

Adoption of Electric Motorcycles: Challenges, Influencing Factors, and the Role of Government Regulations: A Literature Review

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Abstract. The increasing global urgency to address climate change and its adverse impacts has spurred interest in sustainable energy solutions, including electric vehicles (EVs). In Indonesia, the transition from traditional fuel-powered motorcycles to electric motorcycles (EMs) is particularly relevant in underdeveloped regions facing logistical challenges in fuel distribution. This study investigates the determinants of EM adoption by integrating cultural factors within the Unified Theory of Acceptance and Use of Technology (UTAUT). Using a systematic review approach, the research explores demographic, situational, technical, and regulatory factors influencing EM adoption. Data were collected via surveys targeting prospective users, focusing on behavioral intentions rather than actual usage, given Indonesia's early-stage EV adoption. Structural equation modeling was applied to analyze the relationships between constructs, incorporating variables such as performance expectancy, effort expectancy, social influence, and facilitating conditions. The findings highlight that financial constraints and inadequate infrastructure are significant barriers to adoption. However, factors such as performance expectancy and social influence strongly impact purchase intentions. The study underscores the importance of government intervention through policy enhancements, subsidies, and infrastructure development. Additionally, public education initiatives are crucial to emphasize the environmental and economic benefits of EMs. These insights provide a foundation for promoting sustainable transportation in underdeveloped areas, contributing to environmental preservation and economic development.

Keywords: *Electric motorcycles, UTAUT, sustainable transportation, adoption barriers, renewable energy, Indonesia*

1 Introduction

The current global environmental condition is characterized by numerous difficulties and issues that necessitate urgent attention. The results of the national GHG inventory calculation show that the level of GHG emissions in the 2022 activity year reveals that energy use in the industry sector (including fuel use in power and heat generation, and fuel use in oil refineries) is the largest contributor to emissions in the energy sector (42.3%), followed by the manufacturing industry (28.6%), transportation (21.9%), residential (3.8%), fugitive emissions from oil and gas (2.1%), emissions from non-specified sources (0.5%), fugitive emissions from surface coal mining (0.4%), and emissions from commercial activities (0.3%). Meanwhile, coal processing does not produce GHG emissions in its processing activities [1]. As Indonesia has become a newly industrialized country, it is inevitable that its energy consumption as well as CO₂ emissions will increase significantly [2], and it's important to promoting electric vehicles (EVs) to decrease road transport's final energy consumption and CO₂ emissions especially in Indonesia [3].

PLN, a government-owned enterprise in the electric energy sector, has been tasked by the government to contribute to the attainment of the net zero emission (NZE) goal by 2060. PLN's initiatives to achieve this objective encompass the provision of new and renewable energy and the enhancement of infrastructure for the electric vehicle ecosystem through the establishment of public electric vehicle charging stations (SPKLU). The Ministry of Energy and Mineral Resources (ESDM) aims to achieve a target of 2.19 million battery electric vehicles (KBLBB) and establish 31,859 electric vehicle charging stations in Indonesia by 2030. The Government endorses these initiatives by Presidential Instruction (Inpres) Number 07 of 2022, which pertains to the utilization of KBLBB as operational service vehicles and/or individual service vehicles for central and regional government agencies.

The predominant mode of transportation nowadays is vehicles powered by internal combustion engines (ICE) that utilize fuel oil in their combustion process [4]. In Indonesia, the transportation industry is responsible for 23% of CO₂ emissions, with land transportation being the predominant source, representing 90% of the total [5]. Gasoline-powered automobiles emit 167 grams of CO₂ per kilometer, but diesel-powered vehicles emit 134 grams of CO₂ per kilometer. Hybrid vehicles release 145 grams of CO₂ per kilometer, while electric vehicles emit 114 grams of CO₂ per kilometer [6]. Continuous availability of fuel is essential for the operation of these vehicles [7]. Nonetheless, the availability of fuel in undeveloped regions remains severely constrained due to logistical distribution challenges. Therefore, it is necessary to make an in-depth effort to

explore the option of transitioning from fuel-powered vehicles to electric vehicles in underdeveloped areas.

This paper aims to develop a comprehensive review of several studies related to the adoption of electric motorcycles. Based on their findings, research conducted in 2029 and 2024 is classified into two different categories. The findings are then compared, and suggestions for future research are provided.

2 Methodology

This literature analysis utilized a systematic technique to comprehensively analyze factors affecting electric motorbike adoption in undeveloped regions. The initial step entailed delineating the scope and objectives, concentrating on demographic, socioeconomic, technical, and regulatory factors influencing adoption. Targeted research questions were formulated to discern critical trends and deficiencies in the literature about electric motorcycle (EM) adoption and the corresponding governmental laws. A systematic search method was employed to collect pertinent studies. Databases such as Scopus and Google Scholar were chosen for their comprehensive resources in environmental and technological research. Keywords including “electric motorcycle adoption,” “factors,” and “government regulation” were included to generate targeted search strings. The search was optimized by incorporating parameters that prioritized peer-reviewed studies from the past decade while removing irrelevant or unrelated items. A screening method guaranteed the pertinence and quality of the gathered literature. Titles and abstracts were initially evaluated, succeeded by a comprehensive assessment of works that advanced beyond the preliminary stage. Data pertinent to the study, encompassing techniques, conclusions, and limitations, were extracted and systematically categorized into topic groups. A comprehensive analysis was performed to compare outcomes, emphasize key trends, and pinpoint research deficiencies. The synthesis of these findings is elaborated in the following parts, categorized by principal themes to offer a coherent overview of insights about electric motorbike adoption and regulatory assistance.

