ASHE Monograph

Roadmap to Resiliency

A publication from the Healthcare Leadership Initiative on Maintenance of Power

Eric Cote

Jonathan Flannery

ASHE®
American Society for Healthcare Engineering
A personal membership group of the
American Hospital Association

POWERED For Patients™
Advancing Backup Power & Power Restoration for Critical Healthcare Facilities

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ASHE Disclaimer

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Executive Summary

Major storms and natural disasters such as Hurricane Katrina and Hurricane Sandy have intensified the national dialogue on emergency power for critical health care systems.

This monograph aims to further discussions on emergency power best practices by considering lessons learned from previous disasters, explaining how to assess vulnerabilities, and suggesting new ways to safeguard emergency power through new technologies and innovative protocols that leverage enhanced information sharing. This publication is an outcome of the Healthcare Leadership Initiative on Maintenance of Power, a project of the American Society for Healthcare Engineering (ASHE), which is a personal membership group of the American Hospital Association, and Powered for Patients, a nonprofit organization that works to safeguard emergency power systems and expedite power restoration for critical health care facilities.

Lessons Learned

Hospitals and health systems can learn lessons from previous natural disasters, including:

- Flooding of emergency power system components is a chief culprit in emergency power system failures during hurricanes.
- Insufficient pre-disaster coordination with generator service and fuel providers can result in delays in service at a time when it is most needed.
- Failure to inventory critical spare parts for emergency power systems can result in lengthy delays in the restoration of emergency power.

Assessing Vulnerabilities

To assess potential vulnerabilities, hospitals should consider taking the following actions:

- Conduct an analysis of emergency power supply systems to identify system strengths and weaknesses.
- Evaluate the emergency power capabilities of water and wastewater treatment providers and develop contingencies for the loss of either service during a disaster.

Minimizing Risk

To minimize risks, hospitals should consider taking the following actions:

- Deploy and test flood mitigation technology to protect all components of an emergency power supply system, including generators, fuel sources, fuel pumps, and automatic transfer switches.
- Coordinate before disasters with local emergency management officials to help arrange expedited government support for generator service and fuel providers, which may involve government assistance in gaining access to a disaster-affected facility when access is impeded by natural hazards or police road blocks.
- Identify critical spare parts for emergency power supply systems during "blue sky" days and ensure ready access to these parts during a disaster.
- Register the emergency power supply system with the Federal Emergency Management Agency (FEMA)/U.S. Army Corps of Engineers (USACE) online EPFAT (Emergency Power Facility Assessment Tool), which can reduce the time needed by FEMA/USACE to deploy temporary generators to a facility during a disaster.
- Adopt protocols to provide an early warning to local emergency management and/or public health preparedness officials when a hospital requires emergency power system service or refueling during a disaster. This early warning can be provided by leveraging remote monitoring and automated reporting technologies or through manual early notification via phone, text, or email.
- Explore advanced power generation technologies such as combined heat power (CHP) and microgrids to reduce reliance on the grid and bolster backup power capabilities.
- Embrace advanced technologies supporting traditional diesel powered emergency power systems, such as dual automatic transfer switches that allow preventive maintenance without disabling emergency power.

This monograph explains these issues in further detail in an effort to help hospitals and health systems prepare for future emergencies.

Harnessing Lessons Learned

Natural disasters in recent years have brought to light potential weaknesses in emergency power supply systems for health care systems. Key failure points have included:

- Flooding of emergency power system components
- Mechanical failure of key parts and inability to quickly remedy problems because of a failure to maintain an inventory of critical spare parts for emergency power systems.
- Insufficient pre-disaster coordination between hospitals, their generator service, fuel providers and government officials to anticipate obstacles that can impede access by service teams at a time when they are most needed.

Health care facilities, emergency preparedness experts, and regulators have used these lessons learned to improve the resiliency of emergency power systems. However, more needs to be done to heed the lessons learned given the loss of emergency power during Hurricane Sandy from the same threats that disabled emergency power during Hurricane Katrina seven years earlier. Hurricane Matthew in 2016 brought new potential challenges to light, requiring new solutions as different lessons were presented.

Hurricane Katrina

In the aftermath of Hurricane Katrina, three acute care hospitals in the New Orleans area remained operational, four maintained some limited function, and 21 were closed, evacuated, or not operational. Many hospital emergency power generators were located at ground level or lower (often below sea level) and were subject to flooding. Fuel pumps were often placed at ground level, and fuel storage tanks were frequently below ground level. Lack of communication was also a challenge.

Hurricane Sandy

Prior to Hurricane Sandy's landfall in October 2012, government officials and administrators of hospitals and nursing homes were involved in a massive pre-storm effort to safeguard patients. Some hospitals evacuated patients before the storm arrived. Others decided to shelter in place and use emergency power systems to supply critical electricity in the short-term absence of power from the nation's power grid.

In many hospitals and nursing homes, emergency power systems functioned as intended, allowing facilities to remain open to care for their most critical patients, or to serve as a refuge for patients displaced from other hospitals and nursing homes.

Greater-than-expected flooding contributed to the loss or preemptive shutdown of emergency power at six hospitals in New York and New Jersey; two had previously evacuated patients. For the four hospitals with patients when emergency power was lost, sizeable evacuations of patients occurred. No fatalities or serious injuries resulted from these evacuations, which is a credit to the extensive pre-planning hospitals undertook to prepare for potential evacuations.

Hospitals and numerous government agencies documented the storm's impact through after-action reports that included many proposed and since enacted local, state, and federal regulations intended to expand the use of and better protect emergency power supply systems.

Hurricane Matthew

In 2016, numerous hospitals in Florida expecting the brunt of Hurricane Matthew decided to pre-evacuate, lessening the risk of a loss of emergency power on patients. In North Carolina, which suffered the most damage from Matthew, the failure of one of five generators at Southeastern Regional Medical Center in Lumberton placed the hospital's full emergency power requirements on the four remaining units. When the local utility was unable to provide an estimated time of restoration given the extensive damage to utility infrastructure, the hospital requested deployment of temporary generators from the state of North Carolina and FEMA. Unlike Hurricanes Katrina and Sandy, where flooding was the main culprit in disabling emergency power, the generator malfunction at Southeastern Regional Medical Center in Lumberton was mechanical in nature. A failed part in the hospital's generator #1 produced a significant amount of smoke, leading facilities staff to shut the unit down. The hospital was able to maintain sufficient backup power with the four remaining generators for four days until a thermostat failed on generator #2. The sudden loss of generator #2 placed too much load on the remaining three generators and triggered a short-term loss of backup power. Despite load shedding, and restarting the first generator, the hospital evacuated pediatric intensive care patients given concerns over the stability of emergency power. The generator with the failed thermostat was repaired within two hours, enabling the first generator to be taken back out of service and ensuring enough emergency power for the remaining units until the power was restored.

