

# Emergency power system basics: Maintaining always-on power for reliable healthcare

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## I. Overview: The importance of uninterrupted power

Despite some of the world's best technologies and strictest regulations, power outages from severe weather to utility failures to human error, natural and national disasters remain a potential reality for the healthcare industry.

For example, during Superstorm Sandy, 89 percent of the hospitals in declared disaster areas experienced considerable challenges in responding to the storm. That said, 93 percent of hospitals needed to shelter in place and serve a multitude of functions during the storm.<sup>1</sup>

In order to support critical life safety equipment, healthcare facilities need to be prepared to withstand temporary and extended outages. Even extremely short power outages of a few seconds can compromise the health of individual patients and cause costly damage to sensitive medical equipment and IT systems. Consequently, standby power is required for all essential electrical systems (EESs), which include evacuation/egress lighting, HVAC systems for patient care and operating rooms, critical process equipment (such as medical imaging devices) and fire suppression equipment to aid response teams in the event of an emergency. Further, healthcare IT systems require back-up power systems to support full functionality in the case of an extended power outage.

A two-part survey sponsored by the American Society for Healthcare Engineering<sup>2</sup> (ASHE) found that up to 17 percent of surveyed healthcare organizations experienced six or more outages between July 1, 2011 and June 30, 2014, which amounts to about one outage every six months. Additionally, 5 percent of those surveyed reported 12 or more utility outages during the same timeframe.

This data shows how important it is for healthcare organizations to plan in advance for utility failures. That planning needs to go beyond the generator and cover the entire emergency power supply system. It will not matter if the generators function if the overall emergency electrical system surrounding it has not been tested, maintained and updated.

**This white paper will assist healthcare organizations in making sound decisions to assure that the present and future power needs of their facilities are met. It is intended to:**

- 1 Provide an overview of the current code requirements and standards for emergency power supply systems
- 2 Define what a complete emergency power supply system looks like
- 3 Offer high-level guidance and best practices for supporting uninterrupted power during both long- and short-term power outages



<sup>1</sup> [Report OEI-06-13-00260](#)

<sup>2</sup> [Inside ASHE, Winter 2014](#)

## II. Codes & standards: A brief overview of industry requirements

The foundation of our electrical codes and standards for healthcare environments was written in an earlier era, when healthcare and energy landscapes were vastly different. Healthcare facilities were not experiencing as frequent and prolonged power outages from severe weather events and an aging, taxed electrical grid. Much of the ubiquitous medical equipment that supports our current healthcare system was not yet developed. Additionally, cybersecurity considerations and electronic health record technology were nonexistent. Many other aspects of our healthcare system today require more – more power, more reliability, more efficiency and more security.

Beyond the evolution of basic electrical system considerations, the role of rural and metro hospital systems has also changed considerably since the basic codes and standards were written. Although the codes and standards enforced are identical, rural hospitals may be the only healthcare facility for miles – which necessitates the ability to operate under back-up power for days or weeks at a time should a regional disaster occur.

All that said, the codes and standards supporting emergency power systems in healthcare facilities continue to improve and evolve. This section briefly summarizes some of the current standard code requirements healthcare facilities must comply with in terms of assuring appropriate emergency power. The National Fire Protection Association establishes the requirements for emergency power supply systems, while the Joint Commission establish those basic guidelines sets the guidelines for the inspection, testing and maintenance of emergency power supply system equipment.

### National Fire Protection Association: The fundamentals

**The National Fire Protection Association (NFPA)** codes form the fundamental standards for emergency power systems. The NFPA regularly publishes and updates several codes pertinent to emergency electrical systems in healthcare facilities. These include: NFPA 70, National Electrical Code (NFPA, 2014), NFPA 99, Healthcare Facilities Code (NFPA, 2015), and NFPA 110, Standard for Emergency and Standby Power Systems (NFPA, 2016).

#### **NFPA 110, Standard for Emergency and Standby Power Systems**

While the National Fire Protection Association (NFPA) was founded back at the turn of the nineteenth century, the fundamental standard for the application and operation of emergency electrical systems was not formed until 1976. The NFPA continues to evolve and is reviewed on a three-year cycle, with the latest version (at the time of writing) the 2016 edition.

NFPA 110 defines the performance requirements for both emergency and standby power systems that provide an alternate source of electrical power to the healthcare facility. In the event that the normal electrical power source fails, transition to backup equipment must occur in a timely and reliable fashion. Systems addressed here include power sources, transfer equipment, controls, supervisory equipment and accessory equipment needed to supply electrical power to the selected circuits.

