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Modernization of Emergency Power Systems in NIH Facilities Part I: Hybrid Technologies and Their Role in Critical Power Systems

Introduction

Reliable emergency power is essential for the National Institutes of Health (NIH), where electrical outages can interrupt patient care, disrupt biomedical research, and compromise critical facility operations. Diesel generator-based emergency power supply systems (EPSS) have long been the foundation of emergency power because they provide dependable, long-duration backup during utility outages. These systems are the primary means of satisfying code-mandated requirements for emergency systems and legally required standby systems under NEC Articles 700 and 701, and for critical operations power systems (COPS) where Article 708 applies. At NIH, they must also comply with NFPA 99, NFPA 110, the NIH *Design Requirements Manual* (*DRM*), and Authority Having Jurisdiction (AHJ) requirements.

Advances in battery energy storage systems (BESS), fuel cells, renewable energy resources, and intelligent energy management systems are expanding the capabilities of conventional emergency power systems. Rather than replacing diesel generators, these technologies improve resiliency, power quality, and operational flexibility while preserving the reliability of the code-required EPSS.

The Hybrid Emergency Power Concept

A hybrid emergency power system combines the traditional diesel generator-based EPSS with one or more supplemental energy technologies coordinated through intelligent controls. The objective is to enhance system performance while preserving the reliability and code compliance of the conventional emergency power system.

Unlike traditional backup systems that simply restore power after an outage, hybrid systems address a broader set of operational needs. Sensitive laboratory equipment, imaging systems, environmental chambers, freezer farms, communications networks, and building automation systems are vulnerable to even brief interruptions and power-quality disturbances. Hybrid technologies protect these loads by providing improved ride-through and power quality, and they further strengthen campus-wide resiliency by reducing generator cycling, improving voltage stability, and enabling microgrid operation.

Common Hybrid System Architectures

Several hybrid architectures are being adopted for healthcare and research facilities. One common configuration installs a BESS on the load side of the automatic transfer switch to bridge the brief interval between utility failure and generator startup. Another operates the battery system in parallel with the diesel generator to provide transient support, voltage regulation, and load leveling, subject to appropriate synchronization, protection, and fail-safe design. Fuel cells may also supplement emergency power where lower-emission operation is desirable, provided that fuel supply, startup characteristics, ventilation, and fire protection requirements are adequately addressed.

At the campus level, microgrids integrate diesel generators, BESS, and renewable energy resources through a central controller, allowing facilities to optimize energy use during normal operation while improving resiliency during utility outages.

Technology Capabilities

Each supplemental technology addresses a different operational need and has its own considerations for implementation.

BESSs provide nearly instantaneous response, making them well suited for ride-through applications, transient load support, power quality improvement, and short-duration backup. Their effective runtime depends on available stored energy, state of charge, discharge rate, and load profile. Commercial installations are commonly designed for two to four hours of operation at rated output. Fuel cells offer lower-emission backup power for extended durations when supported by an adequate fuel supply. Because they require startup time, uninterrupted operation typically requires coordination with a UPS or BESS.

Renewable energy resources, particularly solar photovoltaic and wind systems, improve sustainability and support microgrid operation. However, their output is intermittent and cannot be dispatched on demand, making them unsuitable as the sole emergency power source for critical NIH facilities.

Applications for NIH Facilities

Hybrid technologies provide the greatest value when applied to specific operational objectives rather than as universal replacements for diesel generators. Appropriate applications include support for laboratory instrumentation, imaging equipment, communications systems, freezer farms, building automation systems, and campus microgrids. They can also reduce unnecessary generator cycling during testing and lightly loaded operation, improving overall system efficiency. Although hybrid technologies offer significant operational benefits, they should generally be considered resiliency enhancements rather than replacements for conventional diesel generators. This distinction reflects the extended-runtime requirements placed on NIH emergency power: the NIH *DRM* requires onsite generator fuel storage sufficient for at least 24 hours of continuous operation at the Bethesda campus and generally recommends a minimum of 48 hours at other locations. Because current commercial battery systems are well suited to short-duration applications but cannot sustain critical loads over outages of this length, they supplement diesel generators rather than replace them.

Conclusion

Hybrid emergency power systems represent a practical evolution of conventional emergency power infrastructure. By integrating BESSs, fuel cells, renewable energy resources, and intelligent controls with conventional diesel generators, healthcare and research facilities can improve resiliency, power quality, and operational flexibility while maintaining compliance with established emergency power requirements.

Part 2 of this series will examine the engineering considerations necessary for successful implementation, including battery technology selection, installation safety, system integration, commissioning, and code compliance.

Further Reading

1. Centers for Medicare & Medicaid Services. *Emergency Preparedness Requirements for Medicare and Medicaid Participating Providers and Suppliers*, 42 CFR Parts 482, 483, et al.
2. Institute of Electrical and Electronics Engineers. *IEEE 1547: Standard for Interconnection and Interoperability of Distributed Energy Resources with Associated Electric Power Systems Interfaces*. New York, NY.
3. Institute of Electrical and Electronics Engineers. *IEEE 2030.7: Standard for the Specification of Microgrid Controllers*. New York, NY.
4. National Fire Protection Association. *NFPA 70: National Electrical Code*, including Articles 700 (Emergency Systems), 701 (Legally Required Standby Systems), 702 (Optional Standby Systems), and 708 (Critical Operations Power Systems). Quincy, MA.
5. National Fire Protection Association. *NFPA 99: Health Care Facilities Code*. Quincy, MA.
6. National Fire Protection Association. *NFPA 110: Standard for Emergency and Standby Power Systems*. Quincy, MA.
7. National Fire Protection Association. *NFPA 111: Standard on Stored Electrical Energy Emergency and Standby Power Systems*. Quincy, MA.
8. National Fire Protection Association. *NFPA 855: Standard for the Installation of Stationary Energy Storage Systems*. Quincy, MA.
9. National Institute of Standards and Technology. *NIST SP 800-82 Rev. 3: Guide to Operational Technology (OT) Security*. Gaithersburg, MD.
10. National Institutes of Health, Office of Research Facilities. *NIH Design Requirements Manual (DRM)*. Bethesda, MD.
11. The Joint Commission. *Comprehensive Accreditation Manual for Hospitals*, Emergency Management (EM) chapter, Standard EM.12.02.09 (96-hour sustainability planning). Oakbrook Terrace, IL.
12. UL Solutions. *UL 9540: Standard for Energy Storage Systems and Equipment*; *UL 9540A: Test Method for Evaluating Thermal Runaway Fire Propagation in Battery Energy Storage Systems*. Northbrook, IL.