Emergency Power System Failures

The 2013 FEMA Mitigation Assessment Team Report detailed Hurricane Sandy's physical impact on critical infrastructure to health care systems. The report includes the following details about hospitals affected by that storm.

NYU Langone Medical Center

The emergency generators for the New York University Langone Medical Center in Manhattan were located on the roof of one of the campus buildings with a 250-gallon tank that was expected to provide power for up to 3 hours. A 20,000-gallon fuel tank sat in a below-grade vault near a pump house, with a dry-floodproofed fuel pump for longer-term emergency power needs. The fuel oil pumps for the emergency generators shut down as a result of an electric short circuit in the pump safety shut-off circuitry caused by water infiltration. The pump house was surrounded by about 6 feet of floodwater and was not accessible until water receded the next morning, when the fuel pump was restarted.

NYU Langone Medical Center had previously stopped routine services and discharged more than 250 patients before the storm hit, with 322 patients remaining as the hospital sheltered in place. When emergency power was lost, staff evacuated the 322 patients with no fatalities.

Bellevue Hospital

Bellevue Hospital in Manhattan also stopped routine services and discharged patients before the storm, and expected to shelter the remaining 725 patients in place. Oxygen tanks and fuel pumps were protected using dry floodproofing measures, and emergency generators were elevated.

The hospital had a relatively new electric power plant and emergency generators on the 13th floor. However, one emergency generator and the fuel oil pumps remained in the basement. Bellevue Hospital had installed a submarine door to protect the fuel oil pump system, but the seal around the door failed during Hurricane Sandy. Water flooded the basement and utility systems and the pumps were inadequate for the inundation that occurred.

All utilities and services in the basement were lost, including electrical power, steam, communications, HVAC equipment, IT, computers, fire protection systems, and elevators. Mechanical systems lost or damaged included pumps, electrical switchgear, and a combined domestic water and fire pump system.

Although the fuel pumps and the large fuel tank in the basement had flooded, the below-grade fuel oil tanks were not compromised. The emergency generators and tank on the 13th floor provided power until the fuel was consumed. New York Police Department brought a fuel tanker to the site, and hospital staff spent 13 hours carrying 5-gallon containers of fuel up 13 flights of stairs so the generators could continue to operate using fuel from the tank.

Because the generators on elevated floors were operating, the staff sheltered patients in place until the potable water in roof tanks was depleted. Patients on ventilators were transferred on October 30, and all but two remaining patients were transferred the following day. The last two patients were transferred on November 3. No fatalities or serious injuries resulted from these evacuations, which is a credit to the extensive pre-planning hospitals undertake to prepare for potential evacuations.

In post-Sandy recovery plans, the hospital noted its intention to move selected elevator equipment from the basement to the ground floor so elevators could function during emergencies. Also, the emergency power distribution system was slated for expansion to bring emergency generator power to key areas of the hospital, including sections that house CT scanners and MRI machines, pharmaceutical and chemotherapy facilities, and research laboratories. Options for water pumps included moving them to a higher floor or bringing in additional pumps at street level that could be used as a backup system. Engineering experts were looking for ways to improve protection for the fuel oil pumps and medical gas tanks. The hospital also planned to add connections for mobile boilers that could be brought in to provide heat and hot water if necessary.

Hoboken University Medical Center

Hoboken University Medical Center in Hoboken, N.J., prepared for Hurricane Sandy by evacuating patients to nearby hospitals. To protect the facility, staff installed plywood over doors, sandbagged walls, and covered low-level openings. The hospital had two emergency generators that consumed 350 gallons per hour and drew fuel from 2,000-gallon fuel tanks. Both fuel tanks were located above ground. However, the hospital had an emergency generator tied to switchgear that was located at a lower elevation and was subject to flooding, so the hospital de-energized the switchgear to minimize damage. The hospital lost power on October 29. Elevator equipment for two of the eight elevators was flooded. The fuel tanks and the elevated fuel oil pump were not damaged during the flood event. Once the flooding had been addressed, the generators began operating again.

In recovery plans, hospital officials noted plans to elevate the switchgear for the emergency power supply system.

Key Reports

In the aftermath of Hurricane Sandy, local, state, and federal agencies studied the storm's effect on critical infrastructure, including emergency power supply systems. These efforts produced valuable reports that highlighted additional lessons learned and recommendations. Many of these reports included calls for new requirements for preventing power loss.

The reports include:

- "The Hurricane Sandy After Action Report and Recommendations to Mayor Michael R. Bloomberg" (Gibbs and Holloway 2013)
- The New York City Special Initiative for Rebuilding & Resiliency (2013) and its report "PlanNYC: A Stronger, More Resilient New York"
- "The New York City Building Resiliency Task Force Report to Mayor Michael R. Bloomberg and Speaker Christine C. Quinn" (Urban Green Council 2013)
- The New York State 2100 Commission's "Preliminary Report and Recommendations to Improve the Strength and Resilience of the Empire State's Infrastructure" (NYS 2100 Commission 2013)
- FEMA's "Mitigation Assessment Team Report," detailing Sandy's physical impact on critical infrastructure (FEMA 2013)

In 2016, the Centers for Medicare & Medicaid Services (CMS) adopted new emergency preparedness requirements for all 17 types of health care facilities licensed to provide services to Medicare and Medicaid beneficiaries. The final rule, Department of Health and Human Services, Centers for Medicare & Medicaid Services 42 CFR Parts 403, 416, 418, et al. Medicare and Medicaid Programs; Emergency Preparedness Requirements for Medicare and Medicaid

Participating Providers and Suppliers; reflected lessons from previous storms and required hospitals to test emergency power equipment as outlined in current codes and standards and manufacturer requirements. The rule states that hospitals must have a strategy to keep backup power systems operational unless it plans to evacuate.