3 Discussion

3.1 Influencing Factors of EV Adoption

In examining the factors influencing the acceptance of electric motorcycles (EMs), there are four main attributes that categorize the factors based on their characteristics, including demographic, situational, contextual, and psychological [8].

3.1.1 Demographic Attributes

Demographic factors affecting electric vehicle adoption are classified as individual and household variables [9]. The demand for electric bikes is influenced by the community's income level; higher income levels correlate with a stronger desire for EMs [10]. Critical factors affecting electric motorbike use reveal that socio-demographic variables, including age and monthly household income, substantially influence user perceptions regarding qualities of electric motorcycle usage [11]. Research indicates market segmentation by gender, revealing that males have a higher propensity to acquire EMs, and by geography, showing that metropolitan people are less inclined to buy EMs than those in other regions [12].

3.1.2 Situational Attributes

Situational factors affecting the adoption of electric vehicles (EVs) encompass environmental, technological, financial, and market efficacy considerations [9]. Reduced acquisition prices may enhance the appeal of electric two-wheelers as a preferred transportation option for consumers [11]. Government assistance in research and development, along with access to inexpensive raw materials, would facilitate a sustainable business model for battery electric vehicle manufacturing; addressing these factors would reduce BEV prices and enhance acceptance among new consumers [13]. A recent study identifies product features, including purchase price and running cost, as key barriers to the adoption of electric two-wheelers [14]. The benefits of electric vehicle technology, safety considerations, governmental incentives for electric vehicle users, supporting infrastructure, and the long-term operational costs are viewed favorably as determinants influencing end-users' decisions to embrace electric vehicles. The alignment of prices with the purchasing power of the general populace in Indonesia is essential for achieving optimal commercialization readiness [15]. The technical aspects of electric vehicles significantly impact adoption choices. The factors encompass electric vehicle range, top speed, and design [11], [16], [17], [15], [18], [14], [19].

3.1.3 Contextual Attributes

Factors influencing electric vehicle (EV) adoption encompass governmental policies and charging infrastructure [9]. A set of significant variables driving E2W usage has been found, including purchase cost and charging infrastructure. Vehicle makers and governmental planning agencies may regard these prioritized features to enhance electric motorbike adoption [11]. To facilitate the adoption of EMs, an investment strategy that includes rapid recharge and battery swap stations would address short- to medium-term requirements [16]. The discovery indicates that facilitating conditions are the primary determinant of the intention to purchase EMs. The deployment of EMs is significantly contingent upon the

availability of essential infrastructure, including charging stations and maintenance services; hence, favorable conditions are crucial for the adoption of EMs [17]. Further efforts are required in the domains of "commercialization," "integration," and "market," particularly with electric vehicle infrastructure, including the expansion of charging stations nationwide and enhanced marketing and outreach [15]. Incentives should be tailored to address lower-income users who may perceive electric vehicles as a luxury commodity. Implementing tiered subsidies, tax exemptions, and low-interest loans could enhance the affordability of electric vehicles for a wider demographic [9]. Increased petrol pricing for private automobiles and/or a reduction in power tariffs for charging may incentivize consumers to transition from petrol to electric two-wheelers. Reduced road tax and registration fees enhance the appeal of electric two-wheelers compared to traditional petrol vehicles [12].

3.1.4 Psychological Attributes

Psychological aspects influencing electric vehicle (EV) adoption include attitudes, perceived behavioral control, perceived risks, consumer traits, emotions, societal influences, personal moral standards, and hyperbolic discounting [9]. Social influence is a critical factor in purchase intention; referral marketing and the sharing of experiences by role models, public figures, and peers on social media can expedite the adoption of EMs. The promotion of EMs can leverage (1) their beneficial effects on the environment by diminishing greenhouse gas emissions and pollution, thereby mitigating global warming and enhancing air quality; (2) their role in reducing reliance on fossil fuels as a means of energy conservation; (3) the financial savings associated with energy and maintenance costs; and (4) the stress-free experience associated with their use. Fourth, the simplicity of usage must be exhibited to clients via a complimentary public trial of operating the electric motorcycle. This convenience pertains not only to driving but also to battery charging and the maintenance of EMs [17]. Other research findings indicate various motivations for individuals to adopt battery electric vehicles (BEVs): environmental sensitivity, economic considerations, enhancement of self-image, social influence from friends and family, and a desire for novelty or trend conformity [13]. Consumer awareness and socio-cultural variables are as pivotal as financial incentives and governmental policies in Indonesia [9].