This code requires for a routine maintenance and operational testing program after the emergency power system “passed acceptance tests or after completion of repairs that impact the operational reliability of that system.”<sup>3</sup> It also requires a defined, written schedule for routine maintenance and testing of the emergency power supply systems.

NFPA 110 presents installation, inspection, maintenance, operation, and testing requirements as they pertain to the performance of the

EPSS up to the load terminals of the transfer switch. It requires that transfer switches be subjected to a maintenance and test program that includes all of the following:

- Checking connections
- Inspection or testing for evidence of overheating and excessive contact erosion
- Removal of dust and dirt
- Replacement of contacts when necessary

This document provides a classification structure for EPSS; and provides guidance on energy sources, converters, inverters, and accessories; transfer switches and protection equipment. Other topics covered include installation and environmental considerations as well as routine maintenance and operational testing.

Importantly, the first edition of the NFPA 110 code for emergency and standard power supplies was published in 1985. That is about thirty-five years of so after many hospitals in the U.S. were built; the financial support provided by the Hill-Burton Act (1946) spurred the development of hospitals across the U.S. in the late 1940s and early 1950s.<sup>4</sup> The challenge was in applying the NFPA 110 requirements to existing systems.

#### **NFPA 70 – National Electrical Code®**

Most code requirements for emergency power are intended to assure that individuals inside can evacuate the building quickly and safely. Typically, this is required within a 90-minute to two-hour window of time. Often, meeting the minimum building code requirements is not sufficient for maintaining healthcare operations or services when an outage occurs.

NFPA 70 provides specific requirements for the installation of electrical conductors, equipment, and raceways; signaling and communications conductors, equipment, and raceways; and optical fiber cables and raceways. A portion of the National Electrical Code (NEC) addresses maintenance of electrical distribution system equipment in accordance with manufacturers’ or industry standards. It also provides guidance on specifying personal protective equipment (PPE) and electrical panel labeling. When power issues occur, the NFPA 70 standards for protective device coordination is a key element in ensuring that the system reacts appropriately to prevent a small issue from becoming a major outage.

In addition to emergency power systems, standby systems are also required of critical healthcare facilities under the NEC. Where emergency systems typically assure egress lighting and power; standby systems serve loads that support necessary heating and air conditioning systems as well as sewage disposal and other industrial machinery on-site.

#### **NFPA 99 – Healthcare Facility Code**

Broadly speaking, the scope of NFPA 99 is to establish criteria for levels of healthcare services or systems based on risk to the patients, staff, or visitors in healthcare facilities to minimize the hazards of fire, explosion, and electricity.

With respect to emergency power management, NFPA 99 addresses critical facility power distribution requirements for a wide range of equipment, lighting and receptacles specific to healthcare. It spans three branches within the emergency distribution system and describes equipment for which emergency power must be provided as follows:

- 1 An equipment branch**, which is broken into equipment with automatic connections or automatic or manual connections.
- 2 The critical branch** primarily includes task lighting and select receptacles; additional task illumination, receptacles, and select power circuits needed for effective facility operation.
- 3 The life-safety branch** is generally given the highest priority. It spans egress lighting; exit signs and exit directional signs; communication systems; generator set locations; elevator cab lighting, control and communications; electrically powered doors used for egress; fire alarms and auxiliary functions of fire alarm systems.

Requirements of special note are those regarding generator backup for locations such as the operating rooms and medical labs. These requirements specify that, after detecting a power outage has occurred, the generators must start and stabilize their output within a set number of seconds (in most cases, 10 seconds). FEMA emphasizes that, “Section

<sup>3</sup> Health Care Facilities Code Handbook: NFPA 8.3.2

<sup>4</sup> “Construction Activity in U.S. Hospitals,” by Gloria J. Bazzoli, Anneliese Gerland, Jessica May in Health Affairs, July 2016.

6.4 of NFPA 99 requires fresh air intake louvers to be placed in generator rooms to provide unrestricted airflow to the generator. These louvers are required to fail in the open position to ensure that airflow is not restricted. However, louvers open to extremely low exterior temperatures can rapidly introduce large volumes of cold air into the building that can cause piping systems, domestic water systems, and fire suppression systems to freeze and fail” (FEMA 32). When considering these specifications, facilities based in extremely cold climates should also plan for the fact that some systems, such as the battery systems for starting emergency generators and controlling medium voltage electrical switchgear, may be susceptible to additional climatic factors.

