Planning for Power Failures

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Introduction

Without power healthcare facilities are extremely vulnerable, especially if it is for an extended period of time. Every healthcare facility needs to have a plan in place and be prepared since there is rarely a warning before loss of power except in cases where a slow-moving hurricane or similar natural disaster is approaching.

The purpose of this paper is to offer recommendations and examples of effective power failure planning concepts, including gap analyses, emergency power risk assessments, commentary and recommendations on power failure vulnerability analyses, and other tools to improve readiness for power failures.

This paper also offers several dozen emergency management tracer-type questions on power failures to enable a healthcare organization to test its own readiness. These sample tracer-type questions address the issues discussed in this paper and in the following statement.

> "Reliability and facility infrastructure health are not guaranteed simply by investing in and installing new equipment. Unexpected failures can compromise even the most robust facility infrastructure if appropriate testing, maintenance and due diligence techniques are not employed." [1]

This paper contains references to three excellent documents from the financial business continuity sector. Readers interested in business continuity and power system reliability should review these documents in their entirety. All three are easily available via the listed websites.

Emergency Power Gap Analyses

What is a gap analysis?

Quite simplistically, a gap analysis is a process for change. It enables the user to determine what changes are needed or wanted, and then it facilitates the process of getting there. A gap analysis asks and then requires that the user answer the following questions:

1. Where are we now?
2. Where do we want to be?
3. What do we need to do to get there?

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[1] Reprinted from the "BITS Guide to Business-Critical Power" with permission, published September 2006 by the BITS Financial Service Roundtable, Washington, DC. www.bitsinfo.org.

4. How do we do this?

An emergency power (EP) gap analysis asks the following questions:

1. What is connected to EP now?
2. What else needs to be connected to EP?
3. What should we do in the short term, and how do we get there in the long term?

A gap analysis can also be used to address the results of a power system vulnerability analysis:

1. How vulnerable is my EP [or normal power] system to failures?
    a. Where are my vulnerabilities, and to what types of postulated failures?
    b. What vulnerabilities do I want to eliminate?
    c. What do I need to do to eliminate or reduce those vulnerabilities?
    d. How do I do that?

Gap Analysis Strategy for Power Failures

A detailed gap analysis strategy for power failures might look like the following. There are parallels with a power failure vulnerability analysis since the two analyses are complementary.

- Define the concerns, policies, urgency, data needed, and metrics. Are we concerned about external disasters or internal disasters, or both? Are we concerned about full power loss, partial power loss, or some combination of those? What needs to continue operating? What codes, standards, and policies apply? Are there areas where the organization desires operational flexibility beyond what is presently required by codes?
- Assess current situation. This activity requires load lists and power source identification for all loads of interest. Another helpful approach is to review the last several power shutdowns and look at the temporary wiring that was needed. This assessment will usually identify areas, services, and loads that needed to continue operating even when the power was no longer available. Another helpful approach is to look at the lessons learned from actual power outages, whether caused by external or internal events. The lessons learned by the organization itself and also by others are both instructive. [2]
- Analyze data; summarize gaps. This analysis will look at equipment (clinical, support services, and infrastructure) and systems (mechanical, electrical, etc.). It will also consider specific areas and the power systems that serve those areas.
- Develop recommended actions. The recommended actions for a power system gap analysis might involve additional generation, distribution, modifications to existing systems, and power failure procedures to address infrastructure gaps. The recommended actions will also include assessing the funding needs and avenues for acquiring the necessary funding.
- Brainstorm strategies to bridge gaps and recommendations. A typical brainstorming session could include a group of clinical and facilities stakeholders who consider specific clinical services or areas, and then look at what options there are for dealing with power failures occurring *right now* affecting those services or areas. The brainstorming session

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[2] Stymiest, David L., *Managing Hospital Emergency Power Systems: Testing, Operation and Maintenance*, American Society of Healthcare Engineering (ASHE) Management Monograph, July 2006. www.ashe.org.

does not reject any ideas. Rather, it just records them for later consideration and ranking. A brainstorming session to discuss an infrastructure issue (such as one generator with radial distribution serving a critical service or area) could start with postulating a generator or distribution riser failure that occurs *right now* and what options there are in the short term to address that failure. Further brainstorming can than address what options there are for long term improvements to mitigate the effects of, or protect against, future failures of that type.

