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IoT-Based Electric Vehicle Monitoring Systems for Pollution-Free Campus Transportation

Vaibhav Kisan Ingle, S.C. Gajbhiye
MASTER OF TECHNOLOGY IN ENVIRONMENTAL ENGINEERING, GURU GHASIDAS VISHWAVIDYALAYA (A CENTRAL UNIVERSITY) BILASPUR

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[1]Vaibhav Kisan Ingle, Bachelor of Engineering in Civil Engineering, Master of Technology in Environmental Engineering. re.er.vkingle2024@gmail.com

[2]S.C. Gajbhiye, Associate Professor, Department of Industrial and Production Engineering, School of Studies in Engineering and Technology, Guru Ghasidas Vishwavidyalaya (A Central University) Bilaspur, Chattisgarh, India. drscgajbhiye@gmail.com

Abstract

Rapid urbanization and growing environmental concerns have increased the demand for sustainable and intelligent transportation systems within institutional environments. University campuses experience continuous internal mobility involving students, faculty members, and service vehicles, which often results in energy consumption and environmental pollution when conventional fuel-based transportation systems operate within campus infrastructure. Electric vehicles offer a clean and energy-efficient transportation alternative capable of supporting short-distance mobility with zero tailpipe emissions and reduced noise levels. Integration of Internet of Things technologies with electric vehicle systems enables the development of intelligent monitoring frameworks that support real-time supervision, operational efficiency, and centralized management of campus transportation fleets. IoT-enabled monitoring systems utilize interconnected sensors, communication modules, and cloud-based platforms to collect and analyze operational data related to battery status, vehicle location, energy consumption, and system performance. Continuous monitoring of electric vehicle fleets allows transportation administrators to visualize operational data through digital dashboards, improving vehicle tracking, fleet coordination, and maintenance planning. Integration of vehicle tracking systems with campus mobility platforms enhances route optimization, transportation scheduling, and efficient vehicle allocation across institutional environments. Energy optimization and battery monitoring mechanisms further support sustainable electric vehicle operations by enabling intelligent charging management and energy consumption analysis. Data-driven insights generated from IoT platforms strengthen predictive maintenance strategies and improve long-term reliability of electric vehicle fleets operating within campus transportation systems. Development of IoT-based electric vehicle monitoring frameworks therefore contributes significantly to pollution-free campus mobility by improving operational efficiency, reducing carbon emissions, and supporting sustainable smart campus transportation infrastructure.

Keywords: Internet of Things (IoT), Electric Vehicles, Smart Campus Transportation, Fleet Monitoring Systems, Energy Management, Sustainable Mobility.

Introduction

Rapid urban expansion and increasing environmental concerns have created significant pressure on transportation systems across urban and institutional environments [1]. Educational campuses function as dynamic ecosystems where large numbers of students, faculty members, administrative

staff, and visitors move continuously between academic buildings, laboratories, hostels, libraries, and service facilities [2]. Conventional transportation methods operating within campus premises often depend on vehicles powered by fossil fuels such as gasoline and diesel. Continuous use of such vehicles contributes to carbon emissions, air pollution, and noise disturbances within educational environments. Growing global emphasis on environmental sustainability has encouraged academic institutions to adopt environmentally responsible infrastructure practices [3]. Transportation systems within campuses therefore require innovative solutions that reduce pollution while maintaining efficient mobility services. Sustainable transportation initiatives in modern campuses increasingly focus on reducing dependency on fossil fuel-based vehicles and promoting cleaner mobility technologies [4]. Electric vehicle adoption has gained considerable attention in this context because electric propulsion systems operate without producing tailpipe emissions and support energy-efficient transportation. Quiet operational characteristics of electric mobility systems also create a favorable atmosphere for learning environments that require minimal noise interference. Transition toward environmentally responsible campus transportation therefore represents an essential component of sustainable institutional development and environmental stewardship [5].

Electric vehicle technology represents an important milestone in the evolution of sustainable transportation systems. Electric propulsion relies on rechargeable battery systems and electric motors that convert stored electrical energy into mechanical motion [6]. High energy conversion efficiency within electric propulsion mechanisms enables improved utilization of available energy resources compared with internal combustion engine technologies [7]. Campus transportation environments involve relatively short travel distances and predictable movement patterns, conditions that support effective deployment of electric mobility solutions. Electric vehicles used for campus mobility services commonly include shuttle vehicles, service transport units, maintenance vehicles, and small passenger carriers [8]. Such vehicles provide reliable transportation across academic zones while supporting institutional sustainability initiatives aimed at reducing environmental impact. Integration of renewable energy sources within campus electrical infrastructure further strengthens the environmental advantages associated with electric vehicle deployment [9]. Solar-powered charging facilities and energy management platforms contribute to cleaner energy utilization across transportation systems. Growing adoption of electric mobility technologies across universities, research institutions, and smart campuses demonstrates a global commitment toward environmentally responsible transportation infrastructure [10].