NFPA 99 also provides guidelines regarding the operational aspects of the healthcare facility in regard to emergency power. Healthcare facilities are designated as Level IB operations. Additionally, both NFPA 99 and NFPA 1600 define criteria for developing emergency management programs in new and existing healthcare facilities.

Lastly, NFPA 99 requires the use of automatic transfer switches, which by definition need to meet the industry standard for transfer switches: Underwriters Laboratories (UL®) 1008.

### **NFPA 101, Life Safety Code**

The Centers for Medicare and Medicaid Services (CMS) currently requires healthcare facilities to comply with NFPA 101, Life Safety Code (NFPA, 2015). This code spans requirements for emergency power and emergency lighting systems in both new and existing facilities. It also specifies guidelines on such details as how long the generator should run and how much fuel must be stored onsite.

Additionally, under NFPA 101, operational inspection and testing of emergency or standby power supply systems (EPSS) and components is required weekly along with monthly load testing. Attention should be paid to any related fuel systems, lubrication systems, cooling systems, starting systems, controls and alarms, transfer switches and a variety of general conditions. Testing documentation must be maintained.

### **The Joint Commission requirements in brief**

Two key aspects of [The Joint Commission](#) requirements are addressed in this paper EC.02.05.03 and EC.02.05.07. The former addresses requirements for reliable emergency power source, while the latter addresses the related inspection, testing and maintenance (and documentation) requirements of emergency power systems. These requirements are the basics to meet Joint Commission accreditation.

#### **EC.02.05.03**

This Joint Commission code addresses the need for a reliable emergency power source. In 2014 the Joint Commission issued new elements of performance (EPs) and now requires hospitals to perform and submit an inventory of their utility system, which includes the main electrical distribution and emergency power systems.

#### **EC.02.05.07**

This requirement fundamentally relates to the inspection, testing and maintenance requirements of emergency power systems, however it does not require that organizations have the various types of emergency power systems identified in the code. Instead, it provides the guidance for testing, maintenance and inspection for facilities that have this equipment.

The intention of this standard is to provide guidance for testing of emergency power systems so that these systems are less likely to fail during a power disruption. Testing these systems for enough time and regularly helps to increase the probability of identifying reliability issues and reduces the risk of losing emergency power when it is needed.

It is also important to note Life Safety In May 2016, The Joint Commission and [Centers for Medicare and Medicaid Services \(CMS\)](#) published the “final rule” on Fire Safety Requirements to amend the fire safety standards for certain Medicaid and Medicare participating healthcare facilities. The latest ruling requires that hospitals follow the 2012 versions of the Life Safety Code and the NFPA 99 Healthcare Facilities Code. In large part, the latest rule accepts much of the CMS 2014 proposals.<sup>5</sup>

<sup>5</sup>“Accreditation: CMS, Joint Commission adopt 2012 NFPA 101 Life Safety Code.” Joint Commission Online, May 11, 2016.

### **Joint Commission EC.02.05.03 requires an inventory of the following equipment or components:**

- 1 Alarm systems
- 2 Exit route and exit sign illumination
- 3 Emergency communication systems
- 4 Elevators
- 5 Equipment that could cause patient harm when it fails
- 6 Areas in which loss of power could result in patient harm

### **Joint Commission EC.02.05.07 elements of performance include the following testing and related documentation:**

- 1 Every 30 days, functional testing of battery-powered lights required for egress for at least a 30-second duration
- 2 Every 12 months, functional testing of battery-powered lights required for egress for a duration of 1.5 hours or the replacement of all batteries every 12 months and the random testing of 10 percent of all batteries for 1.5 hours
- 3 Every quarter, functional testing of stored emergency power supply systems for five minutes or as specified for its class. Additionally, annual testing at full load for 60 percent of the full duration of its class.
- 4 Twelve times a year, at intervals of not less than 20 days and not more than 40 days, the hospital must test each emergency generator for at least 30 continuous minutes
- 5 The emergency generator tests are conducted with a dynamic load that is at least 30 percent of the nameplate ratings of the generator or meets manufacturers’ recommendations
- 6 Twelve times a year, at intervals of not less than 20 days and not more than 40 days, the hospital must test its automatic transfer switches
- 7 At least once every 36 months, hospitals with a generator providing emergency power test those generators for at least 4 continuous hours
- 8 The 36-month generator test uses a dynamic or static load that is at least 30 percent of the nameplate rating of the generator or meets manufacturers’ recommendations
- 9 If a required emergency power system test fails, the hospital must implement measures to protect patients, visitors and staff until the repairs are made
- 10 If a required emergency power system test fails, the hospital performs a retest after making repairs

