World Journal of Engineering and Technology, 2026, 14(1), 65-87
https://www.scirp.org/journal/wjet
ISSN Online: 2331-4249
ISSN Print: 2331-4222

Comprehensive Analysis of the Social Economic and Technical Impacts of Field Validated Electric Motorcycle Conversion in Bangladesh

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How to cite this paper: Ananyo, D.P., Uddin, M.R., Shuvo, M.M. and Salim, K.M. (2026) Comprehensive Analysis of the Social Economic and Technical Impacts of Field Validated Electric Motorcycle Conversion in Bangladesh. *World Journal of Engineering and Technology*, **14**, 65-87.
https://doi.org/10.4236/wjet.2026.141004

Received: October 14, 2025
Accepted: December 16, 2025
Published: December 19, 2025

Abstract

Electric motorcycles are a cleaner, inexpensive alternative to conventional motorcycles, offering zero tailpipe emissions and reduced air and noise pollution. However, existing research has often overlooked practical aspects such as market dynamics, user acceptance, and rider income and real-world performance data. This study addresses these gaps by evaluating technical specifications, user satisfaction, and the impacts of different motor and battery configurations on operational costs, CO_2 emissions, sustainability, and the financial outcomes for riders using motorcycles as a source of income. Data on battery capacity, motor type, speed, and range were collected from regional companies, service centers, and motorcycle operators engaged in passenger transport services. The analysis reveals that the majority of electric motorcycles are equipped with 1500 W Brushless Direct Current (BLDC) hub motors and lead-acid batteries, offering an optimal balance between cost and performance. Feedback from electric motorcycle users in Bangladesh reveals a positive outlook (73%), highlighting significant cost efficiency and ride comfort, while also addressing some obstacles, such as battery degradation and structural longevity issues. Findings indicate that electric motorcycles can reduce daily CO_2 emissions by approximately 68.2% and lower operational costs by over 84%, leading to significant economic gains. A route-based analysis indicated savings of 28 - 35 Bangladeshi Taka (BDT) per trip and 1700 - 2100 BDT per month, resulting in a 92.5% reduction in costs for electric motorcycles in urban transportation. Riders can save an estimated 3500 BDT per month—equivalent to 13 - 16% of monthly revenue, depending on geographic location. The study underscores the environmental, economic, and social advantages of electric motorcycles, particularly for low- and middle-income users in urban, semi-urban, and rural areas of Bangladesh, reinforcing their potential as a sustainable mobility solution.

Keywords

Electric Motorcycles, Operational Cost Savings, CO_2 Emissions Reduction, Rider Income Impact, Sustainable Mobility

1. Introduction

Motorcycles play an important function in transportation across Bangladesh. People usually use motorcycle not only for personal mobility but also as a source of income. In both urban and rural areas, many riders carry passengers to earn money and support their families through this occupation. But there are certain problems with motorcycles that run on regular fuel. They require considerable maintenance, incur high operating costs, and contribute substantially to environmental pollution through significant CO_2 emissions. Electric motorcycles could be a viable alternative. The global adoption of electric vehicles is rising due to their lower maintenance costs and minimal environmental impact. These vehicles are more economical to operate and do not emit harmful gases. Electric motorcycles in Bangladesh may offer advantages in both urban and rural settings. Compared to auto-rickshaws, they provide greater flexibility and affordability. Individuals can reduce expenses by shifting to electric motorcycles. Riders engaged in passenger transport may also increase their earnings and improve their financial conditions.

The market for electric vehicles (EVs) around the world is increasing rapidly. There are more than 250 million electric two- and three-wheelers in the world, and most of them are in Asia [1]. Several things contribute to this rise, including higher fuel prices, lower maintenance costs, government subsidies, and more worries about air pollution and carbon emissions. In India, for instance, electric motorcycles are predicted to make up 15% of total sales by 2025, due to programs like Faster Adoption and Manufacturing of Electric Vehicles-Phase II (FAME-II) and the growth of charging stations [2]. There has also been an increase in the production of electric motorcycles in the country, which has made them cheaper and easier for more people to get. Electric motorcycles are a practical, affordable, and eco-friendly way to get around, particularly in regions with many people and a great need for both personal and business transportation. Bangladesh depends significantly on motorcycles for moving around and earning money. It would benefit from employing similar approaches to promote electric mobility.

Globally, electric motorcycles have gained rapid acceptance due to their affordability, urban suitability, and low maintenance requirements. Asian countries lead this transition, with China and India dominating production and adoption rates. However, smaller developing economies such as Bangladesh are emerging as significant contributors to the electric mobility transition, driven by domestic manufacturing and government incentives.

Country	Product	Life Cycle
China	Electric Motor	Growing
India	Electric Motor	Exponential
Japan	Electric Motor	Growing
Australia	Electric Motor	Stable
Korea	Electric Motor	Stable
Bangladesh	Electric Motor	High Growth

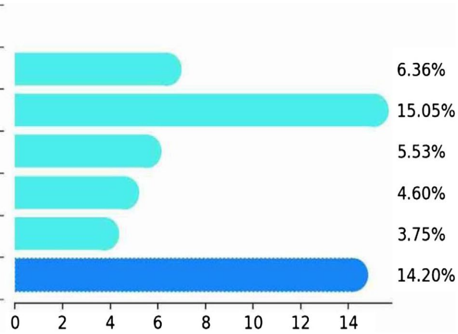


Figure 1. Electric motorcycle sales in Bangladesh and major Asian economies are projected to be comparable in 2027. According to data, Bangladesh's growth rate is higher than that of the area's mature and exponential markets [3].

By 2027, the electric motor market in Bangladesh is projected to grow at a phenomenal 14.2%, above that of other significant Asian economies. Figure 1 illustrates that, whereas Bangladesh has an explosive upward trajectory similar to India's exponential tendency, countries like Japan, Australia, and Korea show stable or moderate growth. This highlights how Bangladesh is quickly becoming a major player in the global electric vehicle market.

