

# Design and Develop an E-Rickshaw as a Sustainable Energy Solution

MCP Dissanayake<sup>1#</sup>, KREMSB Ekanayaka<sup>1</sup>, RDMHM Ariyaratne<sup>1</sup>, and MCH Chandrasiri<sup>1</sup>

<sup>1</sup> Faculty of Engineering, General Sir John Kotelawala Defence University, Sri Lanka.

#<[dissanayakemcp@kdu.ac.lk](mailto:dissanayakemcp@kdu.ac.lk)>

**Abstract**— Sustainable energy alternatives for local transportation are explored in this research paper via the lens of electric rickshaws. Rickshaws are often utilized for local transportation. With a focus on reducing negative impacts on the environment and promoting sustainable mobility, the goal is to create alternatives to traditional automobiles that operate on fossil fuels that are both ecologically benign and economical. In the article's first portion, the importance of finding new ways to use energy in the transportation sector is discussed. After that, the article focuses on the rise of rickshaws as a cleaner alternative to traditional automobile. The low cost and the ability to carry a few passengers at once make rickshaws ideal for short trips in heavily populated regions with high levels of air pollution. This paper provides information on the design of electric rickshaws, including the structure, power transmission, power modes, controllability, and stability of the vehicles. The section titled "Findings and Discussion," emphasize many advantages of electric rickshaws as well as the opportunities for their broad use. Countries like Sri Lanka, who embrace this environmentally friendly and economically viable alternative, stand to gain considerable economic, social, and environmental advantages. The effective execution of this project will help to the creation of a transportation system that is more environmentally friendly and efficient in its use of energy, as well as solve the urgent problems of urbanization, pollution, and resource depletion

**Keywords**— e-rickshaw, sustainable energy solution, transportation, clean energy, environmental impact

## I. INTRODUCTION

The transportation industry is responsible for a significant portion of the world's total energy consumption as well as emissions of greenhouse gases (GHG). The formation of GHGs is basically occurred due to the hydro carbon fuels and the transportation industry causes directly and indirectly to that. The demand for alternative modes of transportation that are both sustainable and environmentally friendly are rising importance as worries about climate change and energy security intensify. E-rickshaws, which use renewable energy instead of fossil fuels, are a realistic choice (Saha, et al., 2011). This article examines electric rickshaws as green local transportation to offer convenient, affordable, and ecologically responsible transportation alternatives.

## II. DESIGN AND DEVELOPMENT

### A. Rickshaw Design

The electric rickshaw's sturdy yet lightweight structure can transport persons and cargo. Eco-friendly wind-resistant, user-comfortable, and secure materials make the exterior durable. Seating, storage, and other amenities are available to passengers.

### B. Power Setting

An electric rickshaw driver may pick from many power levels to suit the vehicle's demands and load. The electric motor may power the front wheel, making the vehicle a motor-assist vehicle. When the electric motor is the only source of propulsion, it may be used. When picking between power modes, energy economy, battery life, and user preferences are all taken into consideration.

At least one of these four unique modes of motion must be present in a hybrid engine. The device may carry signals from the primary mover, such as the motor or pedal, to the wheel. Alternatively, the motor or pedal may stay idle, and the rickshaw may be displaced by the inclination of the road, inertia, or physical impact. Traction would be delivered from the tire to the pedal as a consequence (Saha, et al., 2011). The following are some possible classifications for these motions.

- i. Pedal fixed with motor forward motion (Fully electric mode)
- ii. Pedal forward motion with motor forward motion (Hybrid mode)
- iii. Pedal forward motion with motor fixed (Fully human effort)
- iv. Pedal fixed with motor fixed (idle and motion due to inclination)

To find the hybrid solution, picking a motor and driving mechanism should be done wisely. It is essential to take into consideration the power output, which is determined by both the speed and the torque. The motor must be able to provide an adequate amount of torque both while it is starting up and when it is operating normally. Again, the speed of the motor is a crucial consideration, and it shouldn't be too high or unmanageable, nor should it need a significant drop in speed. The motor's performance must be consistent over a significant amount of time without degrading in any way. The economy and the amount of demand in the market both have an impact on the price and availability of motors.

### C. Electrical equipment

Some electrical components are employed because they are necessary for the operation of the electric propulsion system in a secure manner. These components are as follows: an electric motor, a DC battery, an electric relay, a push-button switch, a fuse, and an ammeter. Also, the system is provided with a solar panel and an inverter to facilitate self-charging capability (Saha, et al., 2011). The characteristics of the electrical components are detailed in Table 1, along with the expected lifespan of the system.