### III. Overview of a complete emergency power system: Essential components

In order to implement a robust emergency power system, it is critical to understand and determine the optimal needs for a facility to combat the loss of power. While code requirements provide a great baseline or starting point, it is important to fully understand the essential components of the entire system needed for maintaining critical functions and operations.

#### Backup power sources: Generators and uninterruptible power systems

Generator specification most often depends on the size of hospital or facility, location, and ease of access to particular fuel types and suppliers. Due to capacity, most hospitals typically employ diesel or gasoline generators. It is also common to see generator quick connect switchboards used in tandem with temporary generators that also run on gasoline.

For reciprocating engines, diesel engines are the most popular choice of generators compared to other forms of power and the relative ease of application. Gasoline engine generator sets are also available and are generally less expensive than diesel generator sets, but suffer from the disadvantages of higher operating costs, greater fuel storage hazards and shorter fuel storage life as compared to diesel. Diesel engines can also run on natural gas, although for maximum efficiency specially-tuned engines for natural gas use are available.

The other alternative for generators is the turbine generator, typically powered by natural gas. Gas-turbine generator sets are generally lighter in weight than diesel engine-generator sets, run more quietly, and generally require less cooling and combustion air, leading to lower installation costs. However, gas-turbine generator sets are more expensive than diesel engine-generator sets, and require more starting time (normally around 30 s compared to the 10-15 seconds for diesels).

The long starting-time requirement and lack of available small sizes (< 500 kW) makes the gas-turbine generators infeasible in some applications. Generator installations must consider the combustion and cooling air required by the generator and prime mover, as well as the provisions for the removal of exhaust gasses. Noise abatement must also be considered.

These considerations increase the installation costs, especially for reciprocating-engine units such as diesel or gasoline engines. Further, the fuel supply must be considered; building code and insurance considerations may force the fuel storage tank to be well removed from the generator(s), usually forcing the addition of a fuel transfer tank near the generator(s).

Care must be taken when sizing engine-generator sets for a given application since several ratings exist for the output capability of a given machine. The continuous rating is typically the output rating of the engine-generator set on a continuous basis with a non-varying load. The prime power rating is typically the continuous output rating with varying load. The standby rating is typically the output rating for a limited period of time with varying load. The manufacturer must be consulted to define the capabilities of a given unit.

#### Generator circuit protection

Generator circuits have unique characteristics that require specially designed and tested circuit breakers. The IEEE developed the special industry standard C37.013 and amendment C37.013a-2007, to address these characteristics.

Applications with high continuous current levels require connections with large conductors of very low impedance. This construction causes unique fault current and voltage conditions. When selecting generator circuit breakers, make sure they are able to handle these high continuous current levels without overheating.

Additionally, generator circuits typically produce very fast rates of rise of recovery voltage (RRRV) due to the high natural frequency and low impedance and very low stray capacitance. The voltages across the open contacts can be as high as twice the rated line-to-ground voltage of the system. Circuit breakers intended for generator protection must comply with IEEE standard through testing that the generator circuit breaker can switch under specified out-of phase conditions.

#### Uninterruptible power systems and energy storage devices

Because motor starting and block loading can have a big effect on the output voltage and also because power is not available during the engine starting period, a buffer between the generators and sensitive load equipment is generally required.

Uninterruptible power systems (UPSs) are a common buffer of choice for these applications. UPSs are available in several different topologies, but the operational goals are the same regardless of topology: The supply of uninterrupted power to sensitive, critical loads. This uninterrupted power must also be supplied during a utility outage, which can be accomplished by utilizing chemical energy storage, such as batteries or supercapacitors or mechanical storage such as flywheels. These options vary in cost, backup time and required maintenance.

The most popular topology for a UPS is the double conversion topology. As long as the batteries are properly maintained, the AC output should not be affected by change in frequency or voltage, or even a complete loss, at the input, when backup time of the UPS is not exceeded. Other topologies exist, including the line interactive, double-conversion rotary, hybrid rotary, and line-interactive rotary topologies, each with advantages and disadvantages of application. UPS systems do not alleviate the need for a generator or second utility service power source, but they do serve to buffer critical loads from the effects of generator starting time and voltage and frequency variations.