3.2 Analysis Methods

Patil et al. proposed Multi Criteria Decision Making (MCDM) methods, since this method allows for the identification and prioritization of key attributes influencing the use of two-wheeled electric vehicles based on the perceptions of prospective users in urban area [20], and conduct identification and prioritization

of attributes such as purchase cost is identified as the most critical attribute of E2Ws adoption.

Yuniaristanto et al. employs the Unified Theory of Acceptance and Use of Technology (UTAUT) expanded with five national cultural dimensions based on Hofstede's theory to identify determinants of electric motorcycle purchase intention, integrate national cultural dimensions into the UTAUT model, analyze direct and indirect relationships, and provide insights for policies and strategies in urban area [21].

Maghfiroh et al. using Japanese technology readiness assessment (J-TRA) to better understand the current readiness level of EVs in Indonesia by analyzing the key stakeholder perception of EV industries in urban area [22]. From the research did, it was found that by involving various stakeholder perspectives (industry, government, experts, and end-users), J-TRA captures a holistic view of the readiness and challenges related to EV technology and can identify gaps and obstacles in the readiness level of EV technology, such as issues in commercialization, infrastructure integration, and cost risks.

Trung et al. using Relative Importance Index (RII) to analyze consumer survey data. Its main purpose is to rank the key factors influencing the adoption of electric two-wheelers (E2Ws) based on their importance as perceived by respondents in rural area [23]. The research stated that the purchase cost, vehicle range and maximum speed, charging infrastructure, and reduction in tailpipe emissions were identified as the most critical economic attribute influencing the adoption of electric two-wheelers (E2Ws)

The usage of business model canvass (BMC) used by Awirya et al. serves as a comprehensive tool to assess the feasibility and impact of introducing EMs in Agats which the EV ecosystem is already shaped. It facilitates an understanding of the interplay between economic, social, and environmental factors, making it a practical approach for recommending policies and interventions tailored to local contexts [24].

3.3 Research Insight

From the explanations provided in the section above, research on electric motorcycle adoption has been conducted using various methods and factors. The factors frequently used in the reviewed studies are categorized into four major attributes: demographic attributes, situational attributes, contextual attributes, and psychological attributes, with details as shown in the following table:

Table 1 Influencing Factors of EV Adoption

a. Demographic Attributes	b. Situational Attributes
- Sex - Age - Qualification - Profession - Conjugal Status	- Top Speed - Power generation - Battery capacity - Charging range - Safety - Market effectiveness
c. Contextual Attributes	d. Psychological Attributes
- Policy incentives - Charging infrastructure - Preferential tax - Parking charge - Driving privileges	- Experiences - Attitude - Perceived behavioral control - Emotions - Societal influences - Personal moral norms

Table 2 Methods used in research

Methods	Usage in research
1. MCDM	To identify and prioritize key attributes influencing the use of two-wheeled electric vehicles based on the perceptions of prospective users.
2. UTAUT	To identify determinants of electric motorcycle purchase intention, integrate national cultural dimensions into the UTAUT model, analyze direct and indirect relationships, and provide insights for policies and strategies in urban areas.
3. J-TRA	to better understand the current readiness level of EVs in Indonesia by analyzing the key stakeholder perception of EV industries in urban area.
4. RII	To rank the key factors influencing the adoption of electric two-wheelers (E2Ws) based on their importance as perceived by respondents in rural areas.
5. BMC	To assess the feasibility and impact of introducing EMs in Agats which the EV ecosystem is already shaped.

From the explanations stated in the table above, research related to electric vehicle adoption still focuses on urban areas. Further studies on this topic need to be conducted, with underdeveloped areas as the primary focus. This is because underdeveloped areas have greater potential for using EMs due to the limited distribution of fossil fuels. In conducting studies on electric motorcycle adoption, it is necessary to examine the acceptance of EV technology among communities in underdeveloped areas. Hence, technology acceptance methods such as

UTAUT can be utilized as an initial step to analyze the intentions and behavior of adopting new technology, focusing on purchase or usage intentions rather than actual adoption.

4 Conclusion

This literary study indicates that the implementation of EMs in underdeveloped areas with limited gasoline availability requires focused research supported by strengthened governmental regulations. The analysis indicates that situational factors such as financial, technological, and infrastructural features are the principal obstacles to the widespread adoption of electric vehicles. A significant barrier is the higher acquisition and operational costs compared to fossil fuel vehicles, together with the inadequate availability of supporting infrastructure, such as charging stations. Therefore, the government must take an active role in reinforcing legislation that promotes the adoption of electric vehicles. This encompasses providing attractive incentives, subsidies to reduce the cost of electric vehicles, decreasing electricity expenses, and establishing supportive infrastructure, including accessible charging stations.

These efforts should be complemented by educational and promotional operations that emphasize the benefits of EMs, such as the decrease in greenhouse gas emissions and the realization of long-term cost savings. Highlighting these advantages can bolster public interest and confidence in the adoption of EMs as an alternative mode of transportation. These strategies are essential for enhancing accessibility and augmenting the appeal of EMs, especially in regions with challenges in energy provision. Through the implementation of regulatory reinforcement, financial aid, and infrastructure enhancement, it is expected that communities in underdeveloped areas will transition to more sustainable and efficient electric vehicle usage.

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