Table 1: Specification and endurance of the electrical system

Description	Specification
Battery capacity	36V, 8.7 Ah
Charging time	3.0 hours
Motor structure	Gear drive
Rated power	250W
Motor efficiency	>80%
Top speed	32km/h
Max torque	30 Nm

Source: KF 30S E-Bick kit manual

### D. Power Transmission

The electric rickshaw's power transmission system is very important to the vehicle's overall performance and effectiveness. In order to do this, an electric motor, adequate batteries, and an appropriate transmission need to be integrated. It is crucial to choose a motor and battery system that is efficient to achieve optimum power conversion and range. When the pedal assist mode is engaged, the pedal and chain are calibrated to efficiently transmit the rider's power to the bicycle's rear wheels by taking into consideration variables such as torque, speed, and gear ratios.

### E. Electrical Transmission

A motor that is mounted in the front wheel provides front-wheel drive while the rickshaw is in electric driving mode. On the reverse side of the rider seat the battery has been integrated. These electrical components are linked together by a cable in order to control and run the system that is propelled by the motor. A battery is used to power the motor, which is then connected to a relay, which keeps the switches from overheating. The motor receives its power from two potentiometers, which allows for a changeable amount of power to be sent to the motor. This switch makes commutation control of the motor simple and ensures its safe functioning.

### F. Pedal power transmission – Design 1 (Old design)

The chassis has become the skeleton of the vehicle. The chassis is responsible for holding all the parts of the rickshaw, such as a motor battery, power transmission mechanism wheels etc (Harsh, et al, 2019). In the initial design, the technique of transferring pedaling power in the electric rickshaw consisted of a pedal sprocket, an intermediate sprocket, and a rear wheel sprocket, all of

which were linked by chains. The design uses a fixed ball assembly found in a fixed hub.

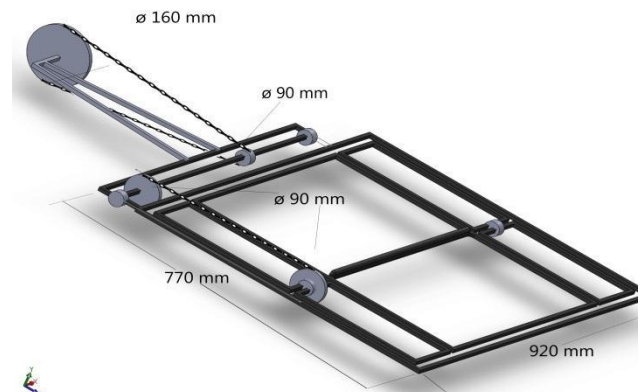


Figure-1. SOLIDWORKS design for the fabrication of power transmission arrangement of design 1 (old design)

Source: Developed by researchers

Because of the way that this mechanism is set up, the user must provide a pedaling force to the pedal lever wheel. The rotation is then sent through a chain to the intermediate pinion in order to complete the transmission. The motion is transferred to the sprocket for the back wheel by another chain, which is located on the intermediate sprocket. The electric rickshaw moves ahead thanks to the back sprocket, which is connected to the wheel.

An intermediate pinion was fitted, allowing the gear ratio to be modified. Depending on the desired amount of pedaling power and the road conditions, the designer may choose the optimal gear ratio by adjusting the size of the idler sprockets. The electric rickshaw benefits immensely from this mobility and adaptability. A typical ball system is used inside the scooter's hub, which allows for efficient energy transfer while also reducing friction.

Nevertheless, this approach calls for a greater number of chains and sprockets, which results in a more intricate design. Because of this complexity, the likelihood of a mechanical failure is increased, and more regular maintenance is required. When there are more chains and sprockets, the system requires more maintenance than when it is simpler. It is essential that chains and sprockets be subjected to routine maintenance, including inspection, lubrication, and adjustment, in order to guarantee smooth functioning.

### G. Pedal power transmission – Design 2 (New Design)

The componentry includes a pedal wheel and a single sprocket that is chained directly to the back wheel of the rickshaw. Additionally, the construction of this system necessitates the installation of bearings on both sides of the rear axle.

The pedal step wheel is subjected to the force that the operator applies to the pedals as part of this configuration. The rotational motion that is created by a cyclist's pedaling is communicated by a chain to a sprocket that is linked to the rickshaw's rear wheel. The sprocket that propels the rickshaw ahead is responsible for transmitting power to the back wheel of the rickshaw.