When selecting a UPS, calculating backup battery runtime is critical. In the event the backup generator does not start, the facility must be prepared to move to "plan B" immediately. For this reason, it is important to know in advance exactly how much battery backup is in place.

First, consider how much backup time is needed in "normal" outages where the generator set starts successfully. Is 30 seconds enough to transition to alternative power sources should a generator failure occur? These needs should be assessed carefully.

Additionally, it is important to note that batteries lose capacity over time. A five year-old battery will only have 80 percent of its original capacity. Will that be enough? If not, one needs to oversize their new battery by about 20 percent. You should also realize it typically takes about 10 times the outage duration to recharge the battery. For example a 10-minute power outage will require 100 minutes to recharge the battery.

Facility managers should avoid UPS systems that rely on trickle charging, as it has the potential to reduce a battery's service life by as much as 50 percent. Instead, opt for UPSs that leverage advanced battery management (ABM) technology. This approach uses sensing circuitry and an innovative three-stage charging technique to extend battery service life and optimize recharge time. ABM-enabled UPS's can help improve efficiency to 99 percent; the decrease in energy consumption means that these systems can pay for themselves in a short time. These highly efficient systems put out less heat as well, which means that the facility's cooling costs might be simultaneously lowered.

Providing another alternative, modern supercapacitor solutions are now available, which provide fast discharge and a high degree of reliability compared to lead-acid batteries in storage and back up systems. Supercapacitor-based modules can provide a longer life than batteries and improve power quality during voltage spikes and brownouts.

Supercapacitor-based energy storage modules are designed for applications that require high-power density, fast discharge and quicker recharging capabilities. Additionally, the technology can help avoid the costs associated with the ongoing maintenance, replacement and disposal fees related to lead acid batteries.

## Automatic transfer switches

An automatic transfer switch switches the critical and life safety loads from the normal utility source to the alternate standby power source. This is accomplished with an automatic transfer switch (ATS) which is defined in NFPA 110 as, “self-acting equipment for transferring one or more load conductor connections from one power source to another.” The industry standard governing the construction and minimum performance criteria for transfer switch equipment is UL1008.

In its most basic form, an ATS consists of a switching mechanism and an intelligent control system capable of sensing the normal supply voltage and initiating a transfer to the alternate source should the normal source fail. There are many options available to the engineer when specifying transfer switches in the healthcare environment.

Standards help to establish minimum performance criteria, but the varying construction types and available options require well-educated decisions. It is important to understand the needs of your facility because over-specifying could result in a very reliable but costly design. On the other hand, under-specifying could result in a less expensive design that does not meet code, safety, and reliability requirements – especially for the long run. Because automatic transfer switches are designed to continuously carry the critical loads they serve, understanding the major construction types and features is required to make the right selection minimizing the potential for misapplication.

The major construction types and features can be grouped into switching mechanism, operation, transition, bypass and automatic controls. A more detailed discussion of these groupings can be found in the Eaton white paper, [“Transfer Switch 101 – An introductory guide to picking the right transfer switch for your equipment.”](#)<sup>6</sup>

For simplified maintenance and improved uptime, bypass isolation automatic transfer switches are a recent advancement that provide dual switching functionality and redundancy for critical applications. The primary switching mechanism (or automatic transfer switch) handles the day-to-day distribution of electrical power to the load, while the secondary switching mechanism (or automatic bypass) serves as a backup or redundant device.

During repair or maintenance procedures, these devices allow service personnel to bypass power around the automatic transfer switch through the automatic bypass to ensure that critical loads remain powered without interruption. When in the automatic bypass mode of operation, the control system continues to monitor the normal power source and will automatically initiate a transfer to the alternate source should the normal source fail. A bypass isolation transfer switch is frequently selected for use in healthcare, as well as in other critical applications, because it provides increased reliability through redundancy and allows the primary switching mechanism to be isolated from the power source(s) to facilitate regular maintenance, inspection and testing as required by code such as NFPA 110.

Furthermore, bypass isolation ATS’s typically include an enhanced feature set designed to simplify maintenance and serviceability, including draw-out of one or both switching mechanisms, compartmentalized construction and safety interlocks. In some cases local or state code, like the California Electric Code, require the use of a bypass isolation ATS in specific facility types such as hospitals and correctional treatment centers.