- Determine best options (short and long term). Once the brainstorming sessions are completed and all possible options have been identified, the consideration, analysis, and ranking of preferred approaches can occur.
- Develop action plans. Action plans include clinical procedures for power failures that document the best course of action developed for the *right now* analysis. They might also include acquiring new generating capacity or contracting for rental generators. These action plans should be as specific as possible (how portable generators will be wired into a power system safely, and then removed safely later.) All stakeholders need to participate in action plans or there will be difficulty in getting them implemented.
- Implement action plans. This could necessitate acquiring more funding if infrastructure improvements are required, even in the short term.

Gap Analysis of Supplied Services

When there are supplied services of a critical nature (fuel oil deliveries if the existing onsite storage is deemed inadequate in the short term, for example) the facility manager (FM) needs to understand any vulnerability in that supplied service. The FM's contingency plan should begin where the service provider's crisis management capabilities end.

Power System Vulnerability Analyses and Risk Assessments

Power system risk assessments and vulnerability analyses consider events that can cause internal power failures and their probabilities. They also consider the potential for common mode failures. Risk elements considered include business and staff impacts and disruption to health care. Other elements are preparedness, the cascade impact of electrical failures on other utilities (such as ventilation of cooling,) and mitigation of the effects of power system failures.

Discussion with Electrical Utility

The Joint Commission's Sentinel Event Alert No. 37 suggested that health care organizations have a discussion with the electrical utility serving their facilities to probe areas of power supply vulnerability. The following list is an excerpted and modified version from a comprehensive list of questions developed for the financial community and published in an excellent resource guide by SIFMA, formerly SIA. It can be a good start for the health care organization in developing its own list of discussion points. [3]

- How many distribution feeders serve this area?
- Can you run alternate supply lines?

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[3] Excerpted with permission from "Business Continuity Planning Critical Infrastructure Guide" published February 2007 by Securities Industry and Financial Markets Association (SIFMA), formerly The Securities Industry Association (SIA). www.sifma.org/services/business_continuity/pdf/SIFMA_BCP_Infrastructure_2-07.pdf.

- Can these alternate lines come into another service point?
- What built-in redundancies do you have?
- How do you advise of service disruptions?
- How comprehensive are your contingency plans?
- What are your restoration time objectives?
- Does my service originate from a single source?
- What generation/distribution backups are there?
- What partnerships do you have with other utilities?
- What restoration priority is my facility? What is above us?
- Will you pass along info regarding scope and expected duration of service interruptions?

Power Failure Vulnerability Analysis

Timothy Adams' 2007 ASHE Management Monograph contains an excellent approach to conducting an emergency power vulnerability analysis. [4] It can also be used to conduct a normal power failure vulnerability analysis as well. The spreadsheets provided with that monograph have been modified slightly for this presentation.

Before a vulnerability analysis is conducted, it is necessary to fully understand and classify facility areas, loads, and infrastructure systems as to their criticality to patient safety and the health care organization's needs for business continuity. The critical load lists in NFPA 99, Article 517 of NFPA 70, and The Joint Commission's Sentinel Event Alert No. 37 provide a good starting point, but any hospital FM who has conducted scheduled power shutdowns realizes that there can be a number of areas, loads, and infrastructure systems not listed in those documents that the organization considers essential to its business continuity and that require backup power supply. Risk assessments and gap analyses will be useful in this effort.