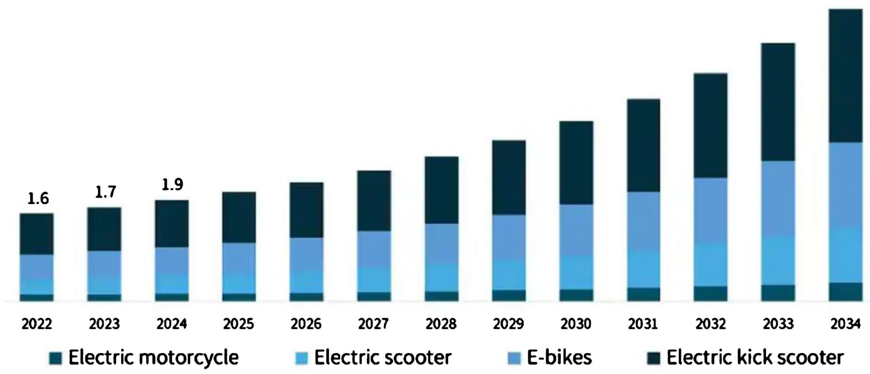


Figure 2. Forecasted global electric motorcycle sharing market size by vehicle category, 2022-2034 (USD billion). Electric motorcycles represent the predominant market segment, with strong customer demand and industry growth across Asia [4].

Extending beyond regional patterns, the global market for electric two-wheelers—including motorcycles, scooters, and e-bikes—has shown a remarkable upward trajectory in recent years. As depicted in Figure 2, the market is projected to expand steadily from USD 1.6 billion in 2022 to over USD 5 billion by 2034, with electric motorcycles constituting the dominant vehicle category. This rapid growth reflects increased urban demand for low-emission personal transport, technological improvements in battery systems, and the expansion of shared mobility platforms. The figure further indicates that the electric motorcycle segment is expected to maintain a strong growth share relative to electric scooters and kick scooters, underscoring the pivotal role of motorcycles in shaping sustainable mobility across developing Asian economies [4].

Figure 3. Conversion of a conventional motorcycle into an electric motorcycle at the IUB Formula E laboratory setup.

In the Formula E lab at the Independent University of Bangladesh (IUB), they converted a conventional motorcycle into an electric motorcycle, as seen in Figure 3. This prototype shows what the research is really regarding, looking into how implementing electric motorcycles in Bangladesh will affect technology and the economy. Electromagnetic fields have large economic advantages because they cut down on fuel and maintenance costs by a lot. This is especially true for businesses that rely on passenger transit for income. This change corresponds with bigger national aims like protecting the environment, making sure we have enough energy, and reaching our sustainable development goals. Ahmed *et al*. [5] state that vehicles with internal combustion engines (ICE) are responsible for greenhouse gas emissions, which are a big cause of pollution. Egbue and Long [6] emphasized that, when backed by the right infrastructure and regulatory frameworks, electric vehicles offer a sustainable substitute for reliance on fossil fuels and urban air pollution. According to Bloomberg NEF [7], EVs made up 14% of all new car sales worldwide in 2022, and this significant rising trend is expected to continue over the next ten years. However, according to Karmaker and Ahmed [8], the adoption process in Bangladesh is still slow because of infrastructure issues, regulatory obstacles, and low public awareness. Mahobiya *et al*. [9] suggested a cheap way to convert regular motorcycles into electric ones using BLDC motors and lithium-ion batteries, concentrating on cost-effectiveness and environmental friendliness. Hanifah *et al*. [10] and Fitch [11] both noted that electric motorcycles could reduce the need for car trips and highlighted the importance of policy incentives in speeding up their adoption. Łebkowski [12] reported on the successful development and road testing of an electric motorcycle with incorporated Permanent Magnet Synchronous Motors (PMSM) and $LiFePO_4$ batteries, showing that efficient electric two-wheelers are technically possible. Starkey *et al*. [13] performed a life-cycle research of electric motorcycles in Pakistan, finding that large emissions and pollution decreases are achievable, assuming there is access to a clean energy system and supportive government measures. Hossain *et al*. [14] looked at electric two-wheelers in Dhaka and found that they are a cheaper and better option for the environment than regular motorcycles because they lower running costs and make the air cleaner. Md. Al-Amin and Md. Sahabuddin [15] assessed the impact of electric auto-rickshaw adoption on Bangladesh's national grid and identified challenges in utilizing solar energy as a renewable alternative. Amit Kumar Podder *et al*. [16] reviewed the state of the art in vehicle charging systems based on renewable energy, with an emphasis on hybrid combinations of solar PV and biogas technologies, and evaluated their feasibility in promoting sustainable transportation for auto-rickshaws and easy bikes in developing countries.

These studies demonstrate that electric motorcycles are technically feasible, economically beneficial, and environmentally friendly. Key advantages include reduced fuel and maintenance costs, lower pollutant emissions, and improved air quality in urban areas. However, a common limitation across the existing literature is the lack of empirical user data, absence of comparative analyses between different motor and battery types, and the unavailability of comprehensive assessments regarding usability and cost-effectiveness from both individual and commercial user perspectives—especially within the Bangladeshi context. This study involved converting a conventional motorcycle into an electric bike in the university laboratory. This modified motorcycle was then evaluated on diverse roads throughout Dhaka city. Following the practical implementation, a cost analysis was conducted to determine the financial savings achieved. The study offers a comparative analysis of the extent to which operating costs can be reduced by using an electric motorcycle instead of a petrol-powered alternative. This study studies the gap by evaluating motor and battery configurations, their influence on usability, affordability, and environmental consequences, as well as their impact on real-world results for individual and commercial users. The study analyses economic benefits and CO_2 reductions using data from users, manufacturers, and service centers, providing actionable insights for consumers, manufacturers, and politicians contemplating Electric Motorcycle adoption.

While many studies have investigated the effects of electric motorcycles, there is a lack of studies using empirical data from Bangladesh. This study integrates real Bangladeshi datasets, including consumer reviews and user experiences that reflect both positive and negative feedback on electric motorcycle use. The study additionally emphasizes the types of motors and batteries primarily used in the local setting. This study analyses the potential decrease in CO_2 emissions resulting from the adoption of electric motorcycles in Bangladesh and Dhaka city.

Additionally, the financial advantages of switching from a Conventional motorcycle to an electric one—such as lower costs for frequent riders and higher profit margins for ride-sharing companies—have been demonstrated both theoretically and through real-world experiments conducted across several locations in Dhaka. All of these results set this study apart from previous studies.

2. Methodology of the Proposed Paper

This study employed a mixed-methods methodological framework that integrates market analysis, technical evaluation, experimental motorcycle conversion, and user-based field investigation. The methodology was designed to capture both quantitative performance parameters—such as battery capacity, motor power, energy consumption, and CO_2 emissions—and qualitative insights obtained through rider interviews, dealership visits, and manufacturer engagement. Analytical models were developed to estimate range, top speed, and cost differentials, while experimental validation was conducted through the conversion of a conventional motorcycle into an electric configuration. Together, these components provide a comprehensive basis for assessing the technical, economic, and environmental implications of electric motorcycles in Bangladesh.

