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Electrifying Mobility: A Smart Conversion of a Go-Kart to Electric Drive

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ABSTRACT – *The global shift towards sustainable transportation has catalyzed interest in electric vehicle (EV) technologies across all scales, including recreational and educational platforms. This project presents the design and fabrication of an electric go-kart through the systematic conversion of an existing internal combustion engine (ICE)-powered unit. The main objective is to develop a zero-emission, energy-efficient go-kart while enhancing performance and safety. The process begins with the removal of ICE components such as the engine, fuel tank, and exhaust system. A brushless direct current (BLDC) motor is selected for its high torque-to-weight ratio, efficiency, and low maintenance. A lithium-ion battery pack, motor controller, and throttle system are integrated to complete the electric drivetrain. Custom mounts and housings are designed and fabricated to accommodate the new components while ensuring proper weight distribution and structural integrity. The converted go-kart is expected to achieve a top speed of 40–60 km/h, a range of 20-40 km per charge, and improved torque delivery compared to the original ICE configuration. Additional expected outcomes include quieter operation, reduced maintenance, and lower operational costs, contributing to a more sustainable and cost-effective mobility solution. Performance testing will validate these targets while ensuring the system meets essential safety and durability standards. This project showcases the viability of small-scale electric mobility solutions and serves as a practical educational platform for students to engage with real-world applications of green technology and smart vehicle systems.*

KEYWORDS: Electric Vehicle (EV), go-kart, Brushless DC Motor (BLDC), sustainable transportation, energy efficiency

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1. INTRODUCTION

The global commitment to reducing greenhouse gas emissions and dependence on fossil fuels has led to an increased emphasis on sustainable mobility solutions (Mansor, 2018; Filonchyk et al., 2024). Battery electric vehicles (BEVs) have emerged as a leading solution in energy-efficient mobility (Pemberton et al., 2021). This paper presents the electrification of a recreational vehicle platform, a go-kart, using a systematic conversion of its internal combustion engine (ICE) system to a fully electric drivetrain.

The objectives of this project are to develop a zero-emission go-kart and enhance its performance. The converted go-kart is designed to achieve a top speed of 40 to 50 km/h, a range of 20 to 40 km per charge, and improved torque delivery compared to the original ICE configuration. These goals are also aligned with current trends in clean mobility and support broader educational and technological development initiatives. To achieve this, the project adopts a structured approach that integrates mechanical and electrical components, tests them, and analyzes their performance.

The electrification of vehicles, particularly through retrofitting or converting existing internal combustion engine (ICE) platforms to electric drivetrains, has gained significant attention in both academic and industry circles (Nikam & Fernandes, 2014). This growing interest is driven by the potential for sustainability, cost reduction, and innovation in vehicle design. Electric vehicle (EV) conversions offer several advantages, including lower operational costs, improved energy efficiency, and reduced environmental impact, making them a compelling solution for applications ranging from fleet management to educational settings (Sánchez et al., 2024).

Several key studies have laid the groundwork for the technical and conceptual framework of this go-kart electrification project. White (2024) explored the lifecycle costs of converting ICE vehicles to electric drivetrains, highlighting the initial financial challenges of procuring electric motors and batteries, as well as the long-term savings in fuel and maintenance costs.

In parallel, the safety and thermal management of electric drivetrains have been critical areas of research. See et al. (2022) and Jino et al. (2024) investigated thermal regulation systems and safety features in compact EVs, emphasizing the importance of passive and active cooling techniques to maintain battery performance and prevent hazards. Their study recommends integrating intelligent battery management systems (BMS) and redundant safety mechanisms, especially for retrofitted vehicles that may lack standardized components.

Performance enhancement through regenerative braking is another important consideration. Sathishkumar et al. (2021) stated that regenerative braking systems could improve driving range by 10-20% in urban settings, while also reducing brake wear and dissipating thermal energy. This is particularly relevant to electric go-karts, where frequent acceleration and deceleration cycles are typical in educational environments and short-range applications.

