

# How Unreliable Power Affects the Business Value of a Hospital

An in-depth look at the causes and effects of power outages in hospitals across North America, and recommendations to ensure power reliability.

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# Executive summary

## Overview

Hospitals require extraordinary reliability from their power systems. Life-support systems, as well as critical ancillary infrastructure systems such as HVAC, communications, records management, and security must all remain online during a power disruption. The financial impact of power disruption was demonstrated during the August 2003 blackout, which affected 45 million people in eight US states and 10 million people in parts of Canada. Healthcare facilities experienced hundreds of millions of dollars in lost revenue from cancelled services, legal liability, and damaged reputations. Six hospitals were in bankruptcy 1 year later.

Within the healthcare market, hospitals often are called upon to provide emergency services during disaster situations. Meeting these demands requires power systems that are designed to support highly critical operations for extended durations under often difficult circumstances. Hospital expansions are also an area of concern if power systems are not designed properly.

## Research methodology

Information for this white paper was drawn from multiple sources:

- 100 phone surveys of industry executives who manage healthcare facilities of 100+ hospital beds
- Public and private facilities were included in the surveys, including HMOs, veterans' hospitals, and public, private, and not-for-profit facilities (figure 1)
- Interviews with financial executives from 15 hospitals with more than 100 beds
- Existing data from vendors, analyst, and consulting firms

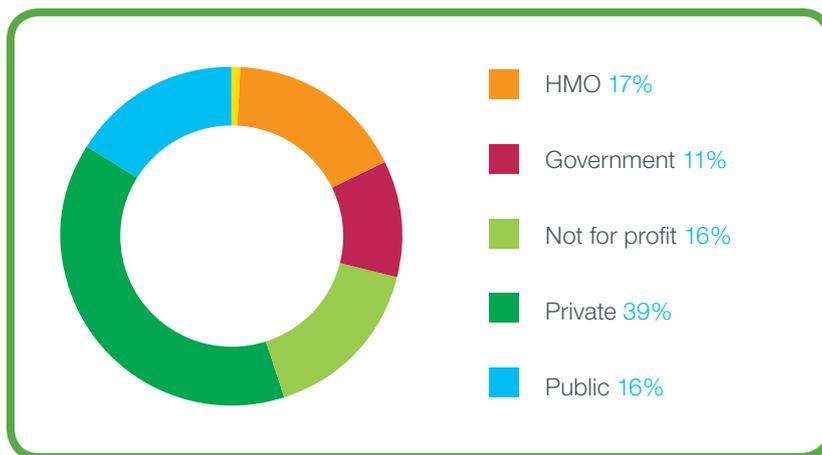


Figure 1. Facilities by type

Much of the data described in the following charts and graphs was collected in 30-minute phone surveys, as well as through in-person interviews with financial executives. The surveys were designed to solicit data regarding the hospital operating environment and history, whereas the in-person interviews produced financial data. Overall industry information was collected from third-party providers and offered background on the types of power supplies available and current data on power outages.

### Key findings

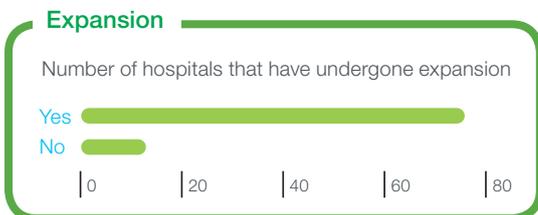
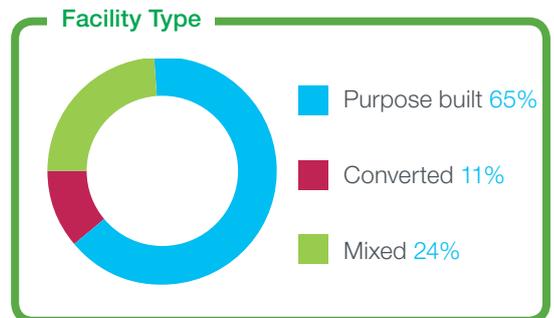
Key findings of the study include:

- Facility managers see power reliability as an absolute necessity. Not only does it ensure quality care is delivered, it also affects the hospital’s bottom line revenue due to the potential cost of disruptions.
- Financial executives expect the power to work, short of a massive natural disaster, and even then for anywhere from 4–12 days, to allow emergencies to be handled and to allow non-emergency patients to be safely transferred.
- Negative consumer perception (leading to lower admissions), accreditations, and donor willingness are among the at-risk areas for facilities that do not have adequate power back-up to provide consistent service levels.
- Financially, power outages can cost hospitals millions of dollars per day, while even short duration outages (less than 1 hour) can cause significant disruptions to services costing tens of thousands of dollars per hour.

