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Electric Trishaw (E-Becha): A Sustainable Urban Mobility Solution for Tourism

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Abstract
This project presents the design, development, and implementation of an electric trishaw (E-Becha) as a sustainable urban mobility solution. Based on the traditional pedal-powered trishaw design, this electric version integrates modern electric propulsion technology to overcome limitations such as physical strain, limited capacity, and environmental impact. The E-Becha is designed to cover 20–40 km per charge, with a maximum speed of 15–30 km/h and a passenger load capacity of up to 200 kg. The development process includes design conceptualization, component selection, prototype fabrication, performance testing, and continuous improvement. Emphasis is placed on safety, durability, and user accessibility. By reducing carbon emissions and providing a reliable short-range transport option, the E-Becha contributes to a cleaner, more inclusive, and efficient urban environment.

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1. Introduction

The trishaw is a traditional mode of transport in Malaysia with deep historical and cultural value, particularly in heritage-rich states like Terengganu. Trishaws are more than just transportation they are cultural icons and popular tourist attractions in areas such as Pasar Payang, Kampung Cina, Pulau Warisan, and Dataran Shahbandar. However, the use of conventional pedal-powered trishaws has declined due to the physical effort required, making them less practical in hot weather or for medium-range journeys. This affects tourism appeal and urban mobility.

To address these issues, the introduction of electric trishaws (E-Becha) offers a sustainable and innovative solution. Unlike traditional trishaws that rely solely on human effort, E-Becha uses throttle-based electric drive, reducing fatigue and enhancing usability. This initiative aligns with efforts to implement eco-friendly transportation that supports sustainable tourism development in Terengganu.

The introduction of an electric trishaw (E-Becha) is seen as an innovative and sustainable solution to the issues faced by traditional trishaws. Unlike the conventional version, which relies on continuous physical exertion from the rider, the E-Becha operates using a throttle-based system, significantly reducing fatigue and enhancing driving efficiency. This innovation aligns with efforts to introduce environmentally friendly transportation systems that support sustainable development and green tourism initiatives in Terengganu.

According to Gössling, the adoption of electric transportation in tourism areas helps reduce air pollution, noise, and traffic congestion, thereby improving the overall tourist experience and reinforcing the destination's image as a sustainable tourism site [1]. This is further supported by the UNWTO, which highlights the importance of low-carbon transport in achieving global tourism development goals that are more inclusive and resilient [2].

This project aims to design and develop an electric trishaw that is practical and suitable for urban tourism settings like Terengganu. The development process involved the use of engineering software such as Autodesk Inventor for designing trishaw components. Subsequent phases included mechanical and electrical work to build a fully functioning E- Becha prototype. Finally, real-world testing was conducted to evaluate the performance and durability of the system. It is hoped that this project will act as a catalyst for broader adoption of electric trishaws in the local tourism sector, thereby contributing to greener, more sustainable urban transportation.

Figure 1. Traditional trishaw in Kuala Terengganu

The scope of the E-Becha project includes key aspects such as design, development, testing, and implementation in rural and paved road environments. The main goal is to construct an electric trishaw that is usable in real-world conditions while meeting user expectations for efficiency, safety, and comfort. Every aspect of the design and component selection was focused on producing a vehicle that is user-friendly, low-maintenance, and capable of supporting sustainable mobility in both tourism and rural community contexts.

The electric trishaw developed in this project is designed to carry a maximum load of approximately 200 kg, making it suitable for transporting two passengers at a time. Physically, the trishaw measures two meters in length and one meter in width, providing adequate space for passengers and ensuring stability during movement. The vehicle uses a 48-volt lead-acid rechargeable battery as the primary power source and is powered by a 250-watt Brushless Direct Current (BLDC) motor.

2. Literature Review

In the context of sustainable development, the tourism transport sector plays a critical role in enabling efficient and eco-friendly travel for visitors. One increasingly adopted solution is the use of electric trishaws, especially for short-distance travel in tourist hotspots. In tourism-focused cities like Kuala

Terengganu, visitors frequently engage in short excursions to heritage sites such as Kampung Cina, Masjid Kristal, and Pasar Payang. These short- distance trips do not require large, high-speed vehicles and are better served by lightweight modes of transport like trishaws, which also offer authentic local experiences.