Additionally, the pedagogical value of electric go-karts has been highlighted in studies, including those by Lequeu et al. (2007) and Jacques (2017), who demonstrated that these platforms can significantly enhance student engagement and understanding of engineering concepts. The hands-on experience with electric propulsion and control systems aligns with modern educational practices, offering students an opportunity to apply theoretical knowledge in a practical context.

Motor design, specifically the optimization of Brushless DC (BLDC) motors, is another critical element in the electrification of go-karts. Badran et al. (2013) found that refined control algorithms, such as vector control and pulse-width modulation (PWM), can significantly enhance the efficiency and torque output of BLDC motors, which are essential for achieving the desired performance characteristics in small electric vehicles like go-karts.

Together, this project provides valuable insights into the technical, safety, educational, and environmental aspects of converting a go-kart from petrol to electric. By integrating these findings into the project framework, the conversion process can be optimized not only to achieve technical success but also to contribute to broader goals such as sustainability and hands-on engineering education.

2. MOTOR AND BATTERY CALCULATION

To meet the performance objectives of achieving a top speed of 60 km/h and a minimum range of 40 km, theoretical calculations were performed to determine the required motor power and battery capacity (Table 1).

TABLE 1: Performance parameters and power analysis at top speed

PARAMETER	VALUE
Top speed, *v*	60 km/h = 16.67 m/s
Total mass (go-kart + driver), *m*	150 kg
Frontal area (A)	$0.6m^2$
Drag coefficient (Cd)	0.7
Rolling resistance coefficient (Crr)	0.015
Air density (ρ)	$1.225\ kg/m^3$
Gravity (g)	$9.81\ m/s^2$
Efficiency of drivetrain (η)	85%

Power required to overcome aerodynamic drag:

$$P_{\mathrm{aero}} = \frac{1}{2} \cdot \rho \cdot \mathrm{Cd} \cdot \mathrm{A} \cdot \mathrm{v}^3 \tag{1}$$

$= 0.5 \cdot 1.225 \cdot 0.7 \cdot 0.6 \cdot (16.67)^3 = 799.8$ W

Power to overcome rolling resistance:

$$P_{roll} = Crr\,.m\,.g\,.v \tag{2}$$

$= 0.015 \cdot 150 \cdot 9.81 \cdot 16.67 = 758.7$ W

Total mechanical power required:

$$P_{total} = 799.8 + 758.7 = 1{,}558.5\ \mathrm{W}$$

Considering drivetrain efficiency:

$$P_{input} = \frac{P_{total}}{\eta} \tag{3}$$

$$\frac{1{,}558.5}{0.85} = 1{,}835.5\ \mathrm{W}$$

Hence, a motor rated at ≥ 2 kW is suitable for the go-kart to reach and maintain the target top speed under full load.

Battery Calculation:

Target range = 40 km = 40,000 m

$$t = \frac{d}{v} = \frac{40{,}000}{16.67} = 2{,}400 seconds$$

Total energy required:

$$E = P_{input}\,.t \tag{4}$$

$$E = 1{,}833.5 \cdot 2{,}400 = 4{,}400{,}400\ \mathrm{J}$$

Convert to watt-hours:

$$E_{Wh} = E/3600 = 4{,}400{,}400 / 3600 \approx 1{,}222.6\ \mathrm{Wh}$$

Thus, to ensure safe operation and a buffer, a battery with at least 1.5 – 2.0 kWh will be used.

3. METHODOLOGY

3.1 The Dismantling of the Existing ICE Components

The conversion of the petrol-powered go-kart to an electric drive system involved several key phases, beginning with the dismantling of all internal combustion engine (ICE) components. This included removing the engine, fuel tank, and exhaust system using standard mechanical tools. Careful attention was given to maintaining the structural integrity of the chassis throughout the disassembly process. The removed components were recorded and weighed to facilitate comparative analysis and assist in evaluating the effects of the conversion on overall weight and spatial layout.