Per NFPA 99, the essential electrical system in a healthcare facility shall be divided into three branches (life safety, critical, equipment) and the division between the branches shall occur at the transfer switches. The number of transfer switches used is based on a variety of considerations including characteristics of the load. Life safety includes lighting, signage, electrical door, communication and elevator control loads associated with emergency egress. The critical branch serves circuits associated with patient care like tissue banks, nurse call stations, and intensive care units. The equipment branch includes a higher percentage of inductive load types like pumps, suction systems, and ventilation typically requiring a transfer switch with higher amperage rating as compared to the life safety and critical branches.

As legacy ATS solutions either require maintenance personnel to work on live equipment or require downtime to turn equipment off, the branch division outlined in NFPA 99, NFPA 110 maintenance requirements and critical need for continuous uptime often result in the specification of bypass isolation ATS for use in new construction or retrofit projects.

## Generator paralleling switchgear

Intelligent communication solutions that interface with generators, switchgear, ATSs and UPSs can help manage critical transitions from the utility company power to an on-site generator and back again. Switchgear and transfer equipment that provides momentary overlap of power sources eliminates power interruptions when returning to the normal source, and those facilities whose electrical demand outstrips the capacity of a single generator will need to consider components with active generator paralleling at the switchgear.

Intelligent communication features that are integrated with generators, switchgear, ATSs and UPSs carry a host of associated benefits including matching available capacity to actual load, adding or shedding loads based on generation capacity, and centralizing all relevant alarms and status at a single interface point

Efficient communication from the emergency system is imperative to maintain system reliability and preserve lives in healthcare facilities. System alerts can be managed through individual components, centralized within advanced switchgear or transmitted to a building management system. With microprocessor-based controls, generator paralleling switchgear can respond to load changes faster, react to a wide variety of conditions and work with the UPS, saving time and improving system reliability during an emergency.

For example, some UPS manufacturers offer remote monitoring and management as a subscription service that collects and analyzes data from connected power infrastructure devices, providing the insight needed to make recommendations and take action on your behalf.

These offers are most often available in a dashboard platform or mobile application with monthly reports detailing data on the ongoing health and energy savings of your UPS. This data delivers information on your unit’s voltages, loads, and external factors such as temperature and humidity, depending on the model.

Additionally, the data provides information about the attached batteries and system availability. All of these factors contribute to a performance index score that allows you to compare your unit’s health relative to optimum UPS operating levels.

Further, these services can inform you when critical events are experienced. Anomalies are checked in incoming parametric or event data logs, upon receipt of a status or event email, respectively. If an anomaly is detected, a customer support specialist can further analyze the data for possible impending failures. These services most often rely on a connectivity card and an environmental monitoring probe (EMP) attached to your UPS.

<sup>6</sup> “Transfer switch 101: an introductory guide to picking the right transfer switch for your environment,” by Charlie Hume, product line sales engineer, Eaton, March 2015.

## System monitoring

The information available through real-time electrical power management system (EPMS) can provide the central intelligence needed to drive improvements in power reliability, energy efficiency, maintenance practices and safety. Based on historical electrical generation and distribution data and reporting, facility managers can more effectively allocate where and when proactive maintenance dollars should be spent.

By utilizing modern EPMS platforms, organizations can go a step further to proactively access vital performance details including circuit loading, peak demand, and equipment status. Such systems also give organizations the ability to proactively set hundreds of alarms that warn building management of underperforming equipment and conditions threatening uptime.

Going a step further, these metrics can be used to simplify Joint Commission testing. By arranging for reports including user-specified statistics to be automatically arranged at predefined intervals, organizations can quickly reduce the time and labor needed to produce and verify reporting documentation.

Additionally, these systems can prove beneficial for event analysis. If a full power outage occurs, the ability to trace the events that led to the failure is key in protecting against liabilities. Electrical systems must be maintained properly to avoid poor performance, abnormalities or outages and failures. When regular event analysis is integrated well with proactive maintenance, problem equipment can be identified well before it fails.

## IV. Best practices for Emergency Power Supply Systems

Illustrating the importance of viewing emergency power supply systems as complete, integrated systems, ASHE compared the results from a recent survey to a prior study following Superstorm Sandy and found that while the duration of utility outages is shrinking, frequency appears to be increasing. There were 370 outages reported by 258 respondents in the recent essential electrical systems survey, versus 139 outages reported by 390 respondents during the Superstorm Sandy Survey.