### Conclusion

The surveyed facilities were a mixture of purpose built and converted; the majority have undergone expansions and continue to change as needs dictate. Expansion requires power system changes and associated changes in the staff’s methods and procedures for handling emergency situations. Adding automated solutions for the testing and documentation of facility safety needed for regulatory agencies can reduce headcount needs and facilitate compliance.

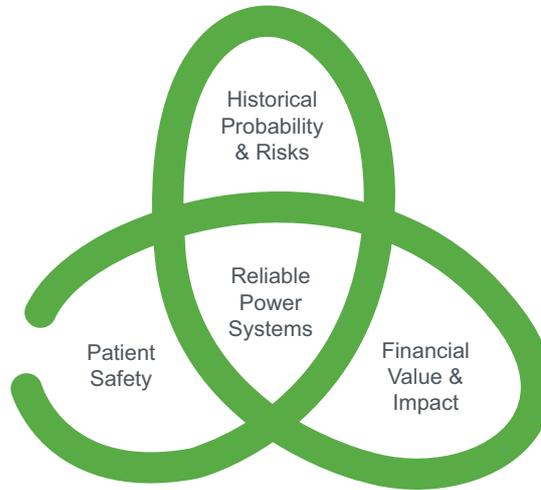
Capital investments in reliable power and monitoring systems and the supporting processes and methodology to take advantage of their characteristics can boost a healthcare facilities’ reputation, and improve revenue-per-patient and overall profitability dramatically. For any facilities with expansion completed or planned, older equipment and/or manual processes, should seriously consider upgrading their power infrastructure as per the recommendations outlined in this paper.



# Introduction

The purpose of this white paper is to investigate the value of reliable power distribution systems to the healthcare industry. In recent years, there has been a spate of high profile power grid failures, some due to nature and some man-made, that have highlighted the fragile state of the US power infrastructure. In any business, power reliability is a key component of emergency preparedness; in the hospital industry it is a factor critical to its success and livelihood. This paper discusses the value of those systems in terms of patient safety (lives saved and reduction of adverse events). Furthermore, this paper includes discussions of risk, the historical probability of an event occurring, and potential financial impact, as well as recommendations on how to mitigate these risks.

The information for this paper is derived from primary and secondary research, including interviews with financial officers and surveys with facility managers of US-based hospitals.



# Financial risk of power failures in hospitals

In 2003, New York City experienced a 16-hour power failure. One hundred twenty hospitals were impacted. As a result, one hospital was forced into bankruptcy and ten experienced subsequent significant revenue losses. Based on our research, 1 in 20 hospitals in the U.S. are not fully prepared for this type of event and an incident of this nature would result on average in greater than \$1 million revenue loss and other costs.

An extended power outage within a hospital can have a devastating impact on its financial standing. Without considering patient safety, and the liabilities associated with patient mortality or other injury, there is an immediate loss of revenues from the discontinuation of patient admissions and services. In addition to revenue loss, there are the unavoidable fixed costs regardless of the hospital's operability (like salaries, utilities, infrastructure costs, and so on) that the hospital continues to pay even when it is not generating revenue. Consensus amongst healthcare finance executives interviewed for this paper was that these unavoidable costs represented a minimum of 70% of revenues per day. Furthermore, they estimated that the subsequent decrease in annual revenues would be between 5% and 25%. If one takes into consideration a 5% chance of experiencing an outage, the financial exposure or risk due to a power outage<sup>1</sup> lasting 1 day is approximately 3.75% of annual revenues.

To estimate your specific financial exposure, enter your annual revenues into the simple equation below where (A) = your average annual revenues.