2.1. Overview of the Electric Motorcycle Market in Bangladesh

A market analysis was carried out to compare the available electric motorcycle models in Bangladesh. Data were collected from official websites, brochures, and product catalogs of leading local companies, including Akij Motors [17], Walton [18], and Green Tiger [19], which are prominent in offering models suited to both urban and rural use. The comparison focused on key specifications such as motor power, battery capacity, top speed, and mileage.

Battery Capacity vs. Range:

$$\text{Range (km)} = 2.07 \times \text{Battery Capacity (Ah)} + 1.21 \tag{1}$$

This model suggests that range increases approximately linearly with battery capacity, at a rate of 2.07 km per additional ampere-hour.

Motor Power vs. Top Speed (Theoretical and Empirical Observation):

$$\text{Top Speed} = V_{\max} \times \left(1 - e^{-kp}\right) \tag{2}$$

Where, $V_{\max}$ is the asymptotic maximum speed and k is a system-specific constant and P is the motor power (in watts, W). A power-law regression was used to better show the real market data, providing us:

$$\text{Top Speed} = 2.93 \times P^{0.932} \tag{3}$$

This empirical model demonstrates sub-linear growth, which is what theory says should happen when power expands. Equations (2) and (3) together connect concepts from the concept with practical design limits seen in Bangladesh's electric motorcycle industry.

Battery Capacity vs. Motor Power:

$$\text{Motor Power} = 73.57 \times \text{Battery Capacity (Ah)} - 575.00 \tag{4}$$

This implies that motorcycles with larger batteries usually have more powerful motors. However, the negative intercept indicates that the linear model may not work outside of the range that has been looked at.

2.2. Field Investigation and User Interaction

Electric motorcycles in Bangladesh have a lot of different technical specifications and user-friendly features that have an enormous effect on how many individuals purchase them, how well they work, and how much they are worthy in real life. It is important to evaluate these characteristics in order to figure out how useful they are in everyday life, how reliable they will be over time, and how they will affect user satisfaction across various socioeconomic categories. Electric motorcycles are becoming an essential component of Bangladesh's changing transportation environment as more and more people in both cities and rural areas use them. This section provides a full look into important technical parts, like motor type, battery capacity, and range, as well as how people use the product and what riders say about it. Along with performance parameters, the study also examined the frequency of maintenance required and the availability of charging infrastructure to assess its usability in the real world. The insights come from many trips to dealerships and service centers, talks with people in the sector, and organized interviews with both private users and commercial riders in cities, suburbs, and rural areas. This mixed-methods approach utilizes both technical data and user perceptions to assess the overall usefulness of a vehicle. These data are a foundation for figuring out how electric motorcycles work in different situations and for finding out what users think about their economic and functional benefits.

2.3. Manufacturer Engagement and Technical Data Validation

To confirm the observational data, personal contact was made with manufacturers and authorized service providers. Talking to corporate representatives and service staff in depth gave us a lot of information about technical specs, product ranges, and common maintenance problems. More information was obtained from official brochures and company websites to double-check the system components and ensure that the technologies currently available in the Bangladeshi electric motorcycle industry were accurately represented.

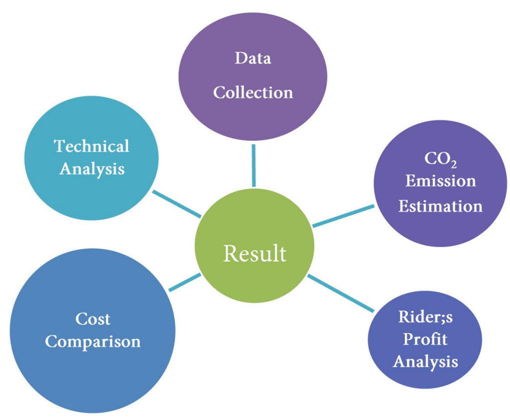


Figure 4. Methodological Framework of the Study.

Figure 4 shows how the process works. The Methodological Framework of the Study begins with data collecting through showroom visits, manufacturer specifications, and user interviews across several locations. A technical study of battery and motor arrangements follows this. CO_2 emissions are then calculated using conventional emission factors, and annual running expenses are assessed based on energy use and maintenance. Finally, rider-level profit analysis considers revenue and expenses to estimate monthly profitability. Collectively, these processes provide a thorough understanding of the economic, environmental, and technical implications of electric motorcycles in Bangladesh.

2.4. Collection of User Feedback and Customer Reviews on Electric Motorcycles

Purposive sampling was employed to gather responses from a small group of electric motorcycle users, selected to represent diversity in motorcycle brands, battery types (lead-acid and lithium-ion), and operating conditions such as urban commuting and longer-distance travel. A survey was administered to approximately 25 electric motorcycle users to collect both favorable and adverse feedback addressing their experiences. The sample size was small due to the limited number of people in Bangladesh who currently use electric motorcycles. Data were gathered through in-person interviews with specific clients, while others were linked via social media to collect the necessary information.

Open-ended questions were used to explore the following key areas:

– Overall satisfaction and performance;

– Battery life and charging experience;

– Maintenance and service support;

– Economic value and common technical issues.

Responses were recorded manually during and after the interviews. A thematic analysis approach was applied to code and categorize the data based on recurring themes, positive feedback, and commonly reported issues.

2.5. Estimation of CO_2 Emission Reduction

This study estimates the potential reduction in CO_2 emissions and operating costs resulting from a shift from petrol-powered motorcycles to electric motorcycles in Dhaka and throughout Bangladesh. The analysis draws on transport statistics and motorcycle registration data obtained from the Bangladesh Road Transport Authority (BRTA) [20]. Indirect emissions from electricity consumption during charging were calculated using the International Energy Agency's grid emission factor for Bangladesh, reported as 0.53 kg CO_2 per kWh [21].

The following assumptions were used:

- 1 million motorcycles in Dhaka and 3.5 million nationwide;
- Average daily travel per motorcycle: 40 km;
- Average CO_2 emission per petrol motorcycle: 0.1 kg/km

$$\text{The Total } CO_2 \text{ (petrol)} = N \times D \times E_p \tag{5}$$

Where:

N = number of motorcycles;

D = distance travelled per day (km);

E_p = CO_2 emission per petrol motorcycle (kg/km).

To estimate the CO_2 emissions from electric motorcycles, the following relation was applied

$$CO_2\,\text{Electric} = E_{100} \times \frac{\boldsymbol{D}}{100} \times \text{EF} \quad (6)$$

Where:

E_{100} = Energy Consumption per 100 km (in KWh);

EF = Grid emission factor (kg CO_2/kWh).

