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Dual Source Renewable Powered Electric Bicycle

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***Abstract*—** *The increasing demand for eco-friendly and sustainable transportation has led to the development of innovative mobility solutions. This research explores the design and analysis of an electric bicycle powered by dual renewable sources: solar energy and dynamo-generated mechanical energy [5]. The system employs a 40W solar photovoltaic panel and a rear-wheel dynamo to charge a 24V battery system (2 × 12V batteries), which in turn powers a 250W electric motor. This hybrid energy configuration is intended to minimize reliance on grid electricity while boosting efficiency and range [3]. Various design configurations were assessed to ensure structural stability, cost-effectiveness, and user convenience. The study's findings suggest that incorporating renewable energy sources into electric bicycles notably enhances sustainability and reduces operational costs, offering a promising alternative for urban and semi-urban transportation needs.*

***Keywords*— *Electric Bicycle, Renewable Energy, Solar Panel, Dynamo Charging, Sustainable Transportation, Hybrid Energy System, Energy Efficiency*.**

I. INTRODUCTION

The swift growth of urban areas and industries has led to increased energy use and environmental damage. Conventional transportation methods that depend on fossil fuels significantly contribute to air pollution, greenhouse gas emissions [9], and rising fuel costs. As a result, there is a growing need for affordable and eco-friendly transportation solutions.

Electric bicycles (e-bikes) have become a practical option, providing low energy use, cost-effectiveness, and ease of use [10]. Nevertheless, traditional e-bikes mainly rely on grid-connected charging systems, limiting their sustainability and effectiveness in remote or energy-deficient regions.

This study focuses on creating an **Electric Bicycle powered by Dual Source Renewable Energy**, utilizing two renewable energy sources:

- Solar power captured using a photovoltaic module
- Mechanical energy produced through a