

Energy Efficiency Comparison Of An Original Conventional Motorcycle And Its Electric Conversion

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Article Info

Article history:

Received August 26, 2026

Revised Sept 10, 2026

Accepted Sept 30, 2026

Keywords:

Energy efficiency;
Electric motorcycle;
ICE motorcycle;
Vehicle conversion;
Energy consumption;

ABSTRACT

This study compared the energy consumption and operational cost of a conventional motorcycle before conversion and the same vehicle after conversion to an electric motorcycle. The study used a comparative experimental approach. The conventional motorcycle and the converted electric motorcycle were tested under the same 16.5 km route condition. The conventional motorcycle consumed 350 mL of Pertalite, whereas the converted motorcycle consumed 5.1 Ah from a 72 V battery system. Using the fuel energy conversion stated in the study, the conventional motorcycle required approximately 191.8 Wh/km of input energy, while the converted motorcycle required approximately 22.3 Wh/km based on battery-side energy. The field-test cost was reported as Rp 3,500 for the conventional motorcycle and Rp 600 for the converted motorcycle, corresponding to reported unit operating costs of approximately Rp 250/km and Rp 36/km, respectively. The converted motorcycle therefore showed substantially lower energy input per kilometre and operating cost under the tested conditions. The results indicate that motorcycle conversion can provide a practical pathway for reducing operational energy demand and daily running costs.

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1. INTRODUCTION

The transportation sector is a major consumer of energy and an important contributor to greenhouse-gas emissions. Conventional two-wheelers predominantly use internal combustion engines (ICEs), in which a substantial portion of the chemical energy of fuel is released as heat rather than converted into useful mechanical work[1]. The final project report considered this low conversion efficiency as one of the motivations for evaluating electric conversion as an alternative propulsion pathway [2].

Electric motorcycles use stored electrical energy and an electric motor to produce mechanical power without the combustion process[3]. In the reported conversion system, the original propulsion components were replaced by a battery pack, battery management system (BMS), controller, and brushless direct-current (BLDC) motor[4]. The report described the BLDC system as having high efficiency, low maintenance requirements, and suitable low-speed torque characteristics [5].

Converting an existing motorcycle may offer a practical alternative to purchasing a new electric motorcycle, particularly where a large installed population of conventional motorcycles already exists[6]. Nevertheless, the actual performance of a converted motorcycle depends on battery capacity, added mass, drivetrain configuration, sprocket ratio, electrical integration, and the quality of the fabricated brackets and alignment[7]. These factors make direct experimental comparison important rather than relying only on nominal component specifications[8].

Therefore, this study compared the energy consumption and operating cost of a conventional motorcycle and the same motorcycle after electric conversion under a common test distance. The main contribution of the work was an empirical



comparison based on the recorded field-test data, including fuel consumption, battery consumption, test cost, and distance travelled. The study also documented practical mechanical issues encountered during conversion, particularly bracket alignment and fabrication accuracy.

2. RESEARCH METHOD

2.1 Research Design

The research followed a comparative experimental procedure consisting of literature study, preparation of equipment, testing of the conventional and converted motorcycles, evaluation of the test data, and preparation of the report. The original research flow is reproduced in Figure 1.

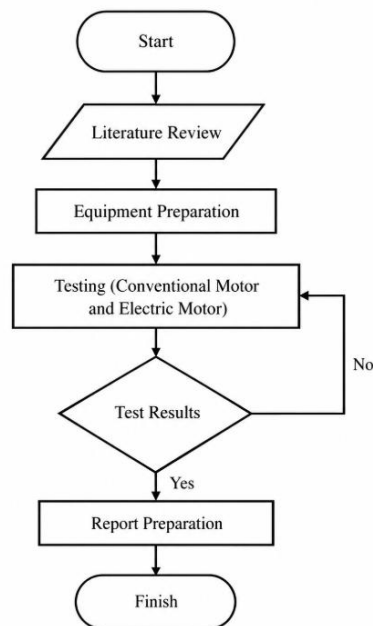


Figure 1. Research flow used in the comparative test.

2.2 Test Object and Equipment

The tested object was a conventional motorcycle in the 110-125 cc class that was converted into an electric motorcycle. The conversion used a BLDC motor rated at approximately 2.0-3.0 kW, a 72 V LiFePO₄ battery pack with BMS, a 72 V controller/inverter, a 72-to-12 V DC-DC converter, high-current cables, an MCB, harnesses, and a twist throttle. The reported test equipment included a chassis dynamometer, DC power meter/wattmeter, graduated measuring glass for fuel consumption, digital tachometer, and mechanical fabrication tools.

2.3 Conversion Procedure

The conversion consisted of four main stages: dismantling of the ICE propulsion system; fabrication and installation of motor and battery brackets; installation of the BLDC motor, battery pack, controller, and chain-sprocket drivetrain; and integration of the electrical wiring, including the main battery circuit, MCB, controller, DC-DC converter, throttle input, and brake cut-off. The report identified bracket alignment and welding accuracy as important practical issues during assembly.

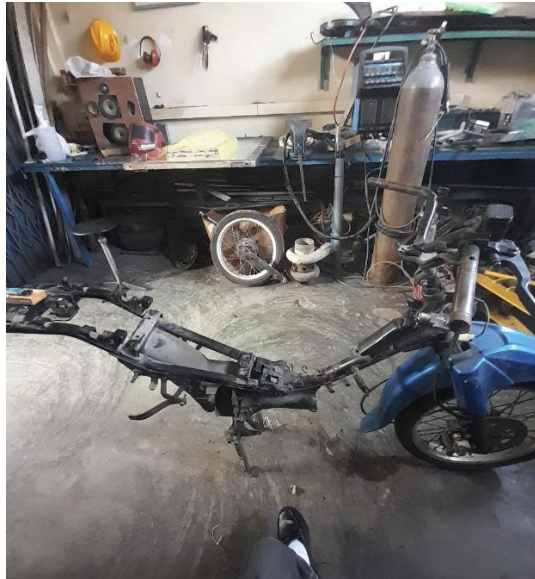


Figure 2. Fabricated frame/bracket arrangement for the converted motorcycle.

