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# Electrification of Ambulances and Emergency Medical Transport Using Solar and Hybrid Energy Systems



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## Abstract

The electrification of ambulances and emergency medical transport systems using solar and hybrid energy solutions presents a transformative opportunity for sustainable, resilient, and low-emission healthcare delivery. As the demand for mobile healthcare infrastructure increases, especially in rural, disaster-prone, and underserved regions, integrating renewable energy into transport platforms becomes crucial for ensuring uninterrupted critical care. This book chapter explores advanced architectures and energy management strategies that enable reliable onboard power generation and distribution using solar photovoltaic systems, battery storage, and hybrid auxiliary sources. It emphasizes the role of intelligent control algorithms, real-time energy allocation, and autonomous power source coordination to maintain operational efficiency across varying conditions, the chapter investigates predictive load management through machine learning, the integration of fail-safe and redundancy mechanisms, and thermal optimization to enhance energy system resilience during extended standby and emergency deployments. Remote fault detection and predictive maintenance frameworks are also addressed, showcasing how sensor networks and IoT-driven diagnostics can improve vehicle uptime and reduce unexpected failures. By presenting a comprehensive analysis of the technical, operational, and safety considerations associated with renewable-powered ambulances, this chapter contributes to the ongoing evolution of green healthcare mobility. The findings underscore the potential of clean energy technologies to not only reduce carbon emissions but also to enhance the reliability, autonomy, and responsiveness of emergency medical services in diverse environments.

**Keywords:** Hybrid ambulance, solar energy systems, battery storage, energy management, predictive maintenance, sustainable healthcare transport

## Introduction

The growing demand for environmentally sustainable healthcare services has accelerated interest in electrifying ambulances and emergency medical transport systems using renewable and hybrid energy technologies [1]. Conventional ambulances, predominantly powered by diesel engines, pose significant challenges related to carbon emissions, operational costs, and energy reliability—particularly in regions [2]. Inconsistent fuel supply chains or where environmental regulations are becoming increasingly stringent [3]. These limitations compromise the

sustainability and efficiency of emergency response systems, especially in underserved and remote geographies where access to stable energy sources is critical [4]. The incorporation of solar photovoltaic (PV) systems, high-efficiency batteries, and hybrid propulsion mechanisms offers a promising alternative to conventional models, reducing dependency on fossil fuels while enhancing operational reliability and environmental performance [5].

Advanced solar and hybrid ambulances are being designed to support a wide array of critical medical functions, including patient monitoring, life-support systems, refrigeration for vaccines and medications, and telecommunications [6]. Unlike traditional vehicles, these platforms must deliver a continuous and autonomous energy supply to maintain uninterrupted healthcare delivery in mobile environments [7]. Achieving this requires the development of highly efficient energy architectures capable of integrating and managing multiple sources such as solar arrays, auxiliary generators, and regenerative braking systems [8]. These systems must not only meet the real-time energy demand but also adapt dynamically to changing environmental and operational conditions [9]. Therefore, intelligent energy management strategies that include power flow optimization, real-time monitoring, and demand forecasting are essential components of the system design [10].