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Modernization of Emergency Power Systems for NIH Facilities Part II: Design, Integration, and Implementation Considerations

Introduction

The benefits of hybrid emergency power systems can only be realized through proper engineering, integration, and life cycle management. While Battery Energy Storage Systems (BESS), fuel cells, renewable energy resources, and intelligent control systems offer significant operational advantages, they also introduce new design, safety, and operational considerations. For healthcare and biomedical research facilities, these technologies must be integrated without compromising the reliability, availability, or code compliance of the Emergency Power Supply System (EPSS).

For NIH facilities, supplemental energy technologies should always enhance, rather than replace, the conventional diesel generator-based emergency power system. Successful implementation requires careful attention to technology selection, code compliance, control philosophy, commissioning, and long-term operation.

Selecting the Appropriate Battery Technology

BESSs have become one of the most practical technologies for improving emergency power performance. However, selecting an energy storage system involves much more than choosing a battery chemistry. The complete listed Energy Storage System (ESS), including the battery management system, thermal management, enclosure, fire protection features, maintenance requirements, and operating characteristics, should be evaluated as an integrated package.

Several battery technologies are available for stationary applications. Lithium iron phosphate (LFP) batteries have become increasingly popular because they provide good thermal stability, long cycle life, and lower thermal runaway severity than many other lithium-ion chemistries. Even so, LFP chemistry does not eliminate thermal runaway, off-gassing, fire, or explosion hazards, and all installations remain subject to applicable safety, testing, and code requirements. In comparison, nickel manganese cobalt (NMC) batteries offer higher energy density and a smaller installation footprint but require greater attention to thermal runaway propagation and off-gas hazards.

Emerging technologies such as sodium-ion batteries offer promising safety characteristics and the potential for competitive life-cycle costs, while flow batteries provide attractive long-duration storage capability with minimal cycle degradation. These technologies should be evaluated carefully based on commercial maturity, manufacturer support, installation constraints, and project-specific requirements rather than on energy density alone.

Installation Safety and Code Compliance

Safety remains the primary consideration when integrating energy storage technologies into healthcare and research facilities. Battery installations should be planned with adequate consideration for patient care areas, research laboratories, vivariums, freezer farms, communications rooms, electrical spaces, means of egress, emergency access routes, and other mission-critical building functions. The installation location should support both operational reliability and emergency response.

BESS shall be designed, installed, and maintained in accordance with the NIH *Design Requirements Manual*, the National Electrical Code, NFPA 855, applicable fire and building codes, manufacturer requirements, and Authority Having Jurisdiction (AHJ) requirements. Systems shall be listed to UL 9540 and supported by applicable UL 9540A fire test data appropriate for the proposed installation. Compliance with these standards helps ensure that energy storage systems meet acceptable levels of safety, performance, and reliability.

System Integration and Control

Integrating supplemental energy resources into an existing emergency power system is often the most challenging aspect of hybrid system design. Batteries, fuel cells, and renewable energy resources must operate in coordination with automatic transfer switches, generator controls, paralleling switchgear, protective relaying, grounding systems, load-shedding schemes, utility interconnections, and the essential electrical system. The objective is to improve system performance while preserving the operation of the code-required emergency power source.

A supplemental energy source shall not be considered a required emergency source unless it fully satisfies the applicable capacity, availability, transfer, reliability, testing,

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maintenance, and documentation requirements, or is specifically approved by the AHJ under a code-compliant design approach.

One of the most important principles in systems design is fail-safe operation. Any failure of a supplemental battery system, inverter, communications network, or microgrid controller should automatically return the facility to conventional diesel generator operation without affecting emergency load service. Likewise, code-required emergency loads should never depend solely on supplemental energy resources. Stored energy should be reserved for the highest-priority emergency and mission-critical loads, and any control system failure should default to conventional EPSS operation.

Proper control strategies can also improve generator performance by reducing prolonged light loading and unnecessary cycling, provided that emergency load acceptance capability and NFPA 110 testing requirements are maintained. Intelligent energy management should enhance system operation without changing the fundamental role of the emergency generator.

Commissioning and Operational Readiness

Comprehensive commissioning is essential to verify that all components operate together as intended. Testing should demonstrate proper transfer sequences, coordinated operation of control systems, protective functions, available battery runtime under the design duty cycle, and fail-safe performance under credible fault conditions. It should also verify that failures within supplemental systems cannot compromise the required emergency power source. Periodic operational testing should continue throughout the system life cycle in accordance with NFPA 110.

As hybrid systems become increasingly dependent on digital controllers and communications networks, operational technology (OT) cybersecurity should also be incorporated into system design. Control systems should comply with applicable NIH cybersecurity requirements and should be developed in accordance with recognized guidance, such as NIST SP 800-82, where appropriate. Cybersecurity should be considered during system design rather than added after initial installation.

Conclusion

Hybrid emergency power systems represent the next stage in the evolution of resilient electrical infrastructure for healthcare and biomedical research facilities. Their successful implementation depends not only on selecting appropriate technologies but also on integrating those technologies into existing emergency power systems while maintaining compliance with applicable codes and standards. For NIH facilities, hybrid technologies should be viewed as resiliency enhancements that improve operational flexibility, power quality, and system performance without compromising the reliability of the conventional EPSS. Careful engineering, rigorous commissioning, and ongoing operational management are essential to ensuring that these advanced technologies strengthen, rather than complicate, the mission of providing dependable emergency power to critical facilities.

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