$((A / 365) + ((A / 365) * .7) + (.05A)) * .05 =$  estimated financial exposure to a power outage

*Between 2002 and 2008, there were 513 outages in the United States recorded by the Department of Energy, an average of 6 per month across the country. Eighty percent were due to weather (not including disasters), equipment failure, and capacity overloads. Of the facilities surveyed for this paper, 10% experienced extended power outages (longer than 4 hours) in the past 2 years.*

## Where:

(A / 365) is equivalent to a day's worth of revenues  
 ((A / 365) \* .7) is the unavoidable fixed and non-variable costs

(.05A) is the subsequent loss in annual revenues (to reflect the most conservative estimate we used a 5% reduction in annual revenues even though the estimates ranged from 5% to 25%)

(.05) is the probability of a hospital experiencing an elongated power outage during a 12-month period

<sup>1</sup> The 5% chance of an outage is based on direct survey results. The percent of survey respondents that experienced an extended outage within the last two years was 10% divided by two to reflect the probability of experiencing an outage in a 12 month period. However, it is recognized that this percentage is higher than typical industry published facts.

# Regulatory compliance

There are industry standards and government regulatory bodies that dictate the compliance obligations of hospitals regarding their power and back-up distribution systems. Standards may be found in the National Electric Code (NEC) and an important regulatory body is the National Fire Protection Association (NFPA).

Another regulatory body, the Joint Commission, provides online report cards about hospital performance (<http://www.jointcommission.org/AboutUs>). Their accreditation and certification is recognised nationally.

Meeting compliance requirements is a strong catalyst for hospital administrators to prioritize the attention given to their power distribution systems. As shown in figure 2, 94% of the survey respondents rated compliance as “important” to the hospital’s ability to maintain accreditation and other essential operations within their facilities. Moreover, 33% of respondents indicated that compliance was “very important”, and 29% deemed it as “critical.”

This sensitivity to compliance with regulations might be expected but does not necessarily explain the levels to which hospitals actually go to meet industry regulations and government legislation.

As we can see from figure 3, all survey participants indicated that their hospitals at least met compliance regulations. Interestingly, 70% of our respondents indicated that they either “exceeded” or “greatly exceeded” them. Perhaps the extra investment in compliance can be explained by the discovery that financial executives almost unilaterally held patient safety as their number one priority. Given this mind set, and the critical role that reliable power distribution plays in a hospital environment, added investment in compliance would make sense.

Although in general our survey group felt as though their hospitals exceeded compliance regulations, achieving this state was not realised without its challenges. For example, figure 4 shows five challenges in keeping the hospital power infrastructure compliant. The five biggest compliance challenges were identified as: capital budget allocation; the recognition by the business