3.2 Selection, Integration, and Performance Testing of Electric Propulsion System

The BLDC motor and lithium-ion battery pack were selected based on torque output, energy efficiency, safety features, and, most importantly, the available project budget. Integration into the existing go-kart chassis required careful consideration of component fit, thermal management, and secure electrical connections using available materials and fabrication resources. Once all components were fully installed, a series of performance tests were conducted to evaluate the BLDC Motor and battery performance, including dynamic testing to assess real-world performance parameters such as acceleration, responsiveness, and top speed. These tests helped evaluate the overall effectiveness of the BLDC motor and battery system under actual operating conditions. Table 2 summarizes the test parameters and the corresponding methods used for data collection.

TABLE 2: Dynamic performance test

Test Parameter	Measurement Method
Maximum Speed	GPS tracker
Acceleration	Timer
Stability	Real-world testing
Range	Battery discharge test

3.3 Custom Mounting and EV Component Interface

After removing the internal combustion engine components, the installation of the electric drive system began. Custom mounting brackets were created to securely fit the motor and battery pack into the go-kart chassis, ensuring structural integrity and balanced weight distribution. These brackets were fabricated at the Centre for Advanced TVET, UMPSA, using available tools and materials. Once mounted, the motor controller was installed and configured, including current limits and throttle response. A hall-effect sensor-based throttle was also integrated for smooth acceleration control.

3.4 Performance Testing and Evaluation

Performance testing was conducted using a chassis dynamometer to quantify the effectiveness of the electric conversion. This testing, carried out at Kolej Kemahiran Tinggi MARA (KKTM) Kuantan, focused on measuring key performance indicators including top speed, acceleration, and torque output. The collected data provided a basis for evaluating the overall success of the conversion and for identifying potential areas for further refinement in both mechanical and electrical systems.

4. RESULTS AND DISCUSSION

4.1 Components Weight

The removal of internal combustion engine (ICE) components, including the engine, fuel tank, and exhaust system, resulted in a total weight reduction of 29.0 kg (Table 3). In contrast, the installation of electric vehicle (EV) components comprising the BLDC motor, lithium-ion battery pack, controller, wiring, and mounting structures added a total of 14.0 kg (Table 4). This led to a net weight reduction of 15.0 kg. The EV components were strategically mounted to ensure balanced weight distribution and maintain structural integrity. This reduction in total weight, alongside improvements in torque delivery, energy efficiency, and system simplicity, enhances the vehicle’s overall performance. Eliminating complex ICE subsystems, such as the fuel delivery and exhaust systems, further reduces maintenance requirements and mechanical complexity, making the EV setup both efficient and user-friendly.

TABLE 3: Recorded weights of removed ICE components from the go-kart

Component	Weight (kg)	Remarks
Internal Combustion Engine	18	Single-cylinder, 4-stroke
Fuel Tank (with residual fuel)	3.5	Plastic tank, approx. 5L
Exhaust System	4.2	Including muffler and piping
Engine Mounting Brackets	2	Steel frame supports
Fuel Line & Carburetor	1.3	Rubber hoses and small parts
	29.0 kg	

TABLE 4: Recorded weights of installed EV components on the Go-Kart

Component	Weight (kg)	Remarks
BLDC Motor	3	3 kW rated motor
Lithium-Ion Battery Pack	4.5	48V, custom pack with BMS
Motor Controller	2.2	Programmable controller
Throttle Interface (Hall Sensor)	0.3	Includes wiring and mounting
Main Power Wiring & Connectors	1	High-current cables and terminals
Custom Mounting Brackets	3	Fabricated steel mounts
	14.0 kg	

4.2 BLDC Motor, Battery Performance and Dynamic Testing

4.2.1 BLDC Motor

Following the installation of the electric drivetrain, the motor controller was configured to ensure optimal performance and protection of the system’s electrical components. The initial setup set a continuous current limit of 100 A and a peak current limit of 150 A, determined based on the battery's rated capacity and the motor’s thermal tolerance. These limits were essential to prevent excessive current draw under sustained, high-load conditions, particularly during acceleration. Additionally, voltage parameters were carefully configured, including a low-voltage cut-off at 48 V to prevent deep battery discharge and an over-voltage threshold at 60 V to protect the system from potential surges or regenerative braking effects.