However, conventional manually pedaled trishaws are limited by human physical endurance, fatigue, and their capacity to carry passengers over extended periods. This is where electric trishaws become highly relevant. Research by Gössling shows that lightweight electric transportation, such as e-trishaws, can reduce both carbon emissions and noise pollution in dense tourist areas [1]. Moreover, they enhance rider and passenger comfort while preserving the cultural aesthetics of the traditional trishaw.

The adoption of Brushless Direct Current (BLDC) hub motors has become widespread in light electric vehicles such as e-bikes, scooters, and electric trishaws due to their energy efficiency, compact size, and minimal maintenance requirements. These motors operate without carbon brushes, offering quieter and longer-lasting performance [3]. For electric trishaws, BLDC hub motors are particularly effective because they are embedded directly in the wheel (in-wheel motors), eliminating the need for chains or external transmission systems and reducing mechanical energy losses. According to Hasan et al, BLDC hub motors rated between 250W to 750W are sufficient to carry loads up to 150 kg at an average speed of 25–30 km/h [4].

Additionally, the combination of BLDC motors with lithium-ion batteries provides significant technical advantages. Motors in the 250W to 750W range can propel electric trishaws smoothly without pedaling, making them ideal for short-range travel (2–5 km), which is typical for daily tourism activities [5]. The use of 48V lithium-ion batteries extends operational life and allows for faster recharging, enabling tourism operators to use the vehicle efficiently with minimal maintenance costs [6].

In terms of performance, BLDC hub motors offer smoother speed control and are well-suited for quiet, low-emission operation in historical or tourism-heavy areas like Terengganu. Ahmad et al. reported that BLDC-powered electric trishaws perform well in short-distance and tourism-oriented applications [7]. Figure 2 shows the front wheel of the electric trishaw (E-Becha) equipped with a Brushless Direct Current (BLDC) hub motor, which serves as the primary propulsion system for the vehicle.

Figure 2. BLDC hub motor

In countries like India and Thailand, electric trishaws have significantly improved access to heritage and urban tourist zones without compromising the environment [8]. These successful implementations serve as valuable models for regions such as Terengganu, which seek a balance between tourism development and environmental preservation. By deploying electric trishaws for short-distance transport, the tourist experience can be made more sustainable, inclusive, and enjoyable. Previous literature clearly indicates that electric trishaws are not only technically feasible but also hold great promise for strengthening local tourism economies through greener and more pleasant visitor mobility.

3. Methodology and Components

The development methodology for the E-Becha project involves several key phases, carried out in stages to ensure the final product meets the desired criteria in terms of design, functionality, and safety. The approach integrates practical engineering methods, including CAD design, component selection, mechanical and electrical system assembly, as well as performance and durability testing. These steps are outlined in the E-Becha project flowchart in Figure 3.

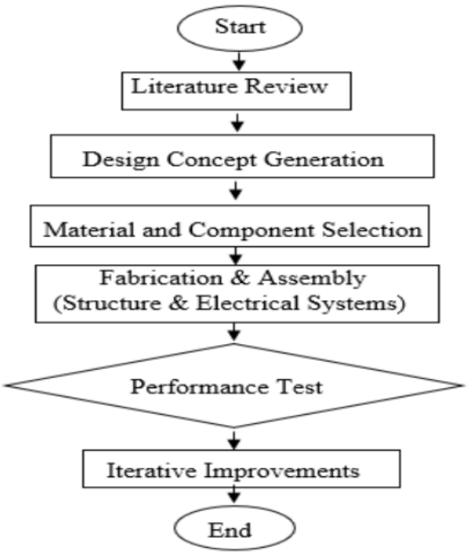

Figure 3. Flowchart of E-Becha project

3.1 Conceptual Design

Autodesk Inventor software was used to generate the conceptual design of the passenger seat frame. This phase involved designing the basic structure of the electric trishaw, taking into account ergonomics, dimensions, a maximum load capacity of approximately 200 kg, and the ability to accommodate two passengers. A three-dimensional technical drawing was produced to guide the fabrication process. Figure 4 shows the design of the two-passenger seating frame mounted on a 24-inch wheel bicycle. Figure 5 illustrates the final design of the E-Becha, complete with the BLDC hub motor, passenger seating, and roof structure.