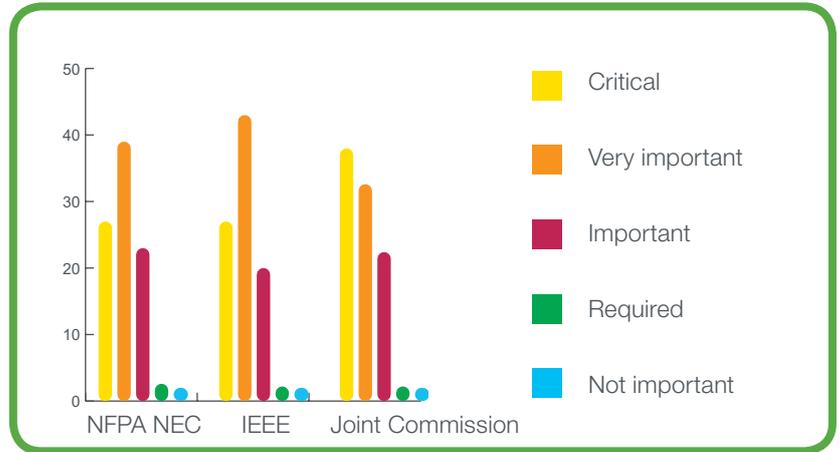


Figure 2. Sensitivity to regulations

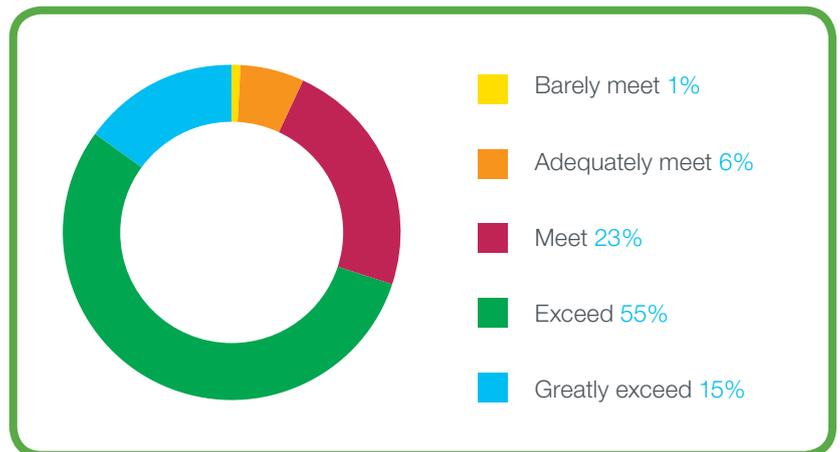


Figure 3. Level of compliance

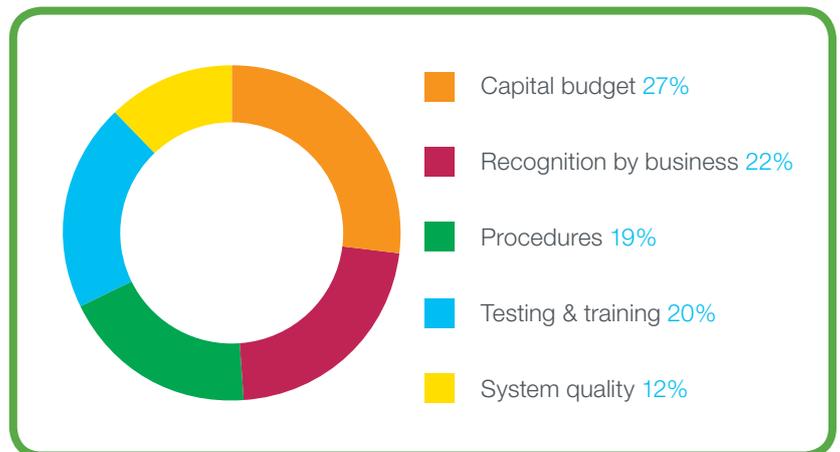


Figure 4. Biggest compliance challenges

or hospital that the power distribution infrastructure is critical to the hospital’s overall ability to serve patients; procedures that support compliance with regulation and legislation; testing of systems and training of hospital staff around emergency and power back-up scenarios; and system quality.

Emergency Power Supply System (EPSS) testing is an area that was acknowledged as particularly troublesome, as legislation such as NFPA 99 and NFPA 110 require mandatory testing, documenting, and audit traceability of testing results of EPSS. Results from our survey indicate that a substantial portion of our participants manually test their EPSS for compliance. This fact is supported by the result highlighted in figure 5 where the most frequently used plan to mitigate the challenges represented by meeting compliance was staff augmentation. Although suitable for most situations, the challenge with comprehensive manual tests is that effectively measuring results is difficult and coordination is a nightmare. Furthermore manual testing practices require involvement from multiple stakeholders within the hospital, including medical, facility, and hospital administration. In short, manual testing of EPSS is costly and inefficient.

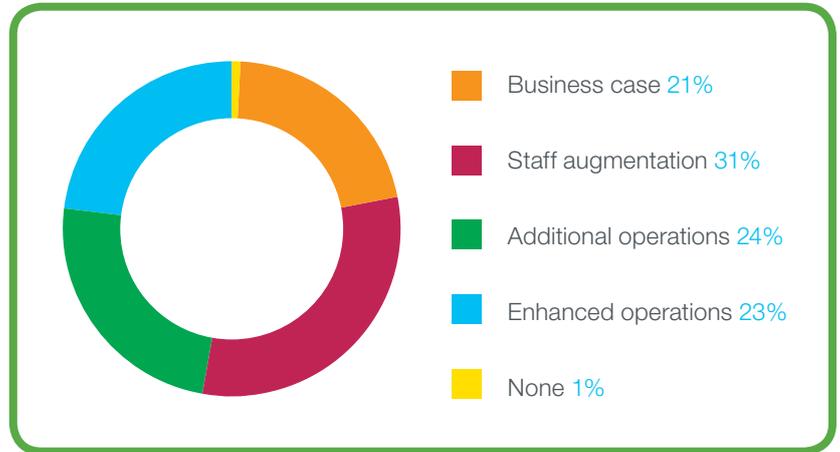


Figure 5. Overcoming compliance challenges

# Hospital power systems and processes

Traditionally, emergency systems have been designed based on code requirements defined in NEC 700 and NFPA 110. As the market has migrated to embrace “defend-in-place” operational practices, new codes have emerged to provide increased guidance for designing critical operation power systems (COPS). This new section of the National Electric Code (NEC 708) attempts to focus more effort on designing high-reliability solutions suitable for extended operation.