To evaluate the thermal performance of the 48V BLDC motor under these configured conditions, a temperature test was conducted by operating the motor at full throttle for approximately three minutes. During this test, the motor's surface temperature was continuously monitored. The results (Figure 1) showed a steady increase in temperature; however, the readings remained well within the manufacturer's specified safe operating limits. This indicates that the motor's internal cooling design and thermal management were effective in dissipating heat even under full-load operation. Stable thermal behavior under stress supports the motor’s reliability for continuous, demanding use, further validating the appropriateness of the current and voltage settings applied during configuration. Overall, the integrated control and thermal testing confirm the motor’s suitability for electric drive systems requiring consistent performance and efficient thermal regulation.

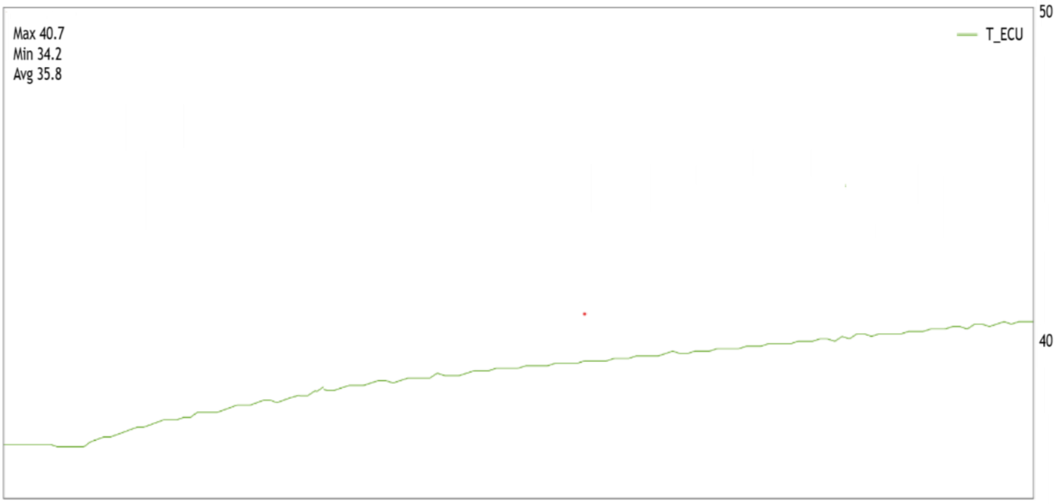


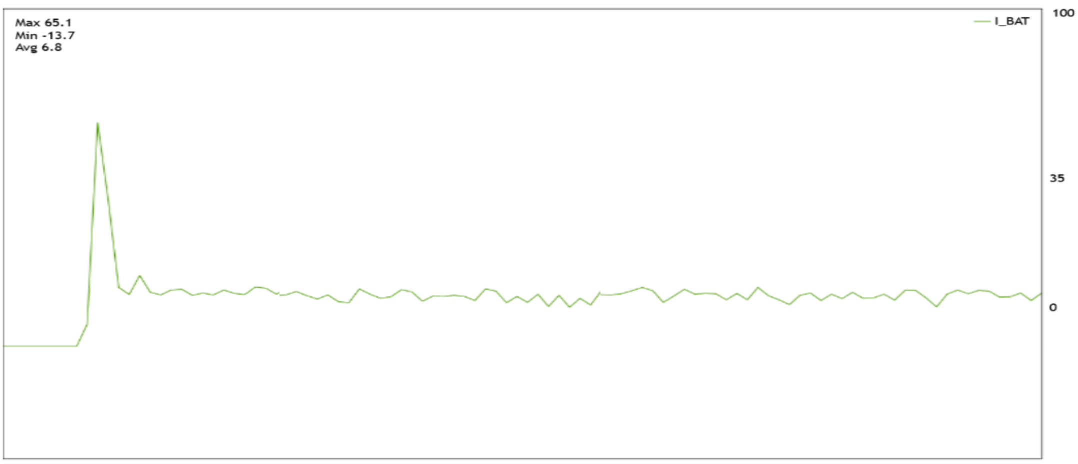
FIGURE 1: Temperature test results

4.2.2 Battery Performance

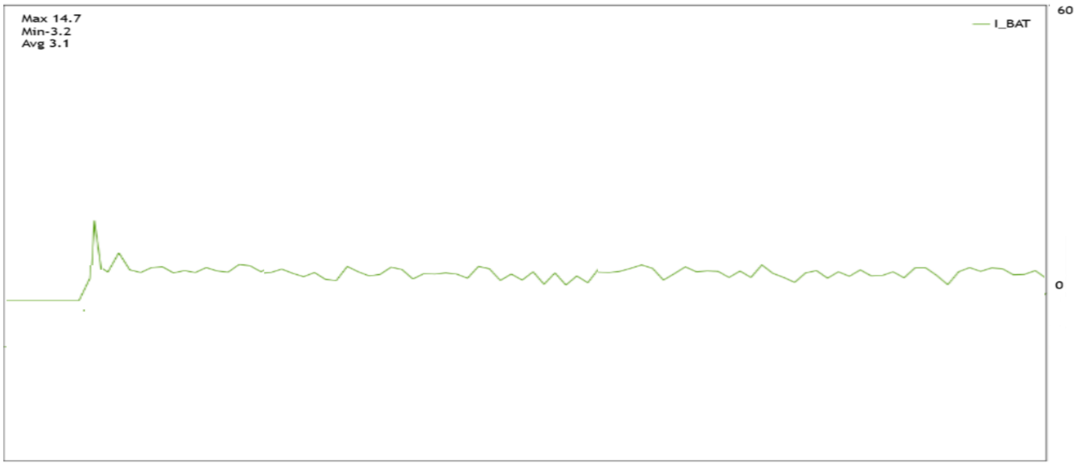
The 72V 40Ah lithium-ion battery was evaluated for current draw under various driving conditions and overall battery efficiency, and the results are shown in Table 5 and Figure 2. Testing included scenarios such as full acceleration, low-speed cruising, and idle motor operation. Additionally, assessments were conducted with the drive tire rotating freely without contact with the ground or road surface to establish a baseline current draw and observe the drivetrain's unloaded performance. These tests provided valuable insights into the energy consumption characteristics and helped estimate the practical driving range and performance of the electric go-kart under real and simulated conditions.

