RADemics

Advanced Battery and Thermal Energy Storage Solutions for Uninterrupted Power Supply in Healthcare Facilities

M. Siddharth, Soumya Mishra
HYDERABAD INSTITUTE OF TECHNOLOGY AND MANAGEMENT, KALINGA INSTITUTE OF INDUSTRIAL TECHNOLOGY

Advanced Battery and Thermal Energy Storage Solutions for Uninterrupted Power Supply in Healthcare Facilities

[1]M. Siddharth, Assistant Professor, Department of EEE, Hyderabad Institute of Technology and Management, Hyderabad, Telangana, India -501401. siddartham.eee@hitam.org

[2]Soumya Mishra, Associate Professor, School of Electrical Engineering, Kalinga Institute of Industrial Technology Bhubaneswar, Odisha, India, 754021. som.kist@gmail.com

Abstract

Ensuring uninterrupted power supply in healthcare facilities is a fundamental necessity for delivering safe, reliable, and high-quality medical care. Traditional reliance on diesel generators and unstable grid connections poses severe limitations in addressing the growing energy demands and environmental sustainability targets of modern hospitals. This chapter presents an in-depth analysis of advanced battery and thermal energy storage systems as integrated solutions to support continuous energy availability in healthcare settings. It highlights the unique energy challenges of medical infrastructures, including the sensitivity of life-support equipment, the complexity of thermal and electrical load profiles, and the critical need for power quality and resilience. The co-design of electrical and thermal storage technologies is examined through simulation-based evaluations, control strategies, and system-level optimization approaches that align with real-time hospital operations. The integration of smart battery management systems, predictive energy management, and hospital automation enables responsive, adaptive, and secure energy delivery, the chapter explores the economic viability, lifecycle benefits, and environmental advantages of hybrid storage systems tailored for both grid-connected and off-grid medical facilities.

Keywords: battery storage, thermal energy storage, uninterrupted power supply, hospital microgrid, healthcare energy resilience, energy management systems.

Introduction

The modern healthcare ecosystem is profoundly dependent on continuous and high-quality energy supply to maintain the integrity of medical operations, safeguard patient lives, and support critical diagnostic and therapeutic equipment [1]. Hospitals and health centers operate as high-reliability environments, where even brief power interruptions can lead to adverse clinical outcomes, equipment failures, or data loss [2]. The increasing integration of advanced imaging systems, life-support machines, electronic health records, and climate-sensitive pharmaceutical storage has intensified the demand for a stable and resilient energy backbone [3]. Simultaneously, rising global energy insecurity and climate-induced grid disruptions have made conventional grid-tied healthcare systems increasingly vulnerable [4]. While diesel generators remain a widely used fallback, they are often associated with high operational costs, frequent maintenance requirements, fuel transport risks, and substantial environmental emissions. These limitations call for an urgent transition toward cleaner, smarter, and more robust power backup solutions [5].

Energy storage systems, particularly advanced battery and thermal energy storage technologies, present a transformative opportunity to address the dual challenge of reliability and sustainability in healthcare energy systems [6]. Batteries, especially lithium-ion and other emerging chemistries, offer rapid response times and can be scaled to support short-term and extended outages [7]. Meanwhile, thermal storage solutions—such as chilled water tanks and phase change materials—are crucial in maintaining HVAC, sterilization, and refrigeration systems that are essential to infection control and patient comfort [8]. Together, these systems allow for the decoupling of energy generation and consumption, providing flexibility to absorb intermittent renewable energy, support peak shaving strategies, and increase autonomy in grid-disconnected scenarios [9]. Their integration into hospital infrastructure enables not only resilience but also significant reductions in carbon footprint and energy-related expenditures [10].