The final rule did not include an initial proposed requirement that hospitals conduct a 4-hour full load test of generators annually instead of every three years as currently required. The intent of the proposed rule was to help identify emergency power systems at greater risk of failure through increased testing. In its final rule, CMS stated: "After carefully considering all of the comments we received and reviewing reports on Hurricane Sandy and Hurricane Katrina we believe that there are not sufficient data to assume that additional testing would ensure that generators would withstand all disasters, regardless of the amount of testing conducted prior to an actual disaster." Instead, the final CMS rule requires hospitals receiving Medicare funding to continue to test their equipment based on National Fire Protection Association (NFPA) codes in current general use (the 2012 edition of NFPA 99, the 2010 edition of NFPA 110, and the 2012 edition of NFPA 101®) and manufacturer requirements. The debate over extending the 4-hour test underscores the critical importance of trying to assess the reliability of emergency power supply systems prior to extended power outages.

CMS also dropped a proposal to require generators above newer flood plain levels. Instead, CMS will require hospitals to follow NFPA 110: *Standard for Emergency and Standby Power Systems* with respect to protecting against flooding.

The CMS ruling that unless planning to evacuate, hospitals must plan to keep backup power systems operational reflects the current requirements from the Joint Commission that a facility must plan on how it will address operations, including emergency power, for the first 96 hours after an event.

Codes Address Lessons Learned

NFPA 110 is the principal document that governs some of the design and installation details related to protections against flooding. Section 7.2.3 of the 2010 edition of NFPA 110 included the following requirement:

> The rooms, shelters, or separate buildings housing Level 1 or Level 2 emergency power supply system (EPSS) equipment shall be designed and located to minimize the damage from flooding, including that caused by the following:

1. Flooding resulting from firefighting
2. Sewer water backup
3. Similar disasters or occurrences

The criteria is intended to relate to the generator itself as well as the transfer switch, fuel supply, fuel pumps, and any related equipment that supports the generator operation. Annex language in the code states that new generator and related equipment should be installed above the known flood elevation when possible.

The 2016 edition of NFPA 110 references two FEMA documents:

- FEMA 543, *Design Guide for Improving Critical Facility Safety from Flooding and High Winds,* 2007
- FEMA 577, *Design Guide for Improving Hospital Safety in Earthquakes, Floods, and High Winds*, 2007

The FEMA design guides include details on floodproof design, including the concept of dry floodproofing, which involves placing critical emergency power supply equipment within a vault or similar structure that would preclude water from entering.

Questions have been raised as to why NFPA 110 simply doesn't prohibit the generator and essential emergency power system components from being located anywhere in a flood-prone zone or area of the structure. Some buildings or properties cannot accommodate this measure without alternate risks, such as fuel storage within or above occupied areas, which may be why NFPA 110 language on this matter is a performance metric rather than a mandatory requirement. The burden is placed on a facility designer and owner to determine how to best protect the generator and related components from flooding hazards.

Assessing Emergency Power System Vulnerability

A vulnerability assessment of emergency power supply systems can provide system operators with an indication of potential problems to address before disaster strikes. This information is also valuable when shared with emergency managers and public health preparedness officials because it provides insight into systems that may be at greater potential risk during a disaster.

Codes and standards call for testing protocols and adherence to manufacturer's recommended maintenance to help ensure reliable performance by emergency generators. Yet, as evidenced by the experience of hospitals in major hurricanes, adherence to testing and maintenance protocols is no guarantee that emergency power systems won't experience failures during disasters.

A no-cost Powered for Patients Emergency Power Supply System Vulnerability Assessment Survey is available online at www.poweredforpatients.org/assessmentsurvey. The survey is a modified version of a previous survey developed by the California Hospital Association, which was developed with significant input from experts in emergency power supply system design and maintenance.

Key questions in the survey include:

- In addition to conducting required testing on backup generators, do you routinely test switchgear equipment?
- Do you have a service contract for your emergency power system?
- Who are your primary service and fuel providers and secondary providers?
- Have you already identified locations for temporary generator installations on your campus?
- Does the hospital have a stock of recommended spare parts for the diesel generator or assurances from local diesel distributor to provide spare parts?
- Have appropriate personnel been trained on manual operation of the diesel generators or emergency system?

- Does your emergency generator system have any unique cooling or operational requirements that may require special measures during a disaster (heat exchangers, cooling towers, etc.)?
- Do you have a protocol for detaching and reattaching to your electric utility during power outages?
- Does your hospital have plans to replace some or all of its generators within the next three to five years?
- Are there restrictions in place with respect to which service companies are authorized to provide service to any of your generators, switchgear equipment, or automatic transfer switches?
- Is your water system dependent on power for water pressure because of building elevation?
- Is your wastewater system dependent on power for sewage flow away from your facility into local sewer or septic systems?
- Are your generator and its components, including fuel tanks, above floodplain and safe from other water surges such as dam and water tower breaks? If no, are system components encapsulated and protected from a flood?
- Approximate age of generator(s) in years?

Advanced Life Cycle Analysis of Emergency Power System Components

Some larger hospital systems have gone far beyond the minimum testing and maintenance requirements for emergency power supply systems by investing in advanced analysis of emergency power system components.

This advanced analysis includes estimating the condition of key components based on a standard life expectancy table and detailed physical inspections of key system components by qualified experts. These inspections often can provide a clean bill of health for some individual system components while leading to recommendations that other components be refurbished or replaced. This approach allows a more surgical and less costly replacement of outdated components rather than a complete replacement of an emergency power supply system. One large hospital system used a life expectancy table and associated rating system (Exhibit 1) to determine the condition of the following categories of emergency power supply system components:

- Normal gear
- Emergency gear
- Generator units
- Fuel oil
- Paralleling gear
- Transfer switches
- Motor control center

Exhibit 1: Life Expectancy Table

Generators	30 years
ATS	25 years
Main switchgear	30 years
Emergency switchgear	30 years
Paralleling gear	25 years
Fuel storage tanks (above ground)	30 years
Fuel storage tanks (below ground)	25 years
Transformers	30 years
Motor control centers	30 years

