations on carbon emissions are making renewable energy increasingly attractive to hospitals. Many states have a Renewable Portfolio Standard that requires that a specific fraction of electricity be produced from renewable energy sources such as solar and wind.

Resiliency and sustainability are the way of the future, says Walter Vernon, PE, LEED AP, EDAC, FASHE, CEO of Mazzetti, a global provider of MEP engineering design and technology/information technology consulting in health care, San Francisco.

"In the old days, design companies like mine would create internal design standards that were backwards looking — how do we avoid making the mistakes of the past," Vernon says. "Now, we are completely retooling our standards so that we are starting every design for a client with a forward-looking set of systems that provide both climate mitigation and resilience."

As part of a follow-up to the Kaiser Permanente Hospital's "Small Hospital Big Ideas" competition, Vernon's team was asked to envision a carbon-neutral hospital, which is part of Kaiser's renewable energy program to reduce greenhouse gases.

"One of the interesting things about the Kaiser Permanent exercise was that it was largely an exercise in 'islanding,' developing a design that would allow the facility to operate without any external energy inputs," Vernon says. "This idea is a core idea for resilient buildings."

Ultimately, the most resilient facility will have the capacity to go off-grid and run autonomously.

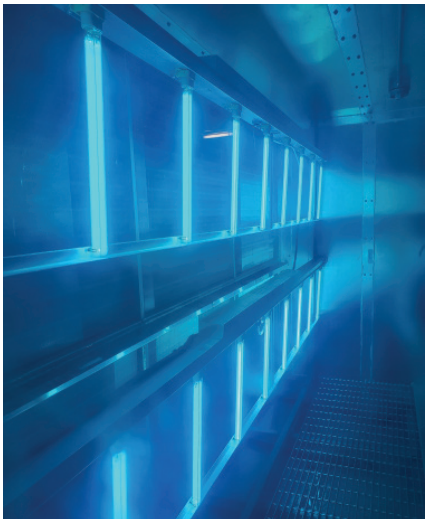
Focus on planning

Even though Memorial Sloan Kettering (MSK), fared better than other East Coast hospitals during Superstorm Sandy in 2012, designers learned from the setbacks experienced by other health care facilities that totally lost power and had to evacuate patients.

When planning the new 760,000-square-foot David H. Koch Center for Cancer Care facility at the MSK Cancer Center outpatient facility, designers embedded infrastructure resiliency and flood-proofing in every aspect of the design. The mechanical and electrical major energy equipment movers are all located above the design flood elevation (DFE) while those systems required to be below grade are located in a waterproof concrete vault with a submarine-style entry door.

"This facility is located within the 100-year flood plain," says Steven Friedman, PE, CHFM, HFDP, LEED AP, director of facilities engineering, design and construction at MSK. "From its inception, the hospital focused on integrating structural

PHOTOS COURTESY OF HKS



University of Florida Health's two newest buildings have hurricane-resistant windows and walls, flood protection and built-in surge capacity while one of its renovation projects includes a fan array and UV lights to minimize mold growth in its humid climate.

AERIAL PHOTO BY AERIAL INNOVATIONS AND COURTESY OF UNIVERSITY OF FLORIDA HEALTH; AND INFRASTRUCTURE PHOTOS COURTESY OF UNIVERSITY OF FLORIDA HEALTH

and engineered resiliency measures for continuity of services to serve our patients and staff.

"The costs to implement these resiliency measures do not nearly compare to the aftermath of building and patient care service loss," Friedman says. "If your new facility is located within a flood zone, do not make the mistake of trying to retrofit later; higher costs and disruption to delivering patient care will be severely interrupted."

MSK utilized dry, floodproofing construction methods to create a continuous flood barrier around the facility and with a foundation system designed to withstand the hydrostatic uplift of water in a flood condition. Designers also installed exterior walls that were reinforced and waterproofed to withstand storm surges.

Code considerations

On the other coast, designers must factor in seismic events and the massive wildfires that are drastically increasing in number and scope, and even creeping closer to the built environment, Pollitt says.

Climate change, often cited as the main cause of the increase in wildfires, has also emerged as a factor in resilient design.

Pollitt, who uses the term "planetary destabilization," strives to design facilities for a post 5-degree world. For example, what would happen to the cooling system if the temperature goes up 5 degrees? Or other systems?

"Even 5 degrees can throw systems out of whack, and we will need make changes accordingly," he says.

While design resiliency is not mandated by law, the design does have to conform to existing codes and standards, which presents challenges for engineers trying to keep up with fast-moving events in different parts of the country. For example, hospitals in Florida must prepare for far different events than those in the Midwest.

"That is one of the challenges with resilience planning in codes," Vernon says "How do we know what to protect against, and how do we codify that on

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Rush University Medical Center's Rush Tower has 40 negative-pressure rooms to prevent cross-contamination and an emergency department that can be rapidly converted to enable high-volume screening.

a national basis when the threats are so different in different places?"

Vernon's goal is to find ways to balance patient safety, climate mitigation, climate resilience and economics, and then incorporate those features into policy.

"Clients tend to like any strategy, mitigation or resilience, that saves them money, so these are always easy," Vernon says. "The harder conversations are always strategies that, in some measure, cost something."

Considering the budget stressors hospitals are facing, securing funding for resiliency projects can be difficult. Flannery says laying out a business case for resiliency by demonstrating cost savings and other benefits can be an effective strategy. For example, if a hospital averages eight power outages a year, he presents data showing the facility will lose more money through those outages than the cost of buying a new emergency generator.

Pollitt suggests proposing smaller, less costly projects that incorporate resilient design. When renovations are needed, the hospital can incrementally add a redundant or flexible feature on a smaller scale. "If you incorporate the idea of resiliency into renovations, it goes a long way," Pollitt says.

Achieving resiliency

Flannery recommends that facilities considering resiliency projects start with the ASHE Roadmap to Resiliency, which offers emergency power best practices, explains how to assess vulnerabilities and suggests new ways to safeguard emergency power through new technology and protocols.

Pollitt also advises hospitals to keep the big picture in mind and consider the impact on the community during a disaster. "Hospitals need to help the public understand the various roles and responsibilities during a disaster. We are all learning through these examples," Pollitt says.

And because of the risk associated with not investing in resilient design, hospitals really can't afford not to make it a priority.

"When it comes to resiliency design, it's a matter of doing the right things for the right reason," Flannery said. "Hospitals have to be able to stay open during emergencies. They are places of safety for patients and the community." HFM

Beth Burmahl is a freelance writer based in Lisle, Ill., and former associate editor for *Health Facilities Management* magazine.

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