Thus, the emission reduction potential per motorcycle is

$$CO_2\,\text{Reduction} = CO_2\,(\text{Petrol}) - CO_2\,(\text{Electric}) \quad (7)$$

2.6. Economic Cost Comparison

An economic analysis was conducted to compare the annual operating costs of petrol and electric motorcycles. A 72 V, 32 Ah (2.3 kWh) battery was selected as a representative mid-range configuration, common in models from Akij and Walton. A lab-modified motorcycle with a 60 V, 25 Ah (1.5 kWh) battery also provided supporting evidence. These setups were used to determine how much energy and money would be required to travel one kilometer. The findings are in the Results section. The research incorporates both energy and maintenance expenditures, which gives a better picture of the costs of owning something over time.

$$\text{Annual Fuel Cost (Petrol)} = D \times FC \times P_f \quad (8)$$

$$\text{Annual Electricity Cost (Electric)} = D \times EC \times P_e \quad (9)$$

Where:

- D = Total annual travel distance (in km);
- FC = Fuel consumption per km (in L/km);
- P_f = Fuel Price (BDT/L);
- EC = Energy consumption per km (in Kwh/km);
- P_e = Electricity Price (BDT/Wh).

The expected annual cost savings from switching to electricity motorcycles estimated as

$$\text{Annual Savings} = \text{Annual Cost Petrol} - \text{Annual Cost Electric} \quad (10)$$

An electric motorcycle was successfully converted from a conventional bike in the IUB Formula Lab. Several mechanical and electrical parts, including the motor, controller, and battery pack, were used in the conversion process. A certain amount of funds was needed to implement these components, and this has been examined and discussed in the Results and Discussion section.

Additionally, the monthly savings from switching from a conventional motorcycle to an electric bike were determined. The Results and Discussion section also includes a discussion of the number of months required to recover the entire conversion cost from monthly savings, based on this data.

$$\text{Playback period} = \frac{\textbf{\textit{Conversion Cost}}}{\textbf{\textit{Monthly Savings}}} \quad (11)$$

To improve the analytical economic model, two practical travel routes in Dhaka city were tested to assess the actual cost differences between petrol and electric motor cycles

- Route 1: Bashundhara → Uttara (15 km);
- Route 2: Bashundhara → Mirpur (12 km).

For both routes, travel distance, energy consumption, and associated costs were calculated using field-based parameters. The petrol motorcycle was assumed to have an average fuel efficiency of 50 km/L, with petrol price P_f = 126 BDT/L. The electric motorcycle used a 60 V, 25 Ah Lithium Iron Phosphate ($LiFePO_4$) battery ($E_b \approx 1.5$ kWh) consuming approximately $E_c = 0.02308$ kWh/km, with electricity priced at $P_e = 8.1684$ BDT/kWh.

The per-trip cost for each type of motorcycle was calculated using:

$$C_p = \frac{\boldsymbol{d}}{\boldsymbol{mp}} \times P_f \quad (12)$$

$$C_e = d \times E_e \times P_e \quad (13)$$

C_p = Petrol trip Cost (BDT);
C_e = Electric trip Cost (BDT);
d = Distance travelled (km);
m_n = Mileage of Petrol motorcycle (km/L);
E_e = Energy Consumption per Km (Kwh/km);
P_f = Patrol Price (BDT);
P_e = Electricity Price (BDT).

Field data were collected from motorcycle riders in Dhaka (urban), Netrakona (suburban), and Kotwali Upazila, Mymensingh (rural) to capture geographic variations in usage and cost. Average daily travel distance and income were recorded. A profit analysis was conducted by subtracting monthly operational costs from riders' earnings to calculate net monthly profit:

$$\text{Net Monthly Profit} = (I_d \times N_D) - C_m \quad (14)$$

Where:

- I_d = Daily Income;
- N_D = Number of Working days per month;
- C_m = Total monthly operational cost (fuel/electricity + maintenance).

3. Result and Discussion

This section presents the key findings of the study by integrating technical performance data, user feedback, environmental assessments, and economic analyses. The results highlight how battery capacity, motor power, and top speed interact to define the performance of electric motorcycles commonly available in Bangladesh. User interviews and field observations provide real-world perspectives on reliability, satisfaction, and operational challenges. In addition, the findings quantify the potential CO_2 emission reductions and substantial cost savings associated with electric motorcycles, supported by both analytical models and experimental data. Collectively, these results offer a comprehensive understanding of the technical, economic, and environmental implications of electric motorcycle adoption in the Bangladeshi context.

3.1. Analysis of Battery, Motor, and Speed Characteristics in the Context of Bangladesh's Electric Motorcycle Models

This section displays the main performance trends seen in electric motorcycle models in Bangladesh, employing data from major manufacturers including Akij Motors, Walton, and Green Tiger. The methods section explain how technical information such as battery capacity, motor power, top speed, and range was obtained from authoritative sources. Table 1 below provides a summary of selected specifications from various manufacturers and models, drawn from a larger dataset for clarity.

Table 1. Key performance specifications of selected electric motorcycle models in Bangladesh.

Manufacturer (Model)	Motor Power (W)	Top Speed (Km/h)	Battery Capacity	Battery Type
Akij Motors (Ponkhiraj)	100	45	48 V 23 Ah	VRLA
Green Tiger (GT-Fenix R)	100	45	48 V 1.2 Ah	Removable Lithium
Walton (TAKYON)	120	50	60 V 38 Ah	Graphene Lead Acid Battery
Green Tiger (GT Elakta XR)	120	50	60 V 1.2 Ah	Portable Lithium

Table 1 compares different electric motorcycle models prevalent in Bangladesh, highlighting distinctions in motor power, maximum speed, battery capacity, and battery type. These parameters show significant patterns in the market for electric motorcycles in Bangladesh. Most manufacturers have a good balance between motor power and battery capacity. They generally pair more powerful motors with batteries that can store more energy to deliver the best performance and range. Lithium battery models tend to have higher energy density, which means they can go the same distance with less space. As lithium technology becomes more affordable, more people are expected to use it, especially in cities where space and efficiency are crucial. This selection illustrates how manufacturers tailor the design of electric motorcycles to suit the infrastructure, usage patterns, and cost of different regions. Furthermore, companies are starting to offer more options to fulfil the needs of both business users who want things that last and individual riders who care about comfort and looks. This strategic match between technological features and what customers want is a big reason why Bangladesh's electric two-wheeler market is growing.