ASHE concluded that of the 5,686 registered hospitals in the US, each facility can expect to face at least one utility outage per year. The majority of these outages will last from under one hour up to 8 hours. But even in outages that last under one hour, ASHE notes that 2,497 intensive care unit (ICU) patients are likely to be impacted in potentially life-threatening ways.

This data proves that, in order to ensure effective response against potential outages, it is vital to take a comprehensive view of emergency power supply systems as an integrated asset rather than focusing on just the requirements of individual components such as generators. By designing and managing these components as interworking systems, organizations are much less likely to run into issues during an outage and can better prepare their facilities to provide uninterrupted power for critical care units.

## Federal Emergency Management Agency Guidance

The [Federal Emergency Management Agency emphasizes that we are more vulnerable to power outages, data loss, and losing the sheer ability to manage operations](#) (FEMA 53). It also recognizes the potential for loss of utility power for extended time periods and the necessity for critical facilities to have access to reliable sources of power to continue operation.

### FEMA P-1019

FEMA provides guidance on the design and operation of emergency power systems in critical facilities so they are able to maintain operations for extended periods even when the utility grid is off. FEMA P-1019 discusses associated mitigation strategies and code requirements intended to mitigate these vulnerabilities in a range of critical facilities (including hospitals and other healthcare facilities).

FEMA defines critical facilities as those that are “essential for the delivery of vital services or protection of a community” (FEMA 54). All healthcare facilities are thus considered critical due to their basic life-supporting nature. As critical facilities, all healthcare sites must include an emergency power system to minimize both downtime and the related potential for loss of life. It should be noted that, at the local level, many smaller healthcare and private business facilities – including nursing homes and assisted living facilities – may also be considered critical by the local, regional, state or federal guidelines.

## U.S. Department of Health and Human Services’ Toolkit

Beyond the FEMA guidance and the NFPA and Joint Commission guidelines, there are numerous other resources available to help establish and maintain critical power systems. The U.S. Department of Health and Human Services’ Sustainable and Climate Resilient Health Care Facilities Initiative (SCRHCFI) is one of those resources and provides guidance on how to maintain the quality of health and human care before, during and after an extreme weather event. The [SCRHCFI Best Practices guide<sup>2</sup>](#) is included in a web-based toolkit and framework that includes a vulnerability assessment for medical facilities as well as suggestions for resilience, checklists and other resources to encourage real-world best practices for supporting power reliability even when the power grid may be down.

## Ongoing testing, inspection and maintenance

Regular testing and inspection of high-value electrical equipment is vital and allows staff to determine whether adverse environmental changes or equipment changes have occurred that should be corrected to maintain desired reliability.

As the demands on healthcare facilities continues to change due to advancements in treatment technology, power systems will also need updated. Many hospitals operate with power equipment that is decades past its useful life. In those cases, enhanced inspection and maintenance are critical to continued dependable operation. Retro-commissioning can play a large role in this process. This systematic process involves identifying less-than-optimal performance in your facility’s equipment and systems and making the necessary adjustments. While retrofitting involves replacing outdated equipment, retro-commissioning focuses on improving the efficiency of what’s already in place.

<sup>2</sup> [“Sustainable and Climate-Resilient Health Care Facilities Toolkit.”](#) U.S. Department of Health and Human Services’ Sustainable and Climate Resilient Health Care Facilities Initiative, December 2015.

Emergency power systems must meet the minimum inspection, testing and maintenance requirements stipulated in NFPA 110, Standard for Emergency and Standby Power Systems. Additionally, when testing for NPFA and Joint Commission standards, it is important to arrange the time needed for shutdowns to perform necessary preventative maintenance, as well as equipment and controls modernization.

Annual infrared thermographic scanning of electrical power equipment is also a recommended best practice. It helps organizations to discover potential problem areas and correct them before they develop into dangerous and disruptive failures. It also can be used as a predictive maintenance tool.

Electrical power equipment maintenance is a best practice, but is hard to accomplish within health care facilities. The 2012 American Society for Healthcare Engineering (ASHE) management monograph titled "Managing Hospital Electrical Shutdowns" contains a robust discussion of issues and recommendations related to this topic.