### III. RESULTS AND DISCUSSION

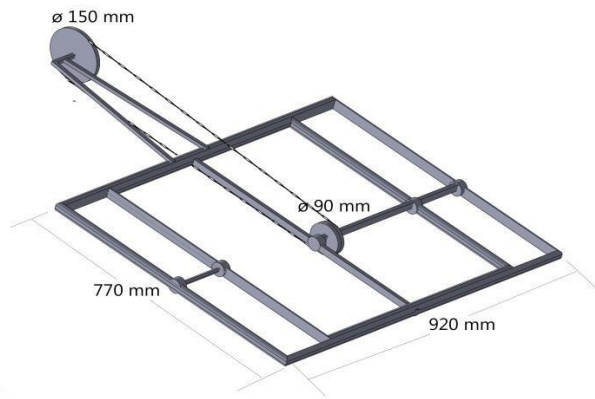


Figure-2. SOLIDWORKS design for the fabrication of power transmission arrangement of design 2 (new design) Source: Developed by researchers

Since the pedal wheel is attached directly to the sprocket, the transmission of power is efficient, and the quantity of energy lost is minimal. This effectiveness allows the rider to put more of their pedaling power to good use.

The new method is simpler to assemble and maintain because of its well-defined structure and minimal moving parts. A single sprocket and a direct chain connection between the pedal wheel and the rear wheel reduce the workload on the motor and the likelihood of a breakdown. As a result of the simplicity of the new method, the number of individual parts required is much less, which in turn reduces the cost of production. Furthermore, the expenses of maintenance and component replacement are often not excessive.

The use of bearings on both sides of the rear axle helps to minimize friction, which in turn leads to smoother steering and improved overall performance. This not only improves the way energy is transferred but also extends the system's lifespan significantly.

Because there is just one sprocket, the gear ratio is always the same, which makes it difficult for the rider to provide the appropriate amount of power for the given terrain and circumstances.

#### H. Stability and Controllability

The safe functioning of an electric rickshaw relies heavily on the driver's ability to maintain stability and control. The weight distribution, suspension, and braking system have all been thoughtfully developed in order to provide a ride that is both secure and pleasant for the passenger(s). Both the steering gear and the handling qualities have been developed to make navigating through urban situations easier. Both of these designs were put through their paces in terms of their maneuverability under varying speeds in order to guarantee that they are both stable and capable of being controlled.

Traditional vehicles that run on fossil fuels have a number of disadvantages that are mitigated by the design and development of the electric rickshaw. When clean energy sources are used, the amount of greenhouse gas emissions and air pollution that are produced are cut down, which helps contribute to an environment that is both healthy and sustainable. An electric rickshaw is a practical mode of transportation, particularly for trips of a shorter distance that take place in places with a high population density. The convenience and availability of electric rickshaws are further increased when charging infrastructure, such as solar grid systems, is readily available. The 'Results and Discussion' section includes statistics on the energy efficiency, performance, and user acceptability of the e-rickshaw, as well as highlighting its potential as a sustainable energy solution.



Figure-3. Performance of Design 1 (old design) and Design 2 (new design) E-rickshaw's Source: Captured by Researchers

The performance of the E-rickshaw was evaluated while it was being driven on a level road with the appropriate amount of tire pressure. In the absence of wind, the vehicle was driven at a speed of around 25 kilometers per hour while carrying a driver weighing 60 kilograms and two passengers weighing 60 kilograms each.

- 1) Comparative study for design 1(old design) with one 8.7 Ah battery:

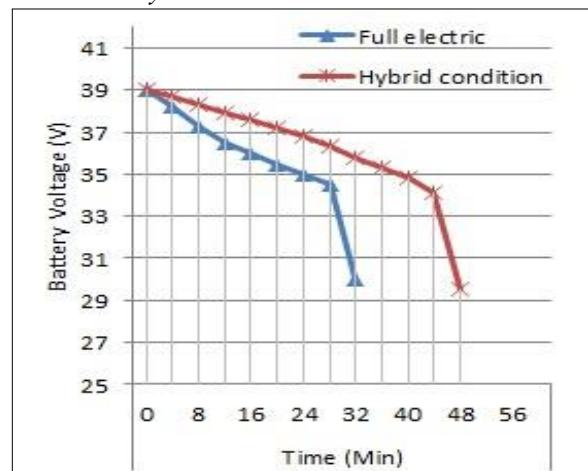


Figure-4. Battery voltage vs time curve for design 1(old design) Source: Developed by researchers based on trials



The fluctuation in battery voltage with respect to time for the completely electric mode and the hybrid state of the E-rickshaw is shown in Figure 4. The total distance driven in totally electric mode was around 13 kilometers, while the total distance traveled in hybrid mode was approximately 20 kilometers.