The survey results illustrate that a variety of situations exist in today’s environment. The age and type of equipment in place vary widely. On average, standby generators were 9 years old, auto switching equipment over 6 years old, and other configurations over 5 years. All of the surveyed hospitals have either one or multiple standby generators; two-thirds have auto-switching with far fewer (23%) having redundant power sources.

The survey results illustrate the various approaches to providing and maintaining power in a hospital. Urban hospitals and major medical centres rely on high-reliability designs using redundant generator configurations. These configurations rely on multiple large-capacity generators connected together through a switchgear configuration. Though highly reliable, this traditional implementation comes with a complexity and cost that limits its use in smaller hospital applications. These smaller applications often use a single emergency generator, or two isolated generators with a limited cross power capability.

When designing back-up power systems, multiple power topologies need to be considered. There are three basic topology choices:

- Single generator
- 2N fully-redundant configuration
- Paralleled generation where two independent commercial power sources are brought into the facility.

Besides the specific equipment, the age of that equipment also needs consideration (figure 6). Unless carefully maintained, the diesel fuel for generators can gradually degrade equipment. Methods and procedures to treat fuel and maintain equipment need to be in place.

Uninterruptible power supplies can also be installed as part of the back-up power system, either individually on each piece of critical equipment or as a centralised function. Using a UPS ensures that there is a smooth power “ride-through” during any power event that requires switching to back-up generation by providing a temporary (battery) power source that can fill in the small gaps that can occur between the loss of utility power and the full functioning of back-up generation.

Additionally, circuit breaker coordination must be carefully managed during initial design phase and as the electrical distribution system grows, to ensure that breakers react appropriately. When coordination is not set appropriately, one of two things can happen:

- There is no trip when there should be a trip, creating a fire hazard.
- A trip occurs at a higher point in the breaker hierarchy than is necessary, causing a bigger outage than is required to neutralise whatever hazard caused the trip in the first place.

<sup>1</sup>For description of “defend-in-place operational practices” please refer to the Appendix

# Mitigation strategies

NEC Article 708 is driving a greater focus on reliability of healthcare services. Within the healthcare industry, especially at acute care hospital sites, back-up power system design and failure mode operating philosophies are critical. One healthcare company has used reliability as a differentiator in the marketplace. With multiple generators installed in the N+1 configuration, redundancy is built-in and reliability is increased because each generator backs up the other. (“N+1” means that if N equals the back-up power assets required to carry the essential load of the facility, an additional asset (“+1”) is added for redundancy.) The resulting gains in reliability for the critical loads are significant. For example, if a standby generator has a reliability of 98%, an N+1 configuration has a reliability of 99.96%, and an N+2 configuration has a reliability of five nines (99.999%), which in real time amounts to about 5.26 minutes of downtime per year.

Though catastrophic failures of standby generators are not common, multiple generator solutions significantly mitigate the effects of such an event. The inherent redundancy of the system ensures back-up power even during equipment failure. When implementing integrated paralleling solutions with small generators, reliability is secured through proper application. Enhancing multiple generator solutions with automated switching gear can increase and improve a facility's ability to switch over with little or no loss of services. With the ever growing presence of computer-aided equipment, the need to provide emergency power more widely increases.

In addition to the equipment itself, today's hospital environment presents comprehensive manual testing situations that are difficult to coordinate with results that are hard to measure. Medical and facility personnel, and the hospital administration need to be involved, making manual testing of EPS systems costly and inefficient. Back-up generation also fails in some cases due to insufficient testing and maintenance. Poorly run tests can also create problems: “wet stacking” can occur, where unburnt fuel or carbon builds up in the exhaust system when generator run times are too short or the test is performed outside recommended operating parameters.

Automating the testing process can eliminate these issues and require less participation from staff while also ensuring regulatory compliance. Industry solutions that offer monitoring and automated testing including safety documentation can relieve the staff burden and also more efficiently handle the ongoing facility upgrades typically incurred.

# Safety & security

In 2007, Tisch Hospital in New York City experienced a 3-hour power outage. Among other limitations, the back-up power powered only one elevator in the 730-bed acute-care general hospital, severely limiting the hospital's ability to provide safe and secure patient care. Paramount for any healthcare facility is the safety and security of the patients. Not only to ensure patient health, but also to ensure that the facility is recognised as one distinguished by its performance. A poor reputation would ultimately affect their bottom line income, and unless the facility has a geographic monopoly, potential patients would seek services elsewhere.