Three meaningful connections were visualized and shown in order to better understand the trends in the technical performance of electric motorcycles in Bangladesh. These graphs show how the battery's capacity, the motor's power, and the vehicle's speed all work together to affect its total performance. Analysis of data from several models reveals distinct trends that underscore design choices employed by local manufacturers to enhance efficiency and usefulness. The regression lines and elevated R^2 values in the figures validate the robustness of these connections and the dependability of the underlying data.

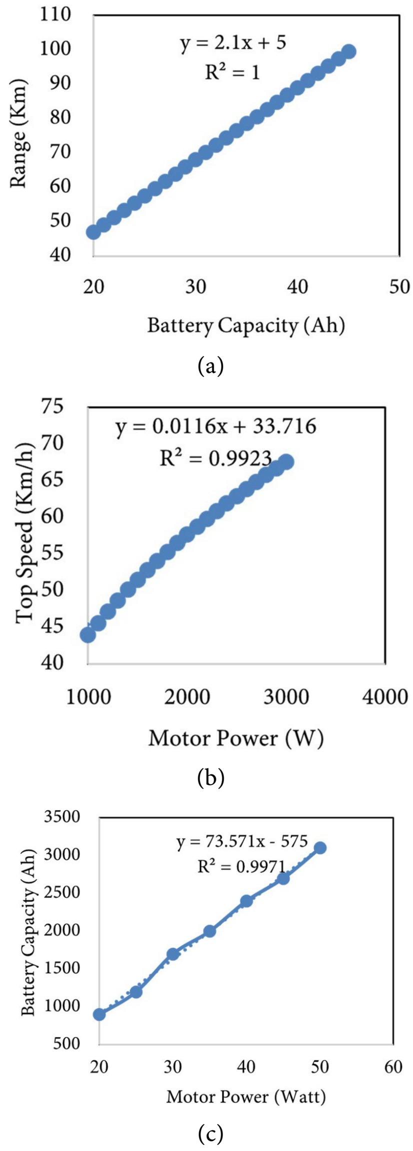


Figure 5. Performance parameter relationships in electric motorcycles in Bangladesh: (a) linear relationship between battery capacity (Ah) and range (km), (b) nonlinear relationship between motor power (W) and top speed (km/h), and (c) correlation between battery capacity (Ah) and motor power (W).

Figure 5 presents key performance correlations in electric motorcycles in Bangladesh. **Figure 5(a)**: A linear relationship between battery capacity and range, as described by Equation (1), indicates that greater battery capacity leads to longer travel distance per charge. The graph demonstrates that as battery capacity increases, the travel distance per charge increases proportionally. The data fits almost perfectly, with an R^2 value of 1.0. This means that battery capacity alone can usually tell you how far one can travel. This strong consistency shows that battery size is still a good way to measure performance across the most common electric motorcycle models in Bangladesh.

Figure 5(b): This figure highlights a slightly nonlinear correlation between motor power and top speed, represented by a power-law regression (Equation 3). The graph shows that while maximum speed increases with motor power, the rate of increase gradually declines, showing a sub-linear tendency. This trend corresponds with what theory says (Equation 2), which looks at things like aerodynamic drag and mechanical inefficiencies that get more severe at greater speeds, causing performance saturation. The model fit is strong, as shown by an R^2 value of 0.99, which means there is a strong correlation and the regression is reliable. The strong correlation between empirical data and the theoretical model reinforces the suitability of the power-law approach for predicting electric motorcycle performance, while also indicating that performance improvements decrease as motor power increases.

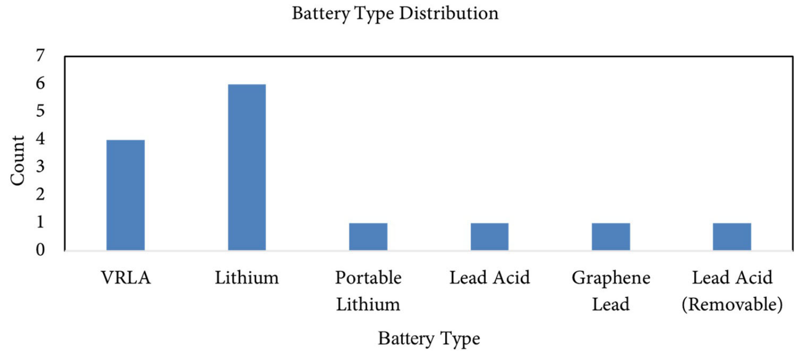
Figure 5(c): A correlation between battery capacity and motor power, based on Equation (4), shows that manufacturers tend to pair higher-capacity batteries with more powerful motors. The trend demonstrates that manufacturers constantly put together larger batteries with more powerful motors to maintain the energy level stable while also making the performance better. The R^2 score of 0.997 shows that there is a strong connection, which means that the same design process was used on multiple models. This alignment ensures that electric motorcycles in the local market provide sufficient speed and range while maintaining energy efficiency.

3.2. Battery and Motor Performance Trends

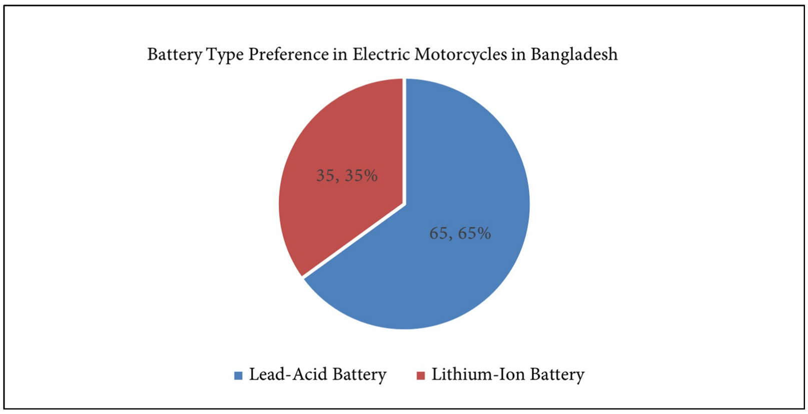
Lead-acid batteries remain the preferred option for electric motorcycles due to their low initial cost, despite being heavier and having a shorter lifespan. Manufacturer data shows that over 65% of riders continue to favor lead-acid batteries, while only 35% opt for lithium-ion batteries. Lithium-ion batteries offer benefits such as reduced weight, faster charging, and longer cycle life, but their higher cost constrains adoption, particularly among businesses and lower-income individuals. Service centers reported that battery replacement, especially for lead-acid units, is one of the most common maintenance issues, underscoring an essential obstacle to long-term user satisfaction and operational costs.