TABLE 5: Battery performance results

Condition Current	Power Draw	Max Current	Range (km)
Full acceleration	4.3 kW	65.1A	37
Cruising (25 km/h)	0.9 kW	14.7A	52



(a)



(b)

FIGURE 2: Battery performance – (a) Full acceleration; and (b) Cruising (25 km/h)

4.2.3 Dynamic Testing

Dynamic tests were conducted to evaluate the go-kart's performance under the UMPSA road conditions. Despite achieving stable handling, the maximum speed of 59 km/h was lower than the desired 60 km/h due to the additional weight of real components. The results are summarized in Table 6 (also Figure 3).

TABLE 6: Dynamic test results

Test Parameter	Measurement Method	Results
Maximum Speed	GPS tracker	59 km/h
Acceleration (0–60 km/h)	Timer	6.9 seconds
Range	Battery discharge test	39 km
Stability	Real-world testing	Stable

FIGURE 3: The GPS tracker interface for dynamic testing displays

4.3 Installation of EV Components

To support the electrical configuration and performance evaluation, two visual references were included: a simplified wiring diagram (Figure 4) and an annotated image of the converted go-kart (Figure 5). Figure 4 illustrates the connection between the 48V battery pack, BLDC motor, motor controller, and Hall-effect throttle sensor.

Meanwhile, Figure 5 presents a photograph of the actual go-kart with clearly labelled EV components, including the battery pack, controller, motor, and throttle. This visual validates the custom mounting strategy discussed earlier, demonstrating effective integration and balanced weight distribution within the chassis. The annotations enhance clarity, showing how each component was positioned for performance and accessibility.