The ASHE vulnerability analysis approach is highly recommended, and includes consideration of the following attributes and their contribution to power failure vulnerability:

- Infrastructure – This category considers infrastructure system features, components, condition, locations, operating flexibility, spares, and maintenance histories. It should consider the vulnerabilities to disruption of electrical utility services, normal power distribution to the transfer switches, the transfer switches themselves, and their load feeders (Essential System branches) and distribution. Additional analysis includes the EP system documentation, labeling, failure procedures, test results, and training.
- Power Sources – Once the mechanical systems, facility areas, and clinical services have been identified in a spreadsheet with both their normal and emergency power sources, I recommend sorting the data by each power train (by each generator, each switchboard, each transfer switch, etc.) This type of data sorting will highlight mechanical systems, groups of facility areas, and groups of clinical services where single equipment failures or single wiring/feeder failures can take down redundant mechanical systems, intended backup facility areas, or intended backup clinical services. This analysis is a *common mode power failure vulnerability analysis*.

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[4] "Performing an Emergency Power Systems Hazard Vulnerability Analysis", Timothy Adams, ASHE Management Monograph, January 2007, www.ashe.org.

- Areas – For each of the functional areas investigated, look for higher power failure vulnerabilities from the infrastructure analysis, such as with less reliable equipment, poorer documentation, lack of power failure procedures or training, a poor shutdown and electrical equipment maintenance history, etc.
- Clinical – The degree of clinical preparation was well addressed by Reference 2 and also by The Joint Commission's Sentinel Event Alert 37. Clinical analyses and the training of clinical personnel should consider each of the following types of failures:
    - Extended loss of normal power with EP available
    - Extended loss of EP in specific areas [see Area analysis above] with normal power available
    - Loss of both normal power and EP.

Emergency Power Risk Assessments

The Joint Commission's risk assessment process includes 7 steps outlined below, along with commentary as to how they can be applied to power system failure risks.

1. Identify the issue – The issue being considered might be that a single generator with a radial distribution system is adequate to provide EP to a clinical area.
2. Develop arguments for that issue – The normal power system serving the area has an excellent operational history, the normal power system has regular shutdowns for maintenance, clinical and facility management action plans developed in support of those shutdowns work well, and there are backup areas served by another building's normal power system and generator.
3. Develop arguments against that issue – The emergency power system (such as the critical branch serving the wing that houses the area being assessed) has never been shut down for full maintenance, or the ongoing thermographic scanning in recent years has shown an increasing incidence of hot spots requiring quickly scheduled localized outages for tightening of cable lugs.
4. Objectively evaluate both arguments – This is perhaps the most difficult part of the risk assessment, but also the most important part. Leave preconceptions at the door.
5. Reach a conclusion – More comprehensive system failure procedures and training are warranted, or the emergency power system's critical branch with the more frequently occurring cable lugs must be scheduled for annual shutdowns and maintenance.
6. Document the process – This is straightforward.
7. Monitor and reassess the conclusion to ensure it is the best decision – This requires good follow-up to make sure that the actions taken did indeed have positive results.

Only one issue was discussed in the example above, but the discussion on each point can provide a starting point for the FM who needs to do his or her own power failure risk assessments. Another issue often faced by health care organizations would be whether a single normal power distribution path is adequate for an existing mechanical system, as opposed to providing EP to it.

Tier Classifications [5]

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[5] Excerpts in this section have been reprinted with permission from The Uptime Institute white paper titled "Tier Classifications Define Site Infrastructure Performance" available from www.uptimeinstitute.org.

Power system risk assessments help to determine how robust the power system infrastructure is. It is helpful for the healthcare community to look at the huge amount of work that has already been done by the financial services community, which has been looking in detail at power system failure risks and power system reliability for many years.

The Uptime Institute's infrastructure tier classifications were developed for all elements of a facility's infrastructure, not just power systems. In this paper we are only looking at power systems, and simplistically at that. The tier classifications with abbreviated descriptions are:

- Tier I, Basic: This tier is probably the most common tier presently in healthcare facilities. It uses non-redundant capacity components and single non-redundant distribution paths. Maintenance requires load interruption. Examples include a single generator and a single critical branch providing emergency power to a critical care area, for example. Maintenance of the critical branch panelboard requires an interruption of power to the red receptacles in the patient care unit served by that panelboard.
- Tier II, Redundant Capacity Components: This tier includes redundant capacity components (two paralleled generators where one will carry the entire EP load) and single non-redundant distribution paths (again one critical branch serving a patient care unit.) Maintenance again requires load interruption.
- Tier III, Concurrently Maintainable: This tier uses redundant capacity components as in Tier II and multiple distribution paths, 1 active and 1 spare. An example could be paralleled generators with two separate critical branches serving an O.R.
- Tier IV, Fault Tolerant: This tier is unlikely in patient care areas, but might be found in the most modern data centers. It involves redundant capacity components and multiple distribution paths in use at the same time. The loads will survive the worst case postulated event or any single failure, and maintenance is possible without any load interruption.

