Chapter 7
Analyzing Fuel Cell Vehicles in India via the PESTLE Framework and Intelligent Battery Management Systems (BMS): Blockchain in E-Mobility

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ABSTRACT

This chapter explores the intersection of blockchain technology, fuel cell vehicles, and intelligent battery management systems (BMS) in the context of India's e-mobility landscape. Using the PESTLE framework, it examines the political, economic, social, technological, legal, and environmental factors influencing the adoption and implementation of fuel cell vehicles. The chapter delves into the significance of integrating blockchain into e-mobility infrastructure, specifically focusing on enhancing security, transparency, and efficiency in data management. Furthermore, it highlights the pivotal role of intelligent BMS in optimizing battery performance and longevity within these vehicles. By amalgamating these technologies and considering the diverse contextual factors, this chapter offers insights into the potential advancements and challenges in shaping India's e-mobility future.

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INTRODUCTION

The emergence of fuel cell vehicles in India's transportation sector is a promising step towards sustainable mobility. Understanding the factors influencing their adoption requires a comprehensive analysis using PESTLE frameworks. This introduction provides a foundational exploration of these facets within the context of fuel cell vehicles in India. India is focusing on transitioning to cleaner and more efficient modes of transportation, particularly e-mobility, due to environmental concerns and energy independence. Fuel cell vehicles, powered by hydrogen fuel cells, offer a zero-emission alternative to traditional engines, reducing emissions and providing extended driving ranges. However, their integration into India's transportation system requires a thorough examination of external forces and internal dynamics influencing their acceptance and integration (R. Kumar et al., 2021).

The PESTLE framework helps analyze the factors influencing fuel cell vehicle deployment in India. Political factors include government policies, incentives, and regulatory frameworks. Economic factors involve cost-effectiveness, infrastructure investments, and market viability. Social elements involve consumer perceptions and readiness for the technology. Technological factors involve advancements in hydrogen production, storage, and distribution infrastructure, crucial for fuel cell vehicle scalability in India's diverse terrain. The legal framework in India is crucial for fuel cell vehicle proliferation, encompassing standards, patents, intellectual property rights, and compliance regulations. Environmental factors also impact the eco-friendliness of these vehicles, assessing their contribution to pollution reduction and carbon footprint reduction in the Indian transportation ecosystem (Anastasiadou & Gavanas, 2022). A comprehensive analysis of political, economic, social, technological, legal, and environmental aspects is needed to successfully integrate fuel cell vehicles into India's e-mobility landscape.

This introduction explores the role of Intelligent Battery Management Systems (BMS) in optimizing battery performance, ensuring longevity, and shaping the trajectory of electric vehicles, emphasizing their crucial role in e-mobility technology. The Intelligent Battery Management System (BMS) is a crucial technology in electric vehicles (EVs), overseeing the charging, discharging, and maintenance of these powerhouses. It is a combination of hardware and software, using advanced algorithms and sensors to monitor and optimize the performance of individual battery cells. This system ensures a balance between safety, energy efficiency, and durability, a key factor in the success of EVs (Kokkinos et al., 2023).

Battery Management Systems (BMS) are crucial in managing the state of charge and state of health of electric vehicles (EVs), preventing overcharging and thermal runaway risks. They also provide predictive analytics for proactive maintenance, enhancing battery lifespan. As battery chemistries and manufacturing processes evolve, BMS systems have become more sophisticated, integrating AI-driven algorithms, machine learning, and real-time data analytics, resulting in more precise and adaptive battery management solutions. The Intelligent Battery Management System (BMS) is crucial for optimizing energy storage capacity, reducing charging times, and ensuring reliability in electric vehicles. Its evolution and refinement are essential for mainstream adoption in India's e-mobility landscape (Mukelabai et al., 2022). This chapter explores the various functionalities, advancements, and implications of BMS in shaping e-mobility trajectory, particularly within India's automotive ecosystem.

India's e-mobility sector is thriving due to a combination of technological innovation, environmental concerns, and government initiatives. This sector, which includes electric vehicles and hybrid vehicles, is being developed as a strategic response to urban pollution, fossil fuel dependency, and climate change mitigation. India's entry into this sector is driven by global environmental commitments and domestic transportation needs. India's e-mobility sector has been bolstered by government interventions and policy