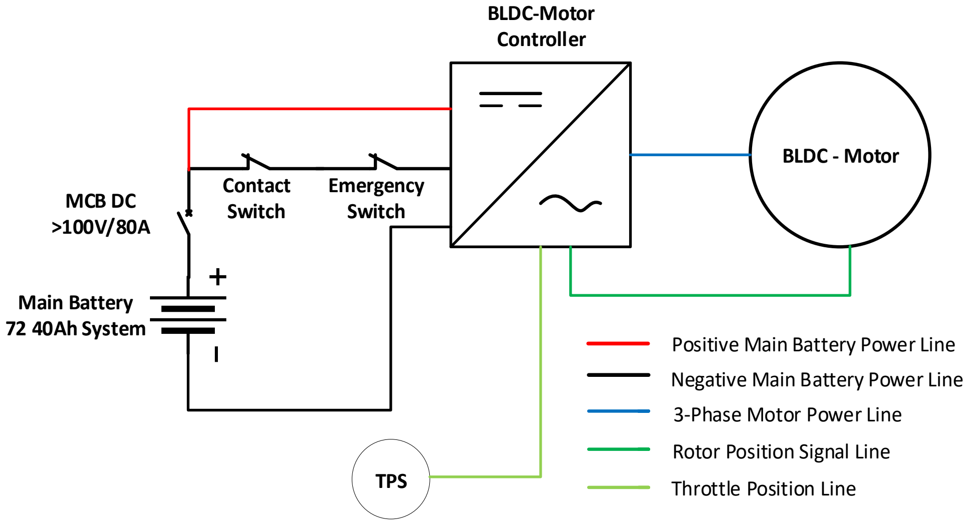


FIGURE 4: EV Go-Kart wiring diagram

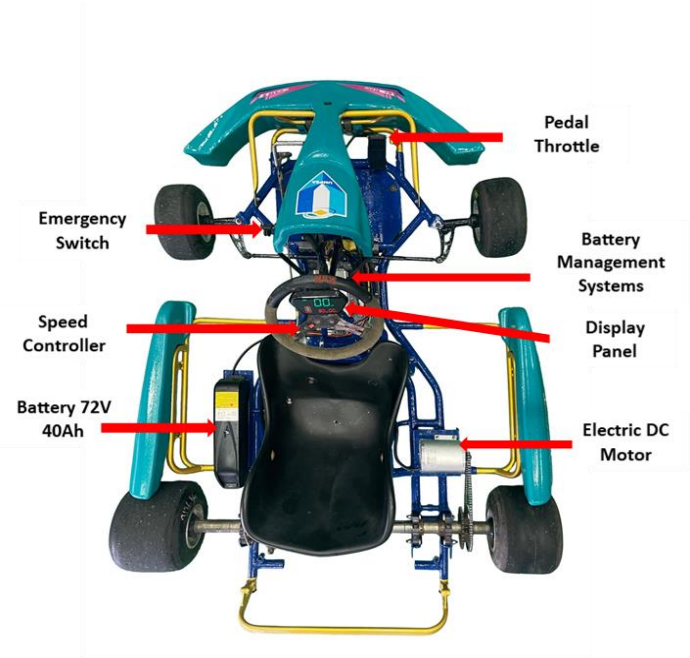


FIGURE 5: Physical layout of the EV go-kart with labeled components

4.4 Dynamometer

The comparison between ICE- and EV-powered go-karts, as illustrated in Figure 6 (also Figure 7), reveals distinct performance characteristics resulting from their fundamentally different drivetrain technologies.

Firstly, the ICE go-kart achieves a higher top speed (65 km/h) than the EV go-kart (55 km/h). This outcome is expected as internal combustion engines, particularly those with higher peak horsepower, often maintain stronger performance at higher RPMs, enabling greater top-end speed. The EV go-kart, while slightly lower in top speed, focuses more on acceleration and torque delivery, characteristics typical of electric drivetrains.