2) *Comparative study for design 2 (new design) with one 8.7 Ah battery:*

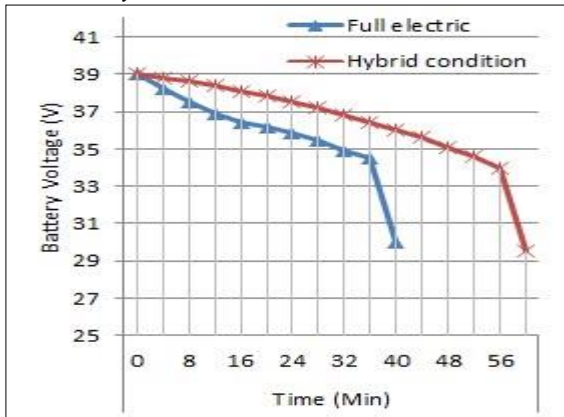


Figure-5. Battery voltage vs time curve for design 2 (new design)  
Source: Developed by researchers based on trials

Figure 5 depicts the change in voltage experienced by the battery as a function of time for both the completely electric mode and the hybrid state of the innovative design. In totally electric mode, the vehicle drove around 17 kilometers, while in hybrid mode, it traveled approximately 26 kilometers.

When compared to all-electric modes, this data makes it very evident that increasing the amount of human effort required for electric propulsion results in a battery life that is 1.5 times longer. In addition, in order to maintain the necessary speed when the battery power is dropping, more human effort is required.

The hybrid system encompasses the battery to charge using solar power and this charged power could be used when using the rickshaw. This facility enhances the power efficiency of the rickshaw and the use of solar power reduces the GHG emission drastically.

3) *Comparative study of both designs when fully electrical mode and hybrid mode with one 8.7 Ah battery:*

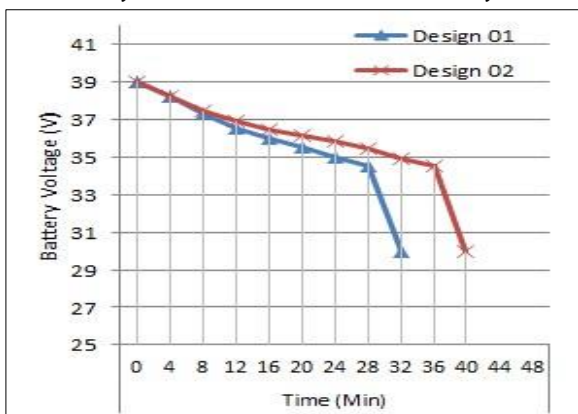


Figure-6. Comparison of Battery voltage vs time curve when both designs operated in fully electrical mode.  
Source: Developed by researchers based on trials

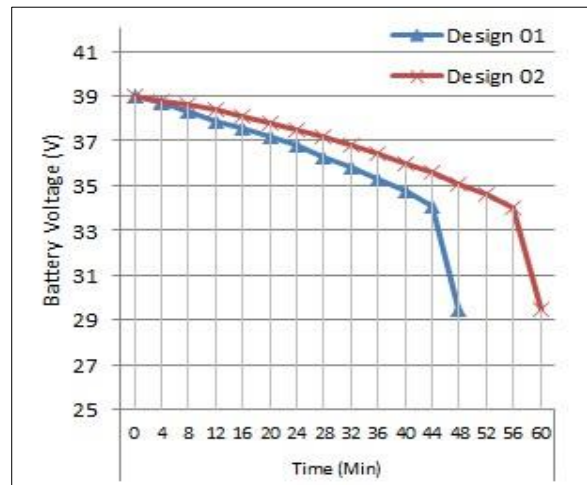


Figure-7. Comparison of Battery voltage vs time curve when both designs operated in hybrid mode.

Source: Developed by researchers based on trials

The powertrain and track of the e-rickshaw are the focal points of the comparison between the two concepts. A chain runs from a quarter wheel, which is part of the design seen above, all the way up to an intermediate sprocket. A second chain runs between the intermediate sprocket and the sprocket that is attached to the back wheel. This design takes advantage of the typical ball assembly that is located on most bicycle hubs.