While the majority of electric motorcycles in Bangladesh currently use BLDC motors, our future strategy includes designing an induction motor for incorporation into an electric bike. Induction motors offer numerous benefits, including enhanced longevity, reduced maintenance requirements, and reliable performance across diverse load conditions, making them a viable option for long-term use.

Likewise, although most industries in Bangladesh continue to rely on lead-acid batteries, they have numerous disadvantages. Inadequate recycling of lead-acid batteries poses environmental risks, and they have considerably lower efficiency and lifespan than lithium-ion batteries. Consequently, a progressive shift from lead-acid to lithium-ion technology by industries and politicians will significantly improve performance and environmental sustainability.



(a)



(b)

Figure 6. Battery types in electric motorcycles in Bangladesh. (a) Distribution by battery type count. (b) Market preference by battery type.

Figure 6 illustrates the distribution and market preference of battery types in electric motorcycles within Bangladesh. Lithium-ion and Valve-Regulated Lead-Acid Battery (VRLA) batteries are the primary technologies employed across various models. However, the pie chart reveals that lead-acid batteries still dominate customer preference, likely due to their lower cost and wider local availability, despite lithium-ion batteries offering superior performance and efficiency.

In Bangladesh, BLDC motors are widely used on electric motorcycles due to their higher efficiency, compact parameters, and excellent low-speed torque, rendering them suitable for urban road conditions. Their hub-mount configuration avoids gear transmission, hence reducing maintenance and attracting cost-sensitive customers. Conversely, induction motors show mechanical robustness and are more appropriate for high-speed, heavy-load applications; however, they demonstrate reduced efficiency at low speeds and require more intricate control systems. BLDC motors rely significantly on electronic controllers and may exhibit suboptimal performance under thermal stress, whereas induction motors have superior thermal resilience but are infrequently utilized in two-wheelers due to their reduced efficiency and challenges in managing stop-and-go traffic. In summary, BLDC motors offer a superior equilibrium of efficiency, cost, and performance for the Bangladeshi electric motorcycle market, whereas induction motors may fulfill specialized high-performance functions.

3.3. Analysis of User Feedback and Customer Sentiments on Electric Motorcycles in Bangladesh

To get real-world data, a wide range of electric motorcycle users in Bangladesh were interviewed, including those using different types of batteries, manufacturers, and usage conditions. Participants involved individuals who ride bikes to work every day, deliver packages, and live in rural areas, which gave a wide range of views on performance and dependability. People liked that they had minimal running costs, were quiet, and were beneficial to the environment. They had concerns about issues like the restricted range, battery life, and charging infrastructure. These results help us understand what users want and add to the technical examination of how well electric motorcycles work.

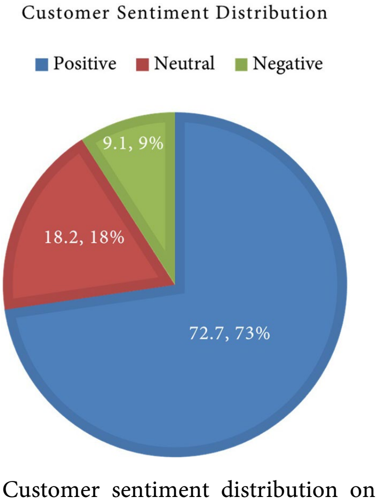


Figure 7. Customer sentiment distribution on electric motorcycles in Bangladesh based on primary data.

Figure 7 presents the distribution of customer sentiments derived from this primary data. The majority of respondents expressed favorable opinions (73%), followed by neutral (18%) and unfavorable (9%) responses. This distribution offers a clear indication of overall user satisfaction while also highlighting specific areas that warrant further attention.

Positive Features:

- Cost Effectiveness: Users mentioned extremely low running expenses, some traveling 100 - 250 km for just 30 - 40 BDT, far less than its petrol-powered equivalents.
- Comfort and Ride Quality: Riders mentioned the smooth and quiet ride, contributing to a less stressful ride.
- Environmental Impact: Users appreciated assistance towards reduced use of fossil fuels and cleaner air.
- Low Maintenance: Particularly in lithium battery variants, long-time users (4 - 6 years) cited fewer technical issues.

Common Challenges:

- Battery Degradation: A majority of users of lead-acid batteries experienced performance declines during the initial 6 - 8 months, prompting early replacement.
- Structural Durability: Consumers complained about frame strength, particularly on bumpy roads.
- Battery Replacement Cost: Replacement of lithium batteries was identified as a significant cost, although mitigated by reduced daily operating expenses.

3.4. CO_2 Emission Reduction Results

Table 2 presents the estimated daily CO_2 emissions from petrol and electric motorcycles in Dhaka and across Bangladesh, along with the corresponding reductions and percentage decrease. This study estimates that motorcycles in Dhaka emit approximately 4000 metric tons of CO_2 per day, while motorcycles across Bangladesh contribute around 14,000 metric tons daily. However, replacing conventional petrol-powered motorcycles with electric alternatives could result in a substantial reduction in emissions—estimated at 1272 metric tons per day in Dhaka and 4452 metric tons per day nationwide. This transition would yield a net CO_2 reduction of 2728 metric tons per day in Dhaka and 9548 metric tons across Bangladesh, corresponding to an overall reduction rate of approximately 68.2% in both cases. These results underscore the significant environmental benefits of widespread electric motorcycle adoption, including a 68.2% reduction in CO_2 emissions. This decrease supports Bangladesh's climate goals by mitigating urban air pollution and improving public health, while also offering concrete data to guide policy-making and infrastructure planning.

Table 2. Daily CO_2 emission reduction from switching petrol to electric motorcycles in Dhaka and Bangladesh.

Region	CO_2 Emission (Petrol) (metric tons/day)	CO_2 Emission (Electric) (metric tons/day)	Reduction (metric tons/day)	Reduction Rate (%)
Dhaka	4000	1272	2728	68.2%
Bangladesh	14,000	4452	9548	68.2%

While the analysis assumes a complete transition from petrol to electric motorcycles, such a scenario may not be fully achievable in practice within Dhaka or across Bangladesh. Therefore, the CO_2 reduction values represent an idealized estimation. Nonetheless, the findings emphasize that electric motorcycles can significantly contribute to reducing national CO_2 emissions and advancing sustainable urban mobility.