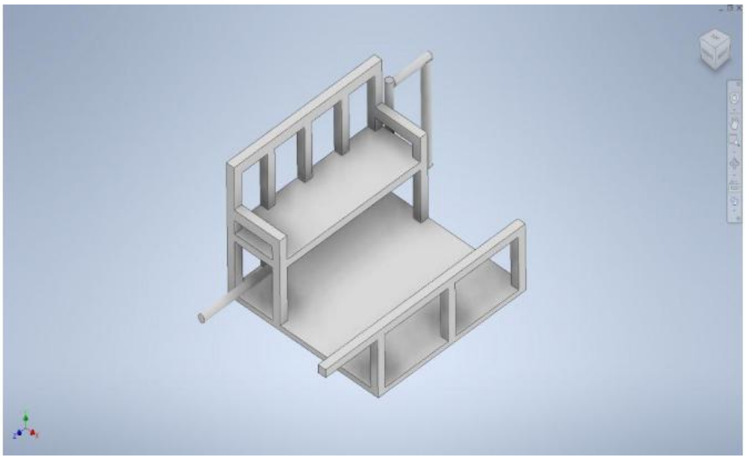

Figure 4. The design of the two-passenger seating frame

Figure 5. Final design of the E-Becha

3.2 Components Used

The main components used in constructing the E-Becha are as follows:

1. A bicycle with 24-inch wheels
2. Brushless Direct Current (BLDC) hub motor, 250W, 32–48V
3. Electronic Speed Controller (ESC) and electric throttle
4. Four 12V lead-acid rechargeable batteries
5. Hollow mild steel (1"x1" and 1"x2") for the trishaw frame

3.3 Fabrication Process

1. Design and Component Preparation
   The complete design is referenced, including frame dimensions, component layout, and seating arrangement.
2. Cutting Steel Tubes
   Hollow steel tubes are cut to size according to the technical drawing using precision metal cutters.
3. MIG Welding
   MIG welding is used to construct the main seating frame and roof structure, selected for its strength and clean finish.
4. Frame Assembly
   The main bicycle frame is integrated with the passenger seat chassis to form the complete E-Becha structure.
5. Electrical Component
   Layout and Adjustment Battery pack measurements are taken, and mounting locations are optimized at the rear to balance the weight.
6. Chassis Enclosure
   Metal plates are cut and installed to cover the chassis and protect internal components.
7. Seat Installation
   Rider and passenger seats are mounted using bolts and support frames for stability and comfort.
8. Electrical Wiring
   Wiring connects the controller, battery pack, motor, and additional electronics (lights, switches, horn, battery display).
9. Painting
   The frame is coated with anti-corrosion paint, followed by decorative finishing for visual appeal.
10. Performance Testing
    Tests are conducted to evaluate maximum speed and battery endurance under real-world conditions.

Figure 6. Completed E-Becha

4. Testing and Results

In this E-Becha project, a 250W Brushless Direct Current (BLDC) hub motor was selected due to its suitability for tourism applications that demand quiet, smooth, and energy- efficient operation. The BLDC motor is known for high efficiency, direct torque transmission to the wheels, and low maintenance compared to traditional brushed motors. The hub motor design eliminates the need for an external transmission system such as chains or belts, simplifying the drivetrain and improving overall energy efficiency. This efficient power delivery helps maximize battery usage, extending the operational range per charge.

4.1 Performance Testing

To evaluate the real-world performance of the BLDC motor used in the E-Becha, a series of tests were conducted under varying passenger numbers and total load conditions. These tests were conducted on a flat test track over a distance of 100 meters to ensure consistent and reliable performance results. Table 1 summarizes the measured operating speeds of the E- Becha corresponding to different total weights, comprising the rider and passengers. The results indicate a clear trend: as the total mass increases, the operating speed of the E-Becha decreases significantly. This performance drop is attributed to the additional energy demand placed on the motor to overcome the added inertia and rolling resistance.