In the healthcare industry, the Joint Commission (a 501(c) not-for-profit organization) provides meaningful information about the performance of Joint Commission-accredited organizations to the public. There are organization-specific performance/quality reports, published since 1994.

The report provides useful summary information about the quality and safety of Joint Commission accredited organizations. Reports are created at the organization level, and provide national and state information that can be compared against locally accredited organizations.

The Joint Commission also lists organizations not accredited by its standards, although no performance/quality reports are available for these organizations.

# Power supply issues and standards

All of the healthcare facilities polled use back-up generators to ensure an uninterrupted power supply; a third have multiple generators to further ensure a steady power supply. In addition, two thirds have implemented auto switching technology to avoid any delays in cutover due to slower manual processes. A quarter of the facilities also utilise redundant power sources; in the event one public utility fails, alternate sources are available. In many areas of the country this option is not available; the local utilities have geographic monopolies regarding the power grid, so this safety consideration cannot be used. In some cases, larger facilities have built or are in the process of building their own power plants. Despite the power supply contingencies, facility managers are still concerned with their equipment. As figure 6 illustrates, 41% of the facility managers surveyed thought the standby generators were the most likely point of first failure. The back-up power equipment varied in age and complexity; manager's concerns correlated to the age of the equipment.

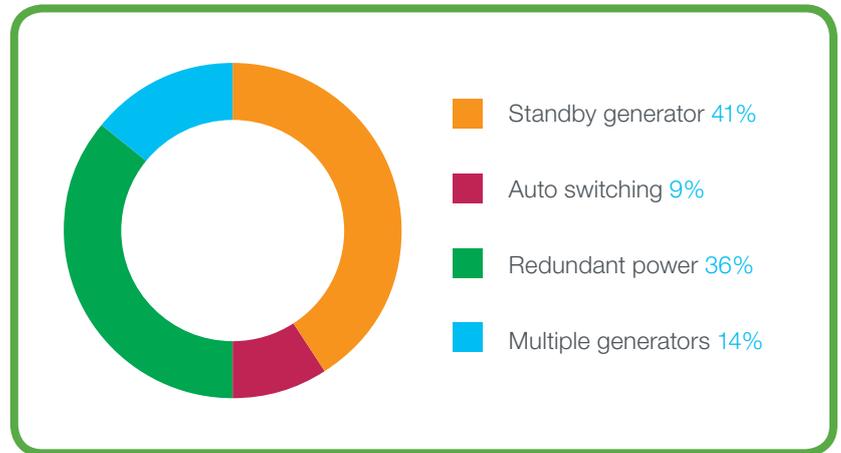


Figure 6. Systems most likely to fail

# Business costs

Several different scales were used to estimate the business impact of power outages. When facility managers were asked to estimate the financial impact of a power outage, their average response was \$900,000 per event<sup>3</sup>. The financial experts were asked to estimate the cost if their facility was down an entire day. They were also asked about the potential impact if occasional power interruptions were endemic to the facility.

Current statistics for the industry place \$8,500 as the average value of a hospital admission in 2009. The financial people we interviewed were quick to point out that number. While relatively accurate for most facilities, it only represents a small portion of the estimated impact. Besides lost or delayed revenue to the hospital, and all other professional services offered at the facility, there are numerous fixed, operational costs that would still be incurred. On average, the financial experts estimated a daily impact of \$700,000 to \$4 million per day depending on the size of the hospital.

The hurdle to upgrading primarily lies in convincing the governing boards that the need exists.

As shown in figure 7, surveyed facility managers listed quantifying risk as the predominate barrier to new investment. There are always other needs for available funds, so justifying additional power systems only becomes apparent when problems occur.

When asked what projects they would fund first were the money available, automatic switching rose to the top of their lists (figure 8). The estimated investment, based on hospital size, is between \$700,000 and \$2.5 million, near the value of one day's outage in these facilities. With typical margins at 4%, the risk/reward ratio in investing would seem to be significant.