2.4 Energy and Cost Calculations

For the conventional motorcycle, the chemical energy supplied by the fuel was estimated using the lower heating value (LHV) of gasoline as stated in the report[9] :

$$E_{ICE} = V_f \times \rho_f \times LHV \quad (1)$$

where V_f is the consumed fuel volume, ρ_f is the fuel density (0.74 kg/L), and LHV is 12.22 kWh/kg. The mechanical power relation used in the report was[10] :

$$P_m = \frac{(2\pi NT)}{60.000} \quad (2)$$

For the electric motorcycle, battery-side energy was calculated from the DC bus voltage, current, and test duration[11] :

$$E_{EV} = V \times I \times t \quad (3)$$

The field comparison used a common distance of 16.5 km. The conventional motorcycle consumed 350 mL of Pertalite, while the converted motorcycle consumed 5.1 Ah from the battery during the recorded test. The reported test costs were Rp 3,500 and Rp 600, respectively.

3. RESULTS AND ANALYSIS

3.1 Energy Consumption

The reported fuel consumption for the conventional motorcycle was 350 mL over a 16.5 km test distance. Using the fuel properties stated in the report, the corresponding input energy was approximately 3.16 kWh for the test, or 191.8 Wh/km. For the converted motorcycle, the recorded battery consumption was 5.1 Ah at 72 V. This corresponds to approximately 367.2 Wh for the test, or 22.3 Wh/km. On this battery-side comparison, the converted motorcycle required approximately 88.4% less input energy per kilometre than the conventional motorcycle. This percentage is a calculation from the reported field-test values rather than a separately measured drivetrain efficiency.

3.2 Dynamic and Mechanical Characteristics

The report calculated conventional-motor mechanical power using 5,000 rpm and 9.2 Nm, giving approximately 4.82 kW. For the electric motor, the report used 6,500 rpm and 56 Nm, producing a calculated value of 38.1 kW. These values should be interpreted as the report's stated calculation results because the input torque and speed conditions differ substantially between the two systems and the electric value is much higher than the nominal motor rating reported for the conversion. A direct efficiency comparison therefore requires identical measurement conditions and clearly defined measurement points.



3.3 Field-Test Comparison

The field-test results are summarized in Table 1. Both systems were evaluated over the same 16.5 km distance. The conventional motorcycle used Peralite, whereas the converted motorcycle used battery energy. The reported operating cost per kilometre was Rp 250/km for the conventional motorcycle and Rp 36/km for the converted motorcycle.

Table 1. Comparison of the reported field-test results.

Parameter	Conventional (ICE)	Converted (EV)	Difference / Note
Energy source	Peralite	72 V battery	Fuel vs. electrical energy
Test distance	16.5 km	16.5 km	Same distance
Consumption	350 mL	5.1 Ah	Recorded field data
Test cost	Rp 3,500	Rp 600	Rp 2,900 lower for EV
Reported cost per km	Rp 250/km	Rp 36/km	Approx. 85.6% lower

The operating-cost reduction was substantial. Based on the reported unit costs, the converted motorcycle reduced the cost per kilometre by approximately 85.6% relative to the conventional motorcycle. The report rounded this result to 85%. The test-cost difference was also clear: the electric conversion required Rp 600 for 16.5 km compared with Rp 3,500 for the conventional motorcycle.

3.4 Maintenance and Practical Conversion Issues

The report described the electric system as requiring less routine maintenance because it contains fewer mechanically moving components than an ICE system. The main practical issue identified during fabrication was misalignment between the motor sprocket and the rear wheel, accompanied by excessive vibration caused by insufficiently precise battery-bracket welding. The recommended solution was to use three-dimensional CAD modelling and CNC laser/plasma cutting where possible, followed by laser alignment of the chain or belt system. These findings are important because the energy benefit of conversion can be compromised by mechanical losses and reliability problems if the drivetrain is poorly aligned.

3.5 Environmental and NVH Implications

The report also highlighted qualitative advantages of the electric conversion. The converted motorcycle produced no direct tailpipe combustion emissions during operation and was expected to have lower noise and vibration because the electric motor does not use reciprocating pistons or a combustion process. However, the report appropriately noted that the environmental footprint of electric vehicles depends on battery production and the electricity generation mix, so a full life-cycle assessment was outside the scope of the present study.

4. CONCLUSION

The comparative test demonstrated that the converted electric motorcycle consumed substantially less input energy per kilometre and had a much lower operating cost than the conventional motorcycle under the reported 16.5 km test condition. The conventional motorcycle consumed 350 mL of Peralite, equivalent to approximately 191.8 Wh/km using the fuel-energy conversion stated in the report. The converted motorcycle consumed 5.1 Ah from the 72 V battery, corresponding to approximately 22.3 Wh/km at the battery side. The resulting calculated reduction in input energy per kilometre was approximately 88.4%. In economic terms, the reported operating cost decreased from Rp 250/km to Rp 36/km, representing an approximately 85.6% reduction. These results support the potential of motorcycle conversion as a practical approach for lowering daily energy demand and operating expenditure. Further work should use repeated tests under controlled speed, load, route, and measurement points, and should include charger losses and direct mechanical-output measurements to establish a rigorous end-to-end efficiency value.

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