To provide additional assistance for facility managers in compliance with the testing mandates of NFPA, healthcare market-specific generator controls are available with features that automate this testing and reporting, as well as incorporating those times when the generators are run in the absence of available utility power that can be applied to meet the testing requirements.

### Scalability of systems for future growth

One of the best ways to get the most value, assurance and reliability out of an emergency power system investment is to practice right-sizing the equipment. FEMA states directly that "careful disaster management planning will help ensure that the emergency power system is adequately sized to provide the required level of electrical service, and that this power can be reliably maintained for the necessary period of time" (FEMA 21).

### Capacity planning and simulation

One can never fully predict future needs accurately. But a good way to preserve the facility's readiness is to pursue investments that add greater agility and flexibility.

For example, while the extra capacity of an oversized UPS is expensive and might never be used; scalable, modular systems are available on the market today, which allow organizations to "pay as they grow." Oversized branch circuit switches can be installed to allow for future expansion with larger fuses. This is one viable approach to assuring that critical processes are not disrupted while system upgrades are underway.

Similar approaches with "expansion ready" switchgear with spare distribution and/or generation breaker provisions and generator control space can avoid substantial retrofit costs as the facility grows.

Similarly, some modern EPMS platforms are available that offer tools for capacity management, simulation and planning across an entire power system.

These features allow users to test the impact of momentary electrical load increases, set capacity thresholds and model potential system upgrades – prior to the addition of new electrical equipment – to help reduce the risk of unplanned downtime and ensure adequate system protection.

For example, facility managers can take daily power-consumption trends into account to alter electrical loads electrical equipment can be powered down when not needed. Or, the technology can be used to simulate the addition of new equipment to determine if adequate backup power capacity exists.

There are a wide range of EPMS solutions on the market that are designed to help track energy usage over time. However, when addressing the future it may be best to look for a platform that can also immediately inform facility management of peak levels and project future demands based on past usage.

This knowledge could prove critical in planning for infrastructure or systems investments, helps to avoid unnecessary expenditure, and simplifies power chain adjustments in support of changing loads – ultimately allowing building management to plan for future requirements more reliably.

### Pre-crisis response planning

"Without a disaster plan in place, a facility could suffer irreversible harm from events both near and far...Performance goals for recovery plans should address the role of a critical facility within the community" (FEMA 53-54).

"Disaster preparedness is not the sole responsibility of government; facility owners and operators have an obligation as part of the "whole community" to plan and prepare for catastrophic events. The social needs of a community are supported by buildings and utilities that also need to remain functional. In particular, critical facilities need to define performance goals for desired levels of functionality for immediate, short term, and long term recovery plans" (FEMA 53).

"Testing and exercises are a critical component of any disaster preparedness and business continuity program. Exercises are designed to evaluate program plans, procedures and capabilities, and they provide a standardized methodology to practice procedures and interact with other entities in a controlled setting. They should be conducted on a regular basis so that required preparedness and response capabilities can be established and maintained" (FEMA 58).

"Once critical functions are identified, the building systems required to support the critical functions can be identified, along with their electrical power requirements. The plan should take into account the changes in normal operational procedures that will be implemented in the event of a disaster, which may serve to reduce the electrical power demands" (FEMA 21).

### Proactive maintenance performance contracts: Overview and importance

FEMA reminds organizations that disaster planning and recovery plans should take special care to account for generator maintenance, testing, and repair (both preventive and during the event). Audit existing systems regularly to identify possible issues and areas for improvement. Repair or replace key components before they fail. Minimize downtime during maintenance. Consideration should be given to the proximity of available manufacturer's service technicians and parts warehousing for both routine and emergency services.

### Closing thoughts

Healthcare facilities require a safe, reliable source of power. A wide range of industry organizations set numerous standards to help outline the characteristics behind a robust, compliant emergency power system. However, maintaining and developing these systems can pose a major challenge for healthcare system designers.

Because of the critical nature of healthcare emergency power systems, Eaton highly recommends working with qualified and trusted professionals to assist with planning, design, selection, installation, compliance and maintenance processes. Backed by years of practical expertise, emergency power system experts can help simplify the task of making intelligent infrastructure decisions and helping healthcare facilities can achieve compliance with federal, state and local regulations. Most of all, working with a trusted team of professionals provides the peace of mind of knowing that critical processes will be supported with the highest levels of continuity and reliability possible, despite the inevitable possibility of power interruptions.

**For additional information, please visit [www.eaton.com/healthcare](http://www.eaton.com/healthcare)**

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