RADemics

Sustainable Medical Imaging and AI-Driven Diagnostic Systems with Renewable Power Solutions

Ajab Singh Choudhary, Bimal Nepal
NOIDA INTERNATIONAL UNIVERSITY, STNM MULTI-SPECIALITY HOSPITAL

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[1]Ajab Singh Choudhary, Assistant professor, SOAHS, Noida International University UP india. ajab.singh@niu.edu.in

[2]Bimal Nepal, Medical Imaging Technologist, Department of Radiology and Imaging Technology, STNM Multi-Speciality Hospital, Gangtok, Sikkim, India. bmlnpl@gmail.com

Abstract

The integration of sustainable energy solutions with advanced diagnostic technologies is transforming the landscape of modern healthcare systems. This chapter explores the convergence of renewable power systems, medical imaging modalities, and artificial intelligence (AI)-driven diagnostic frameworks to achieve environmentally responsible, reliable, and efficient clinical operations. As diagnostic infrastructures evolve in complexity and energy intensity, the demand for intelligent, resilient, and adaptive energy systems has become paramount, particularly in resource-constrained or disaster-prone regions. The chapter delves into the design and deployment of grid-interactive microgrids, energy-aware AI algorithms, and smart diagnostics that co-optimize energy consumption with clinical accuracy. Emphasis is placed on dynamic load balancing, real-time energy monitoring, predictive maintenance of imaging equipment, and the cyber-physical infrastructure that supports secure, uninterrupted functionality of diagnostic services, the chapter examines power-performance trade-offs in AI decision systems, integration strategies for renewable sources such as solar and wind, and the use of digital twins and IoT-based fault detection for continuous operational optimization. The discussion is framed within the context of reducing the carbon footprint of healthcare facilities while enhancing diagnostic reach and precision. By consolidating current technologies, research developments, and system-level innovations, the chapter presents a holistic view of how sustainable energy architectures can be harmonized with diagnostic accuracy in modern medical environments.

Keywords: Renewable energy, Medical Imaging, Predictive maintenance, Artificial intelligence, Smart diagnostics, Energy-aware systems

Introduction

The convergence of renewable energy integration and digital transformation in healthcare has catalyzed the emergence of energy-aware diagnostic systems [1]. Medical imaging technologies such as MRI, CT, PET, and digital radiography, along with AI-enabled diagnostic tools, have become essential for accurate and timely healthcare delivery, these systems are inherently energy-intensive, requiring stable and reliable power to ensure uninterrupted service and diagnostic precision [2]. In many regions, particularly remote and underserved areas, energy insecurity challenges the operational consistency of healthcare facilities [3]. To address this, renewablepowered infrastructures, such as solar microgrids and hybrid energy systems, are increasingly deployed to support mission-critical medical systems [4]. These advancements not only provide autonomy from unreliable grids but also enable reductions in healthcare-related carbon emissions, contributing to global sustainability goals [5].

As healthcare operations scale in complexity and demand, energy optimization becomes a pivotal factor for system resilience [6]. AI-driven diagnostic workflows, which rely on high-performance computing and data-intensive inference processes, place additional stress on energy supply systems. Co-optimizing energy usage and diagnostic efficiency is critical in ensuring that patient outcomes are not compromised under constrained energy availability [7]. Intelligent power allocation strategies are needed to dynamically prioritize diagnostics based on urgency, computational load, and available energy [8]. This alignment requires the deployment of real-time monitoring systems, predictive control algorithms, and decision-support platforms that bridge clinical performance with energy constraints [9]. Developing such integrated frameworks is essential for achieving sustainable, uninterrupted healthcare delivery in both urban and rural settings [10].