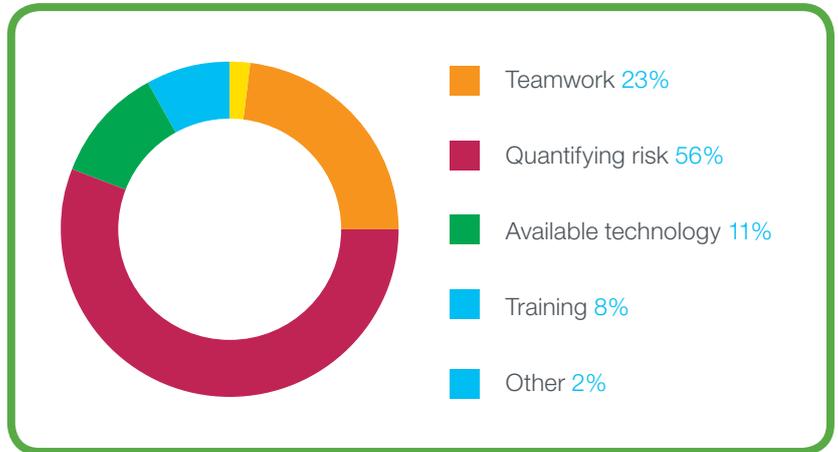


Figure 7. Primary barriers to investment

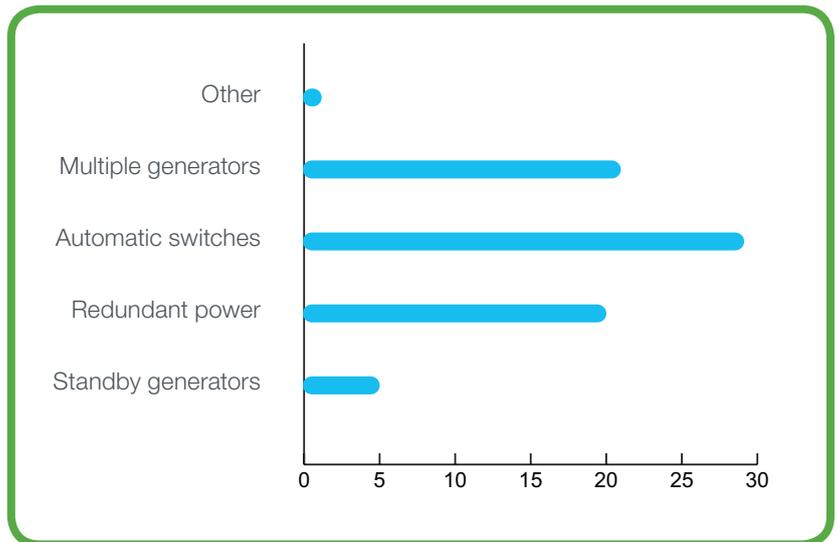


Figure 8. Project to fund

<sup>3</sup> Variation in response between financial executives and facility managers was observed in the survey, in part because financial executives take a wider view of the costs, and because they are estimating costs per day while facility managers tend to estimate costs by event rather than by day. Also, in our survey, the financial executives typically worked at larger hospitals than the facility managers interviewed.

# Recommendations

Given the challenges uncovered during the research conducted for this white paper, there are key recommendations that can be made to optimise the power distribution system and back-up generation assets of a healthcare facility, to support operational efficiency and minimise the impact of power events and outages on the hospital's function and finances.

Recommendations include:

- Cohesive electrical/power distribution architecture:** In new hospitals, the architecture can be designed to be energy efficient and cost-effective for today's hospital, while still flexible enough to accommodate future growth. In existing hospital facilities, a thorough audit and documentation of the existing system will help to identify possible issues and areas for improvement before a crisis occurs.
- Full coordination studies:** When power issues occur, circuit breaker coordination is a key element in ensuring that the system reacts appropriately; if coordination is not set appropriately, a small issue can become a major outage.
- Adequately sized and redundant back-up generation assets:** Ensuring that an appropriate amount of electrical power is available in case of a utility failure is key to true power reliability. Depending on the facility's configuration, this could require N+1 or N2 coverage for all electrical loads, or for some portion thereof, depending on criticality.
- Automated EPSS testing scheme:** As discussed, adequate testing of a facility's back-up power system is a critical element in ensuring its optimal operation when a crisis occurs. By automating the system, facility managers can rest assured that the tests are truly an effective measure of the system's ability to react effectively, without creating headaches for other members of the hospital staff. As well, an automated testing system can ease the regulatory burden of generating reports to demonstrate compliance to standards.
- Uninterruptible power supplies (UPS):** By installing UPSs on critical equipment, or centralised as part of the overall EPSS system, hospital facility managers can ensure that patients and medical staff are never impacted by a power event.
- Regular proactive and preventative maintenance on the entire electrical distribution system:** Healthcare facilities are continually challenged financially and selecting the right balance for critical maintenance is extremely important. Having the necessary system visibility to allocate where and when this maintenance budget is spent offers significant advantages to the facility especially if this analysis is based on historical electrical distribution characteristics, prior events and previous maintenance.