On the other hand, the latest design incorporates a foot lever wheel that is chained directly to the wheel at the back of the vehicle. Additionally, bearings are used on both sides of the rear axle in this design. These bearings have been designed with the goal of lowering the amount of friction experienced by the drive system while simultaneously improving its overall performance.

The new design has a major benefit in the form of an increased stroke. This upgrade is compatible with all electric and hybrid system configurations. The pedals are able to transmit more power to the rear wheel because of the bearings' ability to minimize friction, which, when paired with the vehicle's simplified drive system, results in a more efficient power transfer. Because of this, the e-rickshaw is capable of covering a larger distance while using the same amount of electricity.

The old design, on the other hand, with its convoluted drive system and absence of bearings, may result in significant amounts of lost energy and severe friction losses. As a consequence of this, the overall driving distance of the older model will be less than that of the new design, in particular, while operating in electric and hybrid modes, when maximizing energy efficiency will be essential.

To summarize, the new design boasts a number of improvements over the older one in numerous key areas. Increases in travel distance and improvements in efficiency may be achieved via the use of bearings and the

simplification of the driving system. Also, the new design improves the maneuverability capability to a greater extent. This development is particularly significant for all electric and hybrid systems, especially those in which energy storage plays an essential role.

#### IV. CONCLUSION

There are substantial advantages to be gained from the design and development of the electric rickshaw as a sustainable energy solution, including a reduced negative effect on the environment, increased energy efficiency, and decreased cost.

It is evident that the configuration of the pedal power transmission in electric rickshaws with two independent wheel assemblies comes with a distinct set of benefits as well as drawbacks. The traditional approach, which utilizes a sprocket as an intermediary component, offers both a changeable gear ratio and effective power transfer. On the other hand, it is more difficult to understand and needs more upkeep. The use of a single sprocket and bearings in a newly developed approach offers simplicity, ease, long-term reliability and increased maneuverability. On the other hand, it has a set gear ratio and a restricted range of motion. Which of the two systems an electric rickshaw maker and operator choose to go with is going to be determined by their own requirements, priorities, and line of work.



Figure-8. The final output of Design 1 (old design) and Design 2 (new design)

Source: Developed by researchers based on trials

In conclusion, the new design boasts a number of improvements over the older one in numerous key areas. Efficiency is improved and farther distances may be traveled thanks to the use of bearings and a simple propulsion system. This development is particularly significant for all electric and hybrid systems, especially those in which energy storage plays an essential role. In the next step of development, the battery charging process would be done with human involvement and paddling may charge the battery associating with the dynamo technology.

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#### AUTHOR BIOGRAPHIES



Cmde (E) MCP Dissanayake, CEng (India) is currently performing as the Head of Department (Marine Engineering) and holds 2 patents for his research papers published so far. He is an inventor and published 06 No's publications on Brackish Water Reverse Osmosis application, Fan Boat Building and Oscillation Water Column, Ocean Wave Energy Converter. He was the Director in Research & Development at Sri Lanka Navy and has received commendations on number of occasions from the Commander of the Navy, HE the President of Sri Lanka for his innovation. Further, he was awarded with prestigious, Japanese, Sri Lanka Technical Award for his own developed low-cost Reverse Osmosis Plant, to eliminate Chronic Kidney Disease from Sri Lanka. Moreover, he has vast exposure on marine diesel engines and possesses a Master's degree in Marine Engineering from Australian Maritime College, University of Tasmania, Australia.



LCdr (E) KREMSB Ekanayaka is presently serving as a lecturer in the Department of Marine Engineering, Faculty of Engineering, KDU and possesses a Btech in Mechanical Engineering from Jawaharlal Nehru University India with a 1<sup>st</sup> class merit. He is a Chartered Engineer (India) and an associate member of the Institution of Engineers Sri Lanka (IESL).



LCdr (E) RDMHM Ariyaratne is presently serving as a lecturer in the Department of Marine Engineering, Faculty of Engineering, KDU and possesses a BSc Eng (Hons) in Marine Engineering degree from General Sir John Kotelawala Defence University, with a 1<sup>st</sup> class merit. He is a Chartered Engineer (India) and an associate member of the Institution of Engineers Sri Lanka (IESL).



LCdr (E) MCH Chandrasiri is presently serving as a lecturer in the Department of Marine Engineering, Faculty of Engineering, KDU and possesses a BSc Eng (Hons) in Marine Engineering degree from General Sir John Kotelawala Defence University, with a 2<sup>nd</sup> class upper merit. He is a Chartered Engineer (India) and an associate member of the Institution of Engineers Sri Lanka (IESL).