3.5. Sensitivity Analysis Based on Daily Travel Distance

The comparative analysis of CO_2 emissions from petrol and electric motorcycles offers essential insights into the environmental effects of urban mobility in Bangladesh. Given the country's rapidly developing motorcycle market, comprehending the impact of travel distance on daily emissions is crucial for assessing the real benefits of electric mobility. This analysis quantifies emissions based on actual energy consumption and grid emission factors, demonstrating the significant reduction potential of electric motorcycles compared to conventional petrol-powered motorcycles. These findings endorse policy initiatives focused on carbon-free transportation and advancing sustainable mobility solutions.

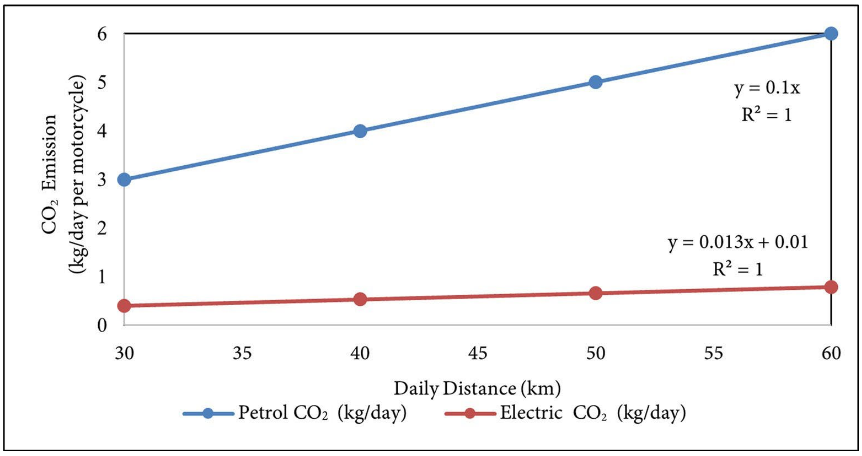


Figure 8. Daily CO_2 emission versus travel distance for petrol and electric motorcycles in Bangladesh. Calculated using equation [5]-[7].

To further illustrate the variation in emissions with travel activity, **Figure 8** presents a sensitivity analysis of daily CO_2 emissions per motorcycle as a function of travel distance for both petrol and electric modes. The results were obtained using Equations 5 - 7 and Bangladesh specific parameters:

E_p = 0.10 kg CO_2 Km^{-1}, derived from an average fuel efficiency of 25 - 35 km L^{-1} and a gasoline emission factor of 2.31 kg CO_2 L^{-1} [20].

E_{100} = 2.5 Kwh Km^{-1} based on manufacturer specifications of the Walton TAKYON 1.00 [18] Akij Ponkhiraj [17], and Green Tiger GT-Sprint PRO [19]; And a grid emission factor E_F = 0.53 kg CO_2 kWh^{-1} from the International Energy Agency (IEA) Emissions Factors 2023 [21].

As shown in **Figure 8**, both emission profiles increase linearly with distance

($R^2 > 0.99$), confirming that travel activity is the primary driver of total CO_2 output. However, the slope of the electric motorcycle curve is substantially smaller—approximately one-seventh that of petrol motorcycles—indicating that electric models release far less CO_2 per unit distance under the current Bangladeshi grid mix. For example, a petrol motorcycle traveling 40 km day^{-1} emits roughly 4.0 kg CO_2 day^{-1}, whereas an equivalent electric motorcycle emits only about 0.53 kg CO_2 day^{-1}. This linear relationship highlights the scalability of emission benefits: as average travel distance or fleet size increases, the absolute reduction in CO_2 emissions becomes increasingly significant.

3.6. Cost and Profit Comparison

This section presents a comparative analysis of the annual operating costs of electric and petrol-powered motorcycles in Bangladesh, based on actual usage conditions and representative specifications for batteries and fuel. The analysis of electric motorcycles focuses on a 72 V, 32 Ah (2.3 kWh) battery configuration, commonly found in mid-range models from Akij and Walton, with an estimated range of approximately 120 km per charge. To support this estimate, performance data were obtained from a laboratory-modified electric motorcycle equipped with a 60 V, 25 Ah (1.5 kWh) battery, which demonstrated an observed range of around 65 km under standard road conditions. The analysis for petrol motorcycles assumes a standard fuel consumption rate of 2.5 liters per 100 km and a gasoline price of BDT 130 per liter, reflecting average market conditions.

Table 3. Estimated monthly operating costs of petrol and electric motorcycles (in BDT), based on data from local companies and a laboratory-converted model.

Expense Type	Petrol Motorcycle (BDT/Month)	Electric Motorcycle (Company based data) (BDT/Month)	Electric Motorcycle (Lab based data) (BDT/Month)
Fuel/Electricity	3024	245.052	247.846
Engine Oil	733	0	0
Spark Plug, Chain, Clutch	200	50	50
Brake Pads & Tires	150	150	150
Battery Replacement	50	200	200
Total Monthly Cost	4157	645.052	647.864

Table 3 summarizes the estimated monthly operating costs of petrol and electric motorcycles in Bangladesh, based on data from local companies and a laboratory-converted model. A comparative analysis was conducted to evaluate the monthly running costs of petrol and electric motorcycles. Based on company data, the total monthly cost of operating a petrol motorcycle was estimated at BDT 4157, while that of an electric motorcycle was BDT 645.05, resulting in a monthly

saving of BDT 3511.95 and an annual saving of BDT 42143.40. Similarly, based on laboratory test data of a converted motorcycle, the monthly electric cost was found to be BDT 647.85, leading to a monthly saving of BDT 3509.15 and an annual saving of BDT 42109.80 compared to the petrol counterpart. These results demonstrate that electric motorcycles provide a substantial economic advantage in daily operation, reducing annual running costs by over 84%.

Table 4. Economic summary of converting electric motorcycle.

Meltric	Value
Conversion cost (one-time)	BDT 95,000
Avg. monthly saving (vs petrol)	BDT 3512
Payback period	~27 months (~2.25 years)

Table 4 indicates that converting a conventional motorcycle into an electric version requires an initial expenditure, after which the user realizes monthly savings on petrol, culminating in a payback period in which the conversion cost is fully recovered. The estimated cost to convert a conventional motorcycle to an electric model is roughly BDT 95,000, including the motor-controller system, a $LiFePO_4$ battery pack, fabrication labor, and necessary electrical components. According to field data, the average monthly savings from switching from petrol to electricity is approximately BDT 3512. The payback period for recovering the full conversion cost is estimated at approximately 27 months (2.25 years), as indicated in Equation (11). Subsequently, all savings directly decrease transportation costs, producing lasting financial advantages for the passenger.

The table indicates that converting a conventional motorcycle into an electric version requires an initial expenditure, after which the user realizes monthly savings on petrol, culminating in a payback period in which the conversion cost is fully recovered.