# Conclusions

Healthcare facilities are constantly expanding and buildings are reconfigured to add equipment and services to accommodate new patient needs. At the same time, their competitive edge is becoming increasingly dependent on modern technology, resulting in more complex systems. That combination makes it more difficult and costly to provide stable power systems with manual emergency procedures involving medical, facility and administrative personnel.

The financial risk for hospitals is too great to allow power systems to be a potential problem source. Organizations should consider the use of outside consulting services to perform an objective risk assessment on their power infrastructure, in order to build a business case for a risk mitigation strategy. They should also leverage an expert firm to assess process and update any operating procedures to address the issues uncovered during the review.

An approach to ensure safe and secure systems should include:

- Raise the level of staff attention and focus on potential sources of errors/adverse events with leadership focus
- Develop manual procedures to prevent individual errors – and audits to ensure compliance
- Root cause analysis and development of systematic approaches to avoid errors
- Implement automated facility systems that accomplish both error prevention and alerts to enforce compliance (built on the model of care, organizational processes, and environmental stressors in a systems approach)
- Implement the electrical distribution system modifications described in the Recommendations section above.

As with the assessment process, hospitals can benefit greatly from the expertise of companies that specialise in electrical distribution and energy management technologies, such as Schneider Electric, the world leader in energy management. Sourcing all electrical distribution system components from a single supplier can increase overall reliability and improve supplier responsiveness in case of issues or failures, as well as providing facility managers with a ready source of expertise and experienced personnel to help solve challenges.

# Appendix: Evacuation or defend-in-place

The two basic occupant-protection strategies are evacuation — either total or staged — and defend-in-place. Determining which strategy is most appropriate depends on a variety of factors, including the type of incident, the occupants' evacuation capabilities, how the building is constructed, and the presence of fire protection and other life safety systems.

Total evacuation is relatively straightforward: an alarm sounds, or other means of emergency notification is activated, and all building occupants simultaneously exit the building.

Staged evacuation is a bit more complicated. Where staged evacuation is used, the location of the fire or other incident in the building is identified, and only those occupants who might be immediately threatened are notified to leave the building. The remaining occupants are typically notified that an emergency has been reported in the building and they are to await further instructions.

Staged evacuation is commonly used in high-rise buildings. An advantage of staged evacuation is that only those occupants in immediate danger are directed to use the exit stairs. With fewer people in the stairs, occupants can exit more quickly, yielding shorter queues at the stair entrances. Staged evacuation requires continuous monitoring of the incident to determine if the evacuation of additional occupants will be necessary. The fire department or other public emergency response agency will usually make this determination.

Both total- and staged-evacuation approaches assume the fire or other emergency is located within the building. Both strategies also assume the occupants are physically able to get out of the building without assistance.

That isn't always the case. Consider, for example, a hospital where patients are confined to their beds. In addition to being unable to evacuate, many patients might be attached to life-sustaining

equipment, and their removal from the building might put them in grave danger. For these reasons, hospitals are designed to accommodate the defend-in-place strategy, whereby occupants are relocated to a safe location on the same floor rather than being evacuated. The safe locations are created by subdividing the floors of the building into two or more smoke compartments or fire compartments, separated by specially constructed walls designed to limit the transfer of smoke or restrict the spread of fire from one side to the other.

Another example of where the defend-in-place strategy might be more appropriate than evacuation is during a weather emergency, such as a tornado. Occupants will likely be safer if moved to a protected location, away from windows, inside the building rather than outside. An area such as the building core — typically the centre of the building where elevators are commonly located — or a basement level might be considered a safe location for such an event. While this might seem like common sense, it's important to document the appropriate actions for various emergency scenarios and, more importantly, to practice them on a regular basis.

# About the authors

## About Schneider Electric

As a global specialist in energy management with operations in more than 100 countries, Schneider Electric offers integrated solutions across multiple market segments, including leadership positions in energy and infrastructure, industrial processes, building automation, and data centres/networks, as well as a broad presence in residential applications. Focused on making energy safe, reliable, and efficient, the company's 100,000 plus employees achieved sales of 15.8 billion euros in 2009, through an active commitment to help individuals and organizations "Make the most of their energy".

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