Condition Rating System

A = Like new (more than 75% of life expectancy remaining)
B = Good condition (more than 50% of life expectancy remaining)
C = Average condition (less than 50% of life expectancy remaining)
D = Workable condition (nearing end of life)
E = At end of life expectancy but in no immediate risk of failure or spare parts are readily available
F = In need of immediate replacement

Minimizing Risk to Emergency Power Through Best Practices, Collaboration, and Information Sharing

Best Practices

One of the most effective approaches to ensure the reliable operation of emergency power supply systems during extended power outages is to test equipment in accordance with code requirements and to strictly adhere to manufacturer recommendations for maintenance. A helpful resource for improving reliability of emergency power systems is the American Society for Healthcare Engineering (ASHE) monograph titled *Managing Hospital Emergency Power Systems: Testing, Operation, Maintenance, Vulnerability Mitigation, and Power Failure Planning* (Stymiest 2014) and FEMA document P-1019: *Emergency Power Systems for Critical Facilities: A Best Practices Approach to Improving Reliability* (FEMA 2014).

Hospitals should deploy and test flood mitigation technology to protect all components of an emergency power supply system including generators, fuel sources, fuel pumps, and automatic transfer switches.

Analyzing emergency power system data is a vital step to allow facility personnel to identify issues before they become systemic problems. Analysis can also provide key opportunities for improved system reliability and training. Additional information on analyzing emergency power system data is provided in the previously mentioned ASHE monograph.

Facility personnel should identify critical spare parts for emergency power supply systems during blue sky days and ensure ready access to these parts during a disaster. A rare-parts assessment should be conducted as part of this review to determine any spare parts that would not be readily available so they can be pre-ordered as a precaution.

Enhanced Collaboration

The U.S. Department of Health and Human Services (HHS) Office of the Inspector General's report on Hurricane Sandy clearly detailed the challenge of insufficient coordination among key stakeholders. The report noted, "Given that insufficient community-wide coordination among affected entities was a common thread through the challenges identified by hospital administrators, we recommend that the Office of the Assistant Secretary for Preparedness and Response (ASPR) continue to promote federal, state, and community collaboration in major disasters" (Levinson 2014, ii).

The recently finalized CMS rule on emergency preparedness includes a number of provisions that require stepped up communication between hospitals, their service providers, and government officials.

An important opportunity for collaboration between hospitals and the federal government revolves around the Emergency Power Facility Assessment Tool (EFPAT), a federal online resource developed by FEMA and the U.S. Army Corps of Engineers (USACE). EFPAT enables hospitals and other critical infrastructure to register their emergency power supply system through the online EPFAT portal. Through this process, detailed information about a facility's emergency power system is uploaded into the FEMA/USACE database. If a facility with uploaded information needs a temporary FEMA generator during a disaster, registration via EPFAT can shave as many as 10 hours off the deployment time frame for a FEMA generator. Adoption of early warning protocols by hospitals through which local government officials are notified during a disaster when generator service or refueling is required can shave an additional 5 hours off the deployment time for a FEMA generator in situations where generator service personnel are unable to repair failing equipment or fuel replenishment is not possible.

Another opportunity for improved collaboration among key stakeholders involves closer coordination between hospitals, their generator service and fuel providers, and local government officials. As noted previously, during Hurricane Matthew, Southeastern Regional Medical Center in Lumberton, N.C., experienced a significant mechanical failure in one of its five generators six hours after power was lost. The hospital's generator service provider was unable to respond to the hospital for more than two days because of severe flooding. In this instance, the delay had no impact on restoration of the disabled generator as it was determined that a part needed to fully restore the generator to normal operating status would take more than a week to secure. Nevertheless, this incident serves as an example of the value of greater pre-disaster coordination between local emergency management officials, hospitals and their generator service and fuel providers. This improved coordination could have enabled government officials to assist the generator service provider in getting to the hospital sooner.

Powered for Patients will be working with national and state leaders to help foster this type of pre-disaster planning.

Enhanced Information Sharing and Advanced Warning

With advance warning of a potential backup power failure, deployment of government and private sector resources to repair a failing generator can be accelerated. In the worst-case scenario of a threatened emergency power supply system that cannot be repaired, an early warning of pending failure can give government officials a significant head start and reduce the amount of time needed to deploy temporary state or FEMA generators to replace failing backup power. This early warning can also enable utilities to reprioritize restoration plans and potentially restore utility power before a facility loses backup power.

Two best practices to achieve early notification of potential generator failure, reflected in new protocols described in this monograph, are discussed here: sharing automated notifications of generator threats produced by remote monitoring technology and providing an early notification to government officials about threats to emergency power during disasters via text, email, or phone call for facilities that do not use remote monitoring.

Remotely Monitored Generator Status Information

One new protocol proposed by Powered for Patients involves hospitals leveraging remote monitoring and reporting technologies already in place at hundreds of hospitals across the United States to provide an early warning to government officials and utilities of threats to emergency power. This technology, which is often described as a fruit of the Internet of Things, can be integrated into building automation systems. Remote monitoring systems detect mechanical threats to emergency power systems and automatically send alerts and notifications to facility managers and service teams. This enhanced awareness can expedite needed service work and refueling of generators during disasters when hospital facility staff are stretched thin. Remote monitoring technologies also provide powerful diagnostic capabilities, enabling remote monitoring service providers to share critically important information about an emergency power system that is failing or has failed with on-site facility managers and service providers. This information could include status reports on utility power coming into a hospital and the condition of critical equipment needed to sustain or restore emergency power. In the absence of remote monitoring, repair of failing or failed emergency power systems could be significantly delayed.

Enhanced Decision Making About Resource Allocation

During a major disaster with widespread geographic effects and extended power outages, significant resource limitations are likely as emergency power equipment, generator fuel, and utility repair crews are stretched thin. Having access to remotely monitored generator data can facilitate more informed decision making about allocating scarce resources.

Consider a scenario where several area hospitals are running on emergency power and a dangerous shortage of diesel fuel is experienced. Advanced remote generator monitoring and reporting technology can give government officials a real-time picture of remaining fuel levels and fuel consumption rates for hospitals running on emergency power. This can help inform and accelerate decision making about which hospitals will receive the limited fuel supply.