Emergency Management Tracer-Type Questions for Power Failures

The following emergency management tracer-type questions are offered to enable health care organizations to test their own readiness for power failures.

- During shift with monthly testing
    - Find personnel recently transferred from another shift: ask about their understanding of EP tests
- How does this equipment react to a power outage? How do you know that?
- Do these (2) (3) makes of equipment react differently to power outages? Explain.
- Uninterruptible power supplies (UPS's)
    - What maintenance is performed on this UPS?
    - How often are batteries (checked) (changed)?
    - Has UPS failure occurred in the past ___ months? Why?
- Do you have normal power maintenance shutdowns?
    - Is there temporary wiring during shutdowns?
    - Where is this documented?

    - Is this included in an EP gap analysis?
- If no, how/when is power system maintained?
    - How do you know that all required equipment is on EP?
- What is your EP loading during a weather event that also causes a working fire in ___?
    - How do you know that?
    - When was your EP loading last measured?
    - What time of day is your peak EP loading?
- What happens in this area if the normal utility power fails?
    - What is on emergency power?
    - What is not on emergency power?
    - What did your EP gap analysis find?
    - What will you do about that?
- What happens in this (critical care) area if the emergency power critical branch fails?
    - How do you know that?
    - What is hard-wired to emergency power?
    - What will you do about that?
    - How long will that take?
- What will you do if this generator fails?
    - Is there a procedure for this?
    - How long will that take?
    - Where will portable generator be connected?
    - How will portable generator be tied into existing ATS engine start circuit?
    - How will portable generator get fuel oil for needed time?
    - Does portable generator location have exhaust issues with existing air intakes?
- What happens if this equipment system (MCC) (distribution panel) (feeder) fails?
    - What will you do about it?
    - Do affected clinical personnel know what to do?
    - Have you practiced this scenario? When?
    - Do you have a procedure for that?
- When the (cooling) (ventilation) (medical vacuum) (pressurization) in this area fails, what do you do?
- What will you do if this ATS fails?
    - Is there a procedure for this failure?
    - How long will that take?
- What will you do if this paralleling switchgear fails?
    - Is there a procedure for this failure?
    - How long will that take?
- What ATS and feeder provide power to (telecom switch) (patient data server)?
    - What will you do if it fails?
    - How long will that take?

Example of Emergency Power Gap Analysis – Emergency Power Supply System

CURRENT STATE	DESIRED STATE	GAP (NEXT ACTIONS)		DATE FIXED & VERIFIED
		SHORT TERM	LONG TERM	
Generator 1 is a single point of failure	Backup generation capability in the event of Gen 1 failure	Establish rental agreement for portable generator, wire existing system into exterior connection box located in secure area	Provide additional generation capacity	
Critical branch (load side of transfer switch to panels) is not maintained regularly	Regular maintenance outages are also used by clinical staff as practice drills for possible branch failures	Use thermographic scanning regularly while planning first branch outage	Establish critical branch master plan that allows for maintenance outages	

Example of Emergency Power Gap Analysis – Essential and Optional Loads

CURRENT STATE	DESIRED STATE	GAP (NEXT ACTIONS)		DATE FIXED & VERIFIED
		SHORT TERM	LONG TERM	
Only limited cooling is connected to generator, generator has insufficient spare capacity	Sufficient cooling with generator backup to sustain essential facility operations during extended power blackout	Arrange rental agreement for portable generator, wire existing chiller plant and auxiliaries into exterior connection box located in secure area	Acquire additional generation capability or portable generation	

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