The acceleration performance (measured from 0-40 km/h) clearly favors the EV go-kart, which completes the sprint in just 4.0 seconds, compared to 6.5 seconds for the ICE go-kart. This significant improvement in acceleration can be attributed to the instantaneous torque delivery inherent in electric motors, which provides immediate thrust without the need for engine revs to build up. Conversely, ICE engines generally require a build-up of RPM to reach their optimal torque output, resulting in slower initial acceleration.

In terms of peak torque output, the EV go-kart again outperforms the ICE go-kart, producing 45 Nm versus 15 Nm. This threefold increase in torque highlights the efficiency and responsiveness of electric drivetrains, especially at low speeds where maximum torque is available immediately. The ICE go-kart, while sufficient for recreational use, cannot match the torque density of the electric motor, resulting in slower acceleration and reduced pulling power at low speeds.

Overall, the data suggests that the EV go-kart provides superior acceleration and torque performance, making it better suited for applications requiring quick, responsive handling, ideal for kart racing in tight circuits or short tracks. However, the ICE go-kart retains an advantage in top speed, which might benefit situations requiring sustained high-speed performance. This comparison highlights the growing potential of electric powertrains in small vehicle applications, particularly where rapid acceleration and high torque are prioritized over maximum speed.

However, the chassis dynamometer results showed higher performance values, such as top speed and acceleration, compared to those observed during dynamic road testing. This difference can be attributed to the controlled and optimized testing environment provided by the dynamometer. Unlike real-world conditions, dynamometer testing eliminates external variables such as road surface irregularities, air resistance, tire slippage, and incline gradients. As a result, drivetrain components operate under ideal load conditions, allowing for more accurate and often higher performance readings. In contrast, dynamic tests are influenced by real-world factors that increase rolling resistance and aerodynamic resistance, resulting in slightly lower acceleration and torque measurements.

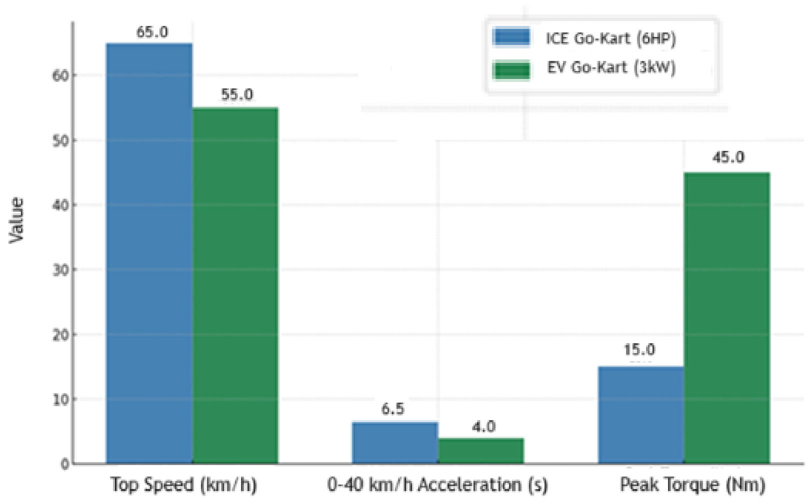


FIGURE 6: Chassis dynamometer result ICE versus EV go-kart

FIGURE 7: Performance testing of the Electric go-kart (EV) using a chassis dynamometer

5. CONCLUSION

The project successfully achieved its primary goal of converting a conventional internal combustion engine (ICE) go-kart into a fully functional electric vehicle (EV). The conversion process, which involved installing a 48V BLDC motor, a motor controller, and a throttle interface, resulted in a go-kart capable of reaching a top speed of 59 km/h, within the desired performance range. Although the achieved driving range was 39 km, slightly below the target of 40 km, the overall system efficiency and reliability remained consistent throughout testing.

Performance evaluation revealed that the electric go-kart outperformed the original ICE version in terms of torque, acceleration, and top speed, highlighting the advantages of electric propulsion in dynamic response and drivability. Most importantly, the shift to electric drive supports sustainable mobility, as EVs produce zero tailpipe emissions, making them significantly more environmentally friendly than fossil-fuel-powered systems. Overall, the project demonstrates the viability of small-scale EV conversions and their potential contribution to cleaner, greener transportation solutions.

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