How it works

A common attribute of most monitoring systems is a series of sensors installed on the piece of equipment to be monitored. A centralized data collection and reporting hub captures data from the sensors, processes that data, and produces actionable status reports. When used for emergency power supply systems, monitoring systems produce alerts, alarms, and immediate notifications when preset conditions are triggered. The collected data can also be gathered for hospital IT systems, clinical functions, and data storage systems.

The controllers on more modern emergency power system components can operate like the black box of an airplane, recording time-stamped data in real time and storing that data in an event log that retains the information even if power is lost. Once power is restored, these black box-like devices automatically transfer stored data to a host device. Remote monitoring technology providers use the information to provide a broader picture of the emergency power system infrastructure.

In the instances where old equipment does not have remote monitoring capability, monitoring companies are able to install sensors to provide the basic information needed to enable remote monitoring. In some of the more advanced remote monitoring and reporting systems, visual monitoring is available with powerful analytic tools that can help decipher between a puddle of water under a generator and a puddle of oil. This advanced capability helps ensure that warnings and alerts reflect true threats to an emergency power supply system. This technology affords many benefits; however, hospitals and their technology partners must take the appropriate steps when designing a system to protect remote monitoring technology from cyber-attacks.

The following are key data points hospitals should consider for remote monitoring:

- Fuel levels and fuel consumption rates
- Battery voltage
- Coolant temperature
- Generator exhaust gas temperature
- Automatic transfer switch operating status
- Compliance with 10-second start up requirement
- Oil pressure
- Generator test results

Early Notification

For hospitals that do not employ remote monitoring and automated reporting for emergency power supply systems, early notification of government officials and utilities of a potential threat to emergency power should still be provided. This early notification can be achieved through a protocol in which a hospital staff member is assigned responsibility to notify the local/tribal/regional/state emergency preparedness official via phone, text, or email anytime a request for generator service or generator refueling is made during a disaster.

When this notification occurs during a disaster, the government official can then notify a utility of a threat to generator power and also pass this notification up the government chain of command. The individuals in the chain of command will vary from state to state. Hospital facility staff should focus on ensuring that they have the right initial point of contact within the chain of command as it is the responsibility of local, tribal, state, and federal government officials to ensure rapid and appropriate communication among levels of government about threats to hospital emergency power. As with early notification enabled by remote monitoring technologies, the notification of a threat to emergency power via phone, text, or email gives a significant head start to government officials and utilities to prepare for the potential failure of backup power.

Creating a consensus

As Powered for Patients advances its proposed protocols to enhance information sharing, an important dialogue is needed among key stakeholders to develop a consensus approach to increased information sharing. Powered for Patients plans to help facilitate this dialogue and the creation of a consensus protocol through its National Working Group on Information Sharing. ASHE also plans to be part of this important discussion. Key questions to be addressed by the National Working Group on Information Sharing include:

1. How will a designated local government point of contact who receives the initial report of a threat to emergency power share this information up the chain of command?
2. Should the local government point of contact seek to assess the threat level to an emergency power system before sending the notification of a potential problem up the chain of command or should the early “heads up” be shared immediately with local, county, state and federal officials?
3. If an assessment is to be made about the threat level facing an emergency power supply system before a reported problem is sent up the chain of command, how should such an assessment be made?
4. For emergency power systems connected to remote monitoring technology that can trigger automated alerts of predesignated government and utility contacts when mechanical threats arise, how far up the chain of command should this information automatically flow?
5. If this information needs to be assessed to determine the threat level to an emergency power supply system before it is passed up the chain of command, how should this threat level be assessed?
6. What type of mechanical threats could a remote monitoring system detect that would signal a grave threat to an emergency power supply system and warrant a rapid sharing of information about this threat up the chain of command?
7. What cyber security safeguards are needed to protect remote monitoring technology and the information it produces from cyber threats?

Time Saving

As is displayed in greater detail in Exhibit 2, the existing process for the deployment of temporary FEMA generators can take close to 40 hours when combining the steps local, state, and federal government officials need to take, along with hospital personnel and their generator service provider, in the continuum of events starting with the onset of a mechanical problem to the deployment of temporary power. Adopting the enhanced information sharing protocols outlined in this document around threats to emergency power, either through manual notification or automated reporting enabled by remote monitoring, coupled with a facility's registration in FEMA's online Emergency Power Facility Assessment Tool (EPFAT), can reduce this time frame by as much as 30 to 40 percent. These time savings are based on projections from FEMA and Powered for Patients and are reflected in the existing, better, and best scenarios shown in the following figure.

The better timeline reflects time savings when manual early notification of a threat to emergency power is provided, while the best timeline reflects the greater time savings associated with early reporting of a threat detected and automatically reported by remote monitoring and automated reporting technology.

ESF-8 refers to the emergency support function for public health and medical response. The U.S. Department of Homeland Security established the ESF (emergency support function) system after 9/11 as part of the National Response Framework (U.S. Dept. of Homeland Security 2013). The 15 key emergency support functions within the system cover the full spectrum of critical infrastructure in the United States. The emergency support functions include

- ESF-1: Transportation
- ESF-2: Communications
- ESF-3: Public works and engineering
- ESF-4: Firefighting
- ESF-5: Information and Planning
- ESF-6: Mass care, emergency assistance, temporary housing, and human services
- ESF-7: Logistics
- ESF-8: Public health and medical services
- ESF-9: Search and rescue
- ESF-10: Oil and hazardous materials response
- ESF-11: Agriculture and natural resources
- ESF-12: Energy
- ESF-13: Public safety and security
- ESF-14:Long-Term Community Recovery — Superseded by the National Disaster Recovery Framework
- ESF-15: External affairs

The situational awareness acceleration points noted in the exhibits refer to points in the timeline when decision making is accelerated as a result of an early notification of government officials of a threat to emergency power that could result in the eventual loss of emergency power.

Exhibit 2: Timelines for Deployment of Temporary FEMA Generators

Reducing the timeline for deploying FEMA generators

Existing process

Range of hours needed for deployment of FEMA generator following onset of mechanical problem with no early warning to government officials of threat to emergency power by hospital and no pre-coordination with FEMA.