Table 1. E-Becha Speed Based on Total Rider and Passenger Weight

Total Weight (kg)	Speed (km/h)
60	30
110	22
150	15

The table shows the relationship between total load (combined weight of rider and passenger) and the resulting speed of the E-Becha during testing. As the weight increases, a significant drop in maximum speed is observed. These findings highlight the direct impact of passenger and load weight on the efficiency and performance of the electric trishaw. Understanding this relationship is essential for determining safe and efficient operating limits, particularly in urban tourism environments with variable passenger loads.

The E-Becha demonstrates a negative correlation between total load and speed. When the total weight is light (60 kg), the vehicle reaches a top speed of 30 km/h. However, as the load increases to 150 kg, the speed drops to just 15 km/h a 50% reduction. This trend suggests that the current motor and power system may be underpowered for heavier loads, highlighting a potential area for future enhancement.

4.2 Speed vs. Load Relationship

A graph was plotted (Figure 7) to illustrate the linear relationship between load and speed. A linear regression model was applied to estimate behavior beyond tested weights. The extrapolated result suggests that at around 210 kg, the speed would fall below 5 km/h indicating the upper limit for practical operation. To ensure optimal performance and motor health, a maximum recommended load of approximately 190–200 kg is proposed. This finding is essential for determining the target user capacity and planning for safe operation in tourism zones.

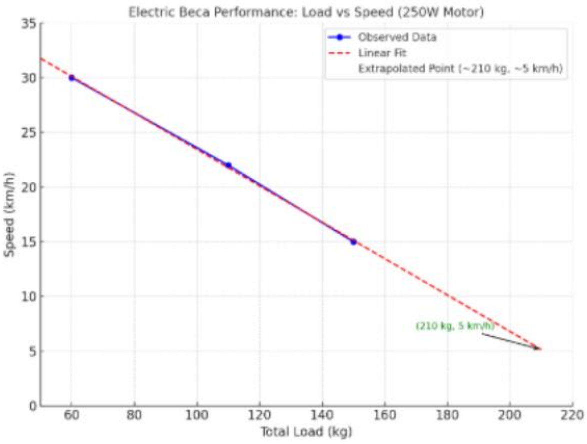

Figure 7. Load vs Speed of E-Becha Graph

4.3 Factors Affecting Motor Performance

While the motor’s load-handling capability is a major performance factor, it is also highly dependent on the voltage level of the battery. Higher voltage allows the motor to produce more torque, improving its ability to carry heavier loads or travel uphill. Conversely, when the battery voltage drops (due to low charge), the motor's performance also decreases. Hence, proper battery management and selection of a battery system with the right voltage and capacity are critical to ensure optimal and consistent performance.

5. Conclusion

The E-Becha project successfully achieved its primary objective of developing a trishaw powered entirely by electricity. By eliminating traditional transmission systems such as chains or belts, the design significantly simplifies maintenance and reduces long-term operating costs. Aesthetically, the E-Becha’s clean and modern appearance makes it especially suitable for use in urban and coastal tourist environments.

In terms of performance, the E-Becha demonstrated consistent operation, comfortably supporting up to three adults (one rider and two passengers). The 250W electric motor provides sufficient power for low-speed travel on flat terrain, which is typical in many tourism zones. However, for use in hilly areas or with heavier loads, enhancements such as higher-capacity batteries or solar power assistance are recommended to maintain optimal performance.

Notably, the E-Becha retains the option for manual pedaling, which is an added advantage when the battery is depleted or operating at low voltage. To ensure smooth electric operation, the battery must be fully charged prior to use. Regular full charging not only helps maintain consistent performance but also extends the lifespan of the battery and motor system.

While the E-Becha performs well on flat surfaces at moderate speeds, there is room for further improvement, especially in load-bearing and uphill travel capabilities. One promising recommendation is the integration of solar energy systems. Installing solar panels on the E-Becha's roof can provide continuous charging during operation, reducing full dependency on wired charging. This not only extends the operational range but also aligns with the use of renewable energy in support of sustainable development goals. Furthermore, incorporating this technology can enhance the commercial appeal and environmental value of the E-Becha within the eco-tourism sector.

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