Table 5. Trip-wise cost comparison between petrol and electric motorcycles for selected Dhaka routes.

Route	Distance (km)	Petrol Cost (BDT)	Electric Cost (BDT)	Cost Saved (BDT)	Saving (%)
1 Basundhara-Uttara	15	37.80	2.83	34.97	92.52%
2 Basundhara-Mirpur	12	30.24	2.26	27.98	92.52%

Equation for percentage saving per trip:

$$\text{Saving (\%)} = \frac{Cp - Ce}{Cp} \times 100 \quad (15)$$

Monthly Travel Cost Analysis

Bashundhara → Uttara

Petrol: 37.80 × 2 × 30 = 2268.00 BDT

Electric: 2.83 × 2 × 30 = 169.80 BDT
Monthly saving: ≈ 2098 BDT
Bashundhara → Mirpur
Petrol: 30.24 × 2 × 30 = 1814.40 BDT
Electric: 2.26 × 2 × 30 = 135.60 BDT
Monthly saving: ≈ 1678.80 BDT

Table 5 analyses two common travel routes, highlighting that electric motorcycles incur significantly lower operating costs than petrol motorcycles, resulting in greater cost savings and a steadily higher percentage of total expense reduction.

The fuel efficiency of 50 km/L results in a petrol cost per trip that is somewhat lower than the prior assumption of 40 km/L, yielding a slightly reduced savings percentage of approximately 92.5%, compared to the earlier estimate of 94%. Nonetheless, each brief urban route yields significant per-trip savings of 27 - 35 BDT, totaling several thousand BDT per month. These empirical observations corroborate the analytical and laboratory findings previously discussed, affirming that electric motorcycles are economically feasible for brief daily commutes. The saved amounts substantially help recover the conversion cost, yielding enduring economic benefits for motorcycle users.

Table 6. Net monthly profit and profit gain from electric motorcycles.

Rider Name	Location	Travel per Day (KM)	Monthly Income (BDT)	Petrol Profit (BDT)	Electric Profit (BDT)
Rudra Sarker	Dhaka	50 - 60	22,500 - 24,000	18,343 - 19,843	21854.95 - 23354.95
Rokon Uddin	Dhaka	60 - 70	25,500 - 27,000	21,343 - 22,843	24854.95 - 26354.95
Suranjit Sutradhar	Netrakona	70 - 75	21,000 - 22,500	16,843 - 18,343	24854.95 - 26354.95
Gias Uddin	Kotwali, Mymensingha	100 - 150	27,000 - 33,000	22,843 - 28,843	26354.95 - 32354.95

Table 6 presents a comparison of net monthly profits for riders using petrol and electric motorcycles across different regions. Economic benefits from using electric motorcycles are evident across various regions. In Dhaka city, where monthly incomes typically range from BDT 22,500 to 27,000, riders save about BDT 3511.95 per month in operating costs. Similar savings are observed in semi-urban areas like Netrakona, where incomes are lower (around BDT 21,000 to 22,500), making the savings represent a larger share of monthly earnings—up to 16%. In rural regions such as Kotwali Upazila, Mymensingh, where monthly incomes range between BDT 27,000 and 33,000, the same amount of savings still contributes significantly to the rider's finances. A regular commuter switching from a conventional motorcycle to an electric bike might reduce maintenance costs and save money. Similar to ride-sharing drivers who earn revenue by transporting passengers, they may reduce their maintenance costs while boosting their profit margins. Even though electric motorcycle operators in Bangladesh have yet to begin carrying passengers, the extent of fare reductions for customers remains unclear. Still, for individual daily use, electric motorcycles offer substantial savings on maintenance costs. These results demonstrate that electric motorcycles provide consistent and substantial cost savings across urban, semi-urban, and rural settings, improving financial stability for riders in different income groups.

This study highlights the technical, economic, and environmental benefits of electric motorcycles in Bangladesh. The electric motorcycle sector in Bangladesh can grow through targeted industry and policy support. Companies may offer EMI-based purchase options and battery leasing or swapping services to reduce upfront costs and improve affordability. Policymakers should encourage a shift from lead-acid to lithium-iron batteries, which last longer, weigh less, are more efficient, and are safer for the environment. Government agencies and NGOs can strengthen the workforce by training rural youth in EV assembly, repair, and maintenance, creating new employment opportunities. Additionally, expanding charging stations—especially renewable-energy-powered ones—will accelerate EV adoption and reduce grid pressure. Collectively, these measures can build a nationwide, sustainable, consumer-friendly electric motorcycle ecosystem.

The analysis is based on short-term data and currently available models, which may not fully capture long-term trends or evolving user behavior. Additionally, user feedback was obtained from a limited sample size. Future research should incorporate broader datasets, extended fieldwork, and an evaluation of the role of renewable energy, the availability of charging stations and enabling policies to more accurately assess the national potential for electric mobility.

4. Conclusion

This study examines the technical, economic, environmental, and social impacts of electric motorcycles in both urban and rural contexts in Bangladesh. Efficiency and viability were evaluated by analyzing motor types and the interrelationships among battery capacity, power, speed, and overall performance. Findings derived from company data and user feedback indicate that electric motorcycles can reduce CO_2 emissions by approximately 68.2% and lower monthly operating costs by over 84%, resulting in monthly savings of around BDT 3500 for typical riders. Route-based evaluation indicated 28 - 35 BDT per-trip and 1700 - 2100 BDT monthly savings, reinforcing the economic feasibility and long-term cost advantage of electric motorcycles. The findings demonstrate that collaborative support from businesses, policymakers, and training institutions can significantly improve the electric motorcycle ecosystem in Bangladesh. However, the study is limited to currently available models, short-term usage, and a relatively small user sample. Future research should incorporate longitudinal studies, a broader range of vehicle categories, and emerging developments in battery and motor technologies. The integration of renewable energy-based charging systems and supportive regulatory frameworks could further accelerate the nationwide shift toward cleaner, more affordable transportation.

Acknowledgements

The authors would like to express their sincere gratitude to the IUB Formula E Laboratory at Independent University, Bangladesh, for providing access to equipment and offering essential technical support for the electric motorcycle conversion project. We also extend our thanks to the motorcycle riders, dealers, and service centers for their active participation and cooperation during the field data collection process. Special appreciation is due to Akij Motors, Walton, and Green Tiger for supplying detailed product specifications and technical documentation. Finally, we are deeply grateful to Professor Dr. Khosru Mohammad Salim for his continuous guidance, encouragement, and support. This research would not have been possible without his invaluable contribution.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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