	Local & State		FEMA		Total Time
More rapid estimate	04:15	+	13:00	=	17:15
Less rapid estimate	10:00	+	28:00	=	38:00

Better: Time savings

Amount of time that can be saved for deployment of FEMA generator based on early warning of ESF-8 chain of command of threat to emergency power by hospital via text, email or phone call and hospital registration in FEMA's online Emergency Power Facility Assessment Tool (EPFAT).

Time Saved in Local and State Process		Time Saved in FEMA Process		Potential Time Savings
01:15	+	10:00	=	11:15

Best: Time savings

Amount of time that can be saved for deployment of FEMA generator based on early warning of ESF-8 chain of command of threat to emergency power by hospital via real time Remote Monitoring notification and hospital registration in FEMA's online EPFAT tool.

Time Saved in Local and State Process		Time Saved in FEMA Process		Potential Time Savings
05:00	+	10:00	=	15:00

Advanced Technologies

A number of advanced power generating technologies have been deployed in existing and new hospitals. These new technologies allow facilities to better safeguard traditional emergency power systems while enabling deployment of more advanced systems that allow hospital to "island" themselves from the power grid for extended periods of time, and in some cases provide 100 percent of a hospital's normal load when operating off the grid. These new technologies fall into the category of distributed generation, the term used when electricity is generated from sources--often renewable energy sources--near the point of use instead of centralized generation sources from power plants (U.S. Department of Energy).

The most commonly deployed distributed generation technology is cogeneration, also referred to as combined heat power (CHP) systems. Approximately 235 cogeneration systems are in place across the nation's 6,500 hospitals (U.S. Department of Energy CHP Installation Database).

In cogeneration, concurrent production of electricity or mechanical power and useful thermal energy (heating and/or cooling) comes from a single source of energy, primarily natural gas-fired equipment.

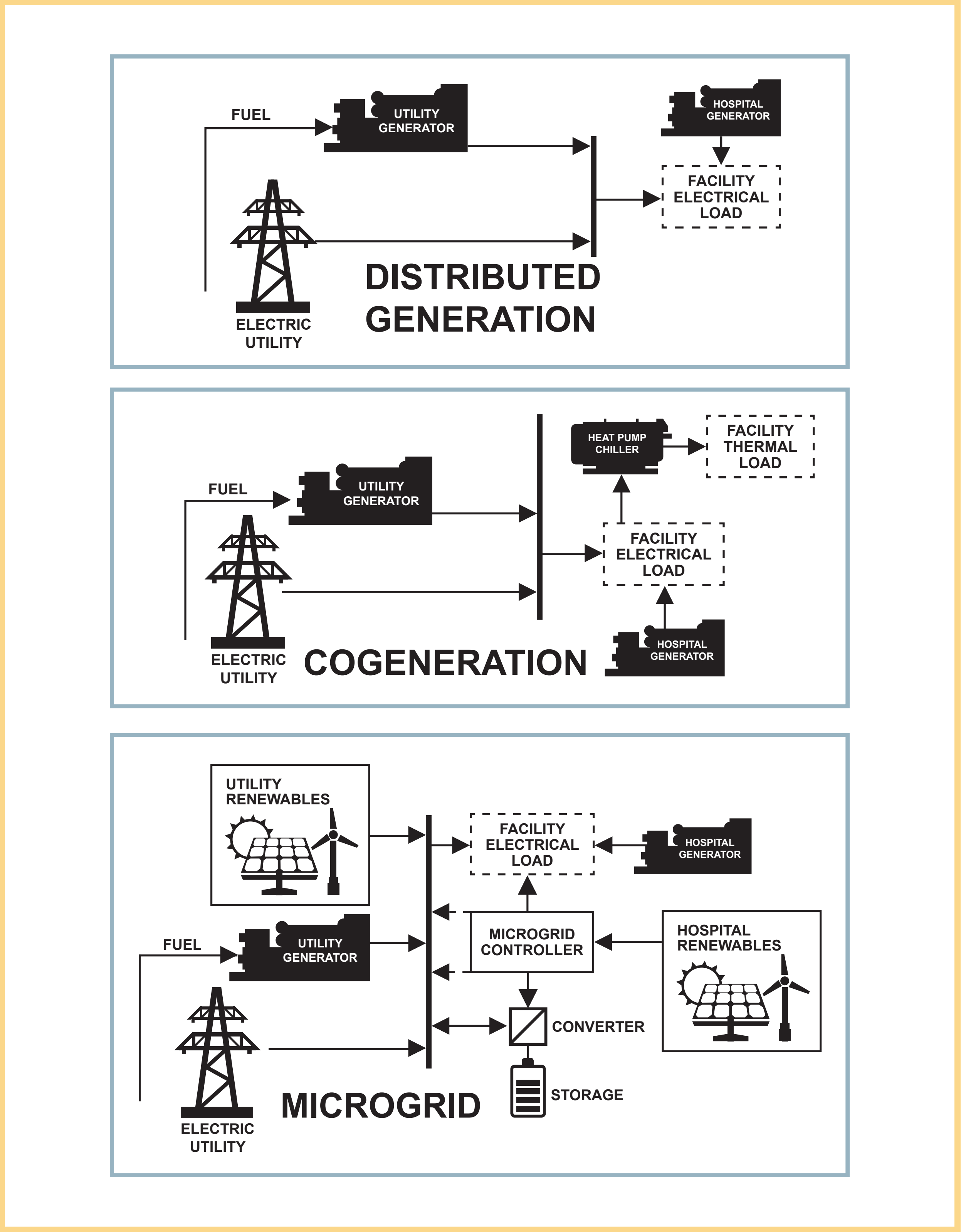
A less common but advanced power system is the microgrid, a localized grouping of electricity sources and loads that normally operates connected to and synchronous with the traditional centralized grid (macrogrid), but that can disconnect and function autonomously as physical and/or economic conditions dictate (Berkley Lab/US Department of Energy).

Exhibit 4 illustrates how distributed generation works with CHP and microgrids.

The current design, operation, maintenance, and performance capabilities of emergency power systems in critical health care facilities are governed by a complex, evolving, and at times conflicting set of codes, standards, and federal, state, and local government requirements.

These requirements establish a minimum level of operations for a hospital that generally requires an emergency power supply system to produce approximately 25 percent of a hospital's normal electrical load.

