# Optimizing Electric Vehicle Battery Management Systems for Enhanced Performance and Efficiency in the Automotive Sector

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Abstract- In the context of global efforts to decarbonize transportation and reduce dependency on fossil fuels, electric vehicles (EVs) have emerged as a vital solution. However, their effectiveness hinges on the performance of one critical subsystem: the Battery Management System (BMS). This research explores how advancements in BMS design and integration, specifically through the adoption of artificial intelligence (AI), real-time analytics, and cloud computing, can significantly enhance the operational efficiency, safety, and user acceptance of electric vehicles. The study further investigates how behavioral factors affect EV adoption, using the Unified Theory of Acceptance and Use of Technology 2 (UTAUT2) and the Value-Belief-Norm (VBN) model, with data gathered from diverse cultural contexts including India, Spain, and Nigeria. The study proposes a modular, cloud-based Automotive Plant Management System (APMS) integrated with BMS data, aiming to digitize internal operations in manufacturing plants. This paper offers comprehensive recommendations for both automotive managers and policymakers to accelerate EV adoption and improve production efficiencies.

# I. INTRODUCTION

The transition from internal combustion engine vehicles to electric vehicles represents a transformative shift in global mobility. While the environmental and economic benefits of EVs are well-documented, their market acceptance and technical performance depend on innovations within the Battery Management System (BMS). Acting as the control hub for lithium-ion batteries, BMS monitors and regulates vital parameters such as voltage, current, temperature, and state of charge. It ensures safety, optimizes performance, and extends battery life. Despite advances, traditional BMS systems often lack predictive analytics and real-time diagnostic capabilities, leading to inefficiencies and reduced battery life. Furthermore, user hesitancy in adopting EVs in developing nations stems from factors like limited infrastructure, high upfront costs, and unfamiliarity with EV technologies. Thus, there is a growing need for a holistic approach that integrates technical innovation with behavioral insights and operational management systems.

# II. LITERATURE REVIEW

A review of existing literature indicates the central role of BMS in EV performance. Research shows that advanced BMS architectures utilizing AI can optimize charging cycles, thermal control, and fault detection. Studies also suggest that cloud integration enables remote diagnostics and systemwide analytics.

Behavioral models like UTAUT2 and VBN provide insights into technology adoption. UTAUT2 focuses on factors such as performance expectancy, social influence, and facilitating conditions. VBN highlights how environmental beliefs and personal norms drive pro-environmental behavior. Integrating these models helps explain EV adoption patterns in different cultural and socio-economic contexts.

Another area of significance is plant-level integration. Literature supports the need for Automotive Plant Management Systems (APMS) that incorporate BMS data to enhance HR, inventory, CRM, and financial processes. This integration promises improved real-time decisionmaking and reduced manual errors.

# III. RESEARCH METHODOLOGY

This study adopts a multi-method research design:

- Exploratory Research: Conducted through interviews at Innoson Vehicle Manufacturing in Nigeria to identify operational challenges.
- Descriptive Research: Designed a cloud-based APMS featuring four key modules: Human Resources, Inventory, CRM, and Finance.
- Causal Research: Conducted surveys with 445 participants across India, Spain, and Nigeria. Structural Equation Modeling (SEM) was employed to test behavioral models.

Data Collection: Data was gathered via online questionnaires (Google Forms) and in-person interviews. Likert scales were used to quantify perceptions, and pretesting ensured clarity and reliability.

Sampling: A combination of purposive and stratified convenience sampling was used. Sample included 150 from India, 265 from Spain, and 30 plant staff from Nigeria.

Variables	Correlation (r)	Interpretation
Performance Expectancy (PE) ↔ BI	0.74	Strong positive relationship
Environmental Concern (EC) ↔ BI	0.66	Moderate to strong positive correlation
Charging Infrastructure (CI) ↔ BI	0.65	Strong influence on adoption
Awareness of BMS (AI) ↔ BI	0.61	Moderate positive correlation

# IV. RESULTS AND ANALYSIS

Key Findings

- EV adoption is strongly influenced by performance expectancy (r = 0.74) and environmental concern (r = 0.66).
- 2. Charging infrastructure and BMS awareness are critical enablers (r = 0.65 and 0.61 respectively).
- 3. Regional differences show Spain leads in ecoadoption, India is cost-driven, and Nigeria lacks infrastructure.
- 4. Behavioral models (UTAUT2, VBN) effectively predict adoption intent.
- 5. BMS integration enhances plant efficiency through real-time data and automation.



Visual Understanding: Visual summary chart of my key findings. It ranks the factors affecting EV adoption and BMS optimization by their estimated impact strength (based on correlation values and qualitative analysis):

# CONCLUSION & RECOMMENDATIONS

This research confirms that enhancing BMS through AI, predictive analytics, and cloud systems is vital for improving EV performance and fostering market adoption. An integrated APMS framework further supports organizational efficiency. Consumer behavior, shaped by environmental values and technology perceptions, must be considered in strategy design. The study highlights the importance of localized approaches in promoting EV adoption globally.

For Managers:

- Invest in smart BMS with real-time data capabilities.
- Digitize plant operations using modular APMS.

- Use behavioral models to craft region-specific marketing strategies.
- Train employees to adapt to digital tools and automation.

For Policymakers:

- Provide subsidies for EV infrastructure.
- Encourage public-private partnerships to install charging stations.
- Launch awareness programs highlighting EV benefits.

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