Exhibit 4: Distributed Generation



Key services to be supported by emergency power include:

- Life safety
- Life support
- Critical equipment
- Additional services determined by the facility

Adding HVAC to Emergency Power More than Doubles the Need for Backup Power

A key function not currently required to be supported by emergency power in a hospital is air conditioning. New proposals to require the addition of air conditioning to the equipment branch of a hospital's emergency power system are advancing on multiple fronts.

Adding air conditioning to an emergency power supply system would require a system large enough to provide approximately 60 percent of a hospital's normal electrical load, more than twice the current minimum requirement.

Hospitals Covering 60 Percent of a Normal Electrical Load Should Consider Covering 100 Percent of Normal Load

When hospitals make the investment to cover 60 percent of the facility's normal electrical load on emergency power to accommodate air conditioning, experts advise that the facility assess the benefit of making the additional investment to cover 100 percent of normal electrical load. Covering 100 percent of the hospital's normal load by a backup power source provides significant savings by reducing investments needed in switchgear that help a hospital shift between utility power and backup power. The ability to be able to fully function while off the grid allows a hospital to avoid negatively affecting non-essential services because of a lack of available power. Although 100 percent coverage is not required by the codes and standards a single outage that affects key revenue generating services can cost the facility more than the difference to provide full emergency power coverage of the hospital's electrical load. Also, many utilities offer generous financial incentives to hospitals to go off the grid during peak energy demand periods. Taking advantage of this opportunity requires a hospital to cover 100 percent of the facility's load on emergency power.

Key Factors Driving Selection of Advanced Power System Technology

The biggest factors that drive the decisions hospitals make when choosing distributed generation systems such as CHP or microgrids relate to power availability and reliability along with financial considerations.

An increase in the number of power outages may be a major incentive for a hospital to build a system to lessen dependence on the grid and reduce the cost of business interruptions. When hospitals with traditional emergency power supply systems (which generally cover about 25 percent of a hospital's normal power load) are forced to rely on emergency power, many important functions in the hospital cannot operate. This often includes elective surgery centers and MRI machines, both of which generate significant revenue for a hospital.

The decisions about which type of system to develop will depend on power availability. A CHP system, for example, would not be a feasible option for a facility that doesn't have access to affordable high pressure natural gas that is considerably less expensive than a facility's electricity costs. This difference between natural gas prices and electricity prices is considered the "spark spread." A location's suitability for alternative forms of energy production, such as wind, solar photovoltaic power, would be instrumental in making a microgrid economically feasible.

Fuel Cell Systems

As a result of changes incorporated into the 2015 edition of NFPA 99 (6.4.1.1.7), fuel cell systems are now considered acceptable alternate sources of power and are permitted to serve all or part of the essential electrical system (EES) provided certain conditions are met. Kaiser Permanente has been a leader in advancing use of this technology, and while only a handful of hospitals across the United States leverage this technology today, this trend is expected to increase.

A West Coast community hospital installed a fuel cell in 2010 and has been able to conserve 1.2 million gallons of water annually and achieve energy savings of $170,000 a year. The fuel cell provides clean, reliable energy to the 350,000-square foot facility. The unit provides 0.64 million BTU/h of high-grade heat (250º F) for space heating and 0.88 million BTU/h of lower-grade heat (140º F) for hot water heating.

The 400 kW fuel cell meets 63 percent of the hospital's electricity needs and 50 percent of the facility's space heating and hot water requirements through on-site distributed generation; reducing the hospital's reliance on the power grid. The fuel cell also reduces nitrogen oxides by more than two metric tons each year. This is the environmental equivalent of removing 121 cars from the road.

Other Advanced Technologies to Safeguard Emergency Power Supply Systems

Infrared scanners

In addition to remote monitoring systems that report data to a central monitoring unit, other technologies help identify potential vulnerabilities in emergency power systems. For example, a number of hospitals use infrared scanners on an annual basis to evaluate concentrations of heat within automatic transfer switches and electrical system components. This helps identify potential trouble spots.

Dual automatic transfer switch technology

New and emerging automatic transfer switch (ATS) technologies provide significant increases in the overall reliability of emergency power supply systems. Many emergency power system failures can by tied to faulty automatic transfer switches. These failures are often the result of older ATS devices that are not maintenance friendly as they require a complete shutdown of power to perform critical preventative maintenance. It is difficult for many hospitals to shut down power, resulting in deferred ATS maintenance. New bypass isolation with dual ATS technology allows hospitals to perform that very important maintenance without shutting down power.

Emergency Power Systems Case Studies

Ascension Health Case Studies

Ascension Health is one of the largest nonprofit health systems in the United States and the world's largest Catholic health system. Ascension's Healthcare Division operates 141 hospitals and more than 30 senior living facilities in 24 states and the District of Columbia.

Several years ago, Ascension Health developed innovative standards and guidelines to drive the design and maintenance of all facilities built or renovated by the organization, including advanced power generation and emergency power supply systems. Key standards include:

- The cooling equipment will be connected to emergency generators so that cooling for essential functions can be provided in the event of an electric utility outage.
- Consideration will be given to emergency power systems to support entire new construction.
- Cost analysis of baseline life safety and critical care emergency power versus 100 percent emergency power will be prepared in pre-design phase. (This is a design practice standard and will be considered for all approved major capital projects and applicable discretionary and threshold projects.)
- In the event of a generator failure, the normal power loads are automatically shed to preserve service to the essential power system.

The following key guidelines were established.

- Depending on the difference between natural gas and electricity rates (the spark spread), consideration will be given to the use of a combined heating and power system.
- Consideration should be given to a distributed generation system with an interruptible or real-time pricing electricity rate, depending on the region and prevailing energy costs.

- The electrical service to the health care facility will be negotiated with the electric utility. Key considerations should include alternative rates and riders, delivery voltage, meter location, power factor correction incentives or penalties, historical reliability, and line extension policy. If the normal power system is not connected to the emergency generators, consideration should be given to an arrangement where the health care facility is served by two sources of utility power with an automatic transfer switch.
- The number of generators and generator capacities will provide at least two units N + 1 redundancy. Generators should be rated at continuous duty. Consideration should be given to the use of dual fuel (fuel oil and natural gas) generators.

Ascension Health

St. Joseph Regional Medical Center, Littleton, Idaho

Background

- 297,000 square foot acute care hospital
- Central energy plant constructed in 2015
- Sized to accommodate future expansion
- Interruptible rates not provided or offered by utility

Project goals

- Fully designed in Autodesk Revit®
- Provide backup power capacity for 100 percent of current loads
- Provide backup power capability for 100 percent of future loads
- Tie emergency power system to normal power system
- Provide a fully automated and controlled system
- Provide a Tier 2 generator system

System advantages

- Eliminates the need for future optional equipment and standby transfer switches
- Reduces future emergency equipment space and size needs
- Reduces size of new emergency equipment by allowing critical equipment to be automatically backed up
- Provides automatic load shedding for all existing automatic transfer switches
- Provides 96 hours of run time for the entire load profile

Results

- Increased resiliency
- Services large rural community
- Accommodates current and future growth
- Planned for 10 years
- State of the art
- Real-time electrical system management

Ascension Health

Dell Children's Medical Center, Austin, Texas

Background

- Began as LEED Platinum Initiative
- First hospital to achieve LEED Platinum
- 4.5 MW solar mercury 50 gas turbine generator
- 22,000 lb./hr. heat recovery steam generator
- 36 kW PV solar array
- 612,000 square feet
- Central electrical plant (CEP) constructed in 2007

Project goals

- Provide capacity for 100 percent of current loads
- Tie emergency power system and normal power system to enable island power
- Spread fixed costs of CEP ownership over wider base
- Provide system integration such that all modules or components operate seamlessly
- Improve reliability, flexibility, and efficiency with reduced cost

System advantages

- Generates costs about half that of traditional generation
- Traditional generation: –34% efficiency
- CHP generation: –80% efficiency
- Cleaner than traditional coal-power generation

- Minimizes disruptions and downtime inherent in any large electrical distribution system
- Enhances reliability by having two sources for power: the distributed generation for island mode and the Austin Energy® grid
- Provides a ready and low-cost source for heating or sterilization by capturing hot exhaust gases from the distributed generation equipment
- Shared HVAC infrastructure and lower energy costs

Results

- First hospital in the nation to achieve LEED Platinum
- Successful public private partnership with Austin Energy
- Inexpensive heat source and process steam used by sterilization equipment

Partners HealthCare

Spaulding Rehabilitation Hospital, Charlestown, Mass.

Background

- Waterfront location drove a system-wide resiliency approach inspired by lessons learned from Hurricane Katrina
- System-wide, $70 million was being spent annually in owned buildings on electric and gas utilities in 2008; this figure was projected to increase to $170 million by 2025 if energy conservation measures alone were implemented
- 2009 Strategic Master Energy Plan (SMEP) was triggered by financial pressure from volatile natural gas prices and a commitment to the environment

SEMP goals

- Reduce greenhouse gas emissions by 30 percent from 2008 levels by 2020 as part of Partners' commitment to the Northeast Regional Greenhouse Gas Reduction Initiative, an effort among northeast states to reduce greenhouse gas emissions
- Invest $64 million over a five-year period on conservation initiatives, actively pursue on and off-site renewables, and install CHP units at all hospitals, one at a time

Spaulding initiatives

- The hospital opened in 2013 and was designed as an "upside down building": critical infrastructure such as emergency power systems, electrical equipment, and IT systems are located on upper floors to avoid flooding, an approach common in hurricane-prone regions but not the northeast
- On-site CHP plant for local electrical generation located on roof of hospital
- Local utility ran the electrical cabling up to the roof rather than terminating it at the ground level in a manhole or vault
- Entire building raised 30 inches above the 500-year flood plain to account for sea level rise
- Important functional areas placed above the ground floor
- Sited gardens using native drought and salt-tolerant vegetation to serve as buffers against flooding
- Low energy design targeted 150 kBTU/square foot, 48 percent below average hospital energy demand. Operating at 226 kBTU/square foot (2015) with ongoing initiatives to reduce further.
- Maximization of daylight and views balanced with a high-performance building envelope including triple-paned windows in patient rooms that eliminated need for perimeter radiation
- Operable windows for both natural ventilation and passive survivability in an emergency situation
- Green roofs to mitigate storm water runoff and reduce cooling loads and to reduce heat island effect

Results

- LEED Gold certified building
- Partners energy conservation initiatives have yielded a 16 percent reduction system-wide (2015)
  * 80 percent of Partners' electricity is from renewable sources (2016)

Conclusion

In this monograph, Powered for Patients and ASHE introduce valuable new opportunities for hospital facility managers and administrators to better safeguard emergency power through new protocols that leverage advanced technology and increased information sharing. This monograph details best practices in assessing the vulnerability of an emergency power supply system to reduce uncertainty over the dependability of backup power. Opportunities are presented that would allow hospitals to island from the grid through innovative power generating technologies that provide the added benefit of covering more of a hospital's critical functions on emergency power.

As hospitals embrace these new technologies and innovative protocols, they can better protect patients and more fully serve the communities that depend on them during disasters. This monograph also conveys important lessons learned from previous natural disasters and reminds us that despite progress made, more work can be done to safeguard emergency power and expedite power restoration for hospitals.

The national dialogue about how to best safeguard emergency power for hospitals and other critical health care facilities will continue and the experiences of future disasters will surely shape that discussion. Other issues relating to emergency power, not addressed here, will permeate future discussions; one such issue not discussed is the state of the nation's hospital infrastructure. As public and private sector leaders call for increased investment in emergency power capabilities, broader questions about how hospitals will finance infrastructure enhancements, including emergency power, must be addressed by the nation's policy makers.

The uniformity of requirements related to emergency power for all hospitals in the United States is another issue that will yield important conversation. Some leaders in health care architecture and design hold the view that when it comes to emergency power capabilities, not all hospitals should be governed by the same requirements. Informing that discussion will be the contrasting realities of evacuating a hospital in a metropolitan area with many nearby facilities who can accept evacuated patients with the challenge of evacuating a rural hospital whose closest hospital neighbor could be many miles and hours away. The value of the rural hospital being able to maintain emergency power operations for multiple days becomes apparent.

Wherever the discussion about safeguarding emergency power and expediting power restoration for hospitals leads, ASHE and Powered for Patients will continue to pursue increased patient safety and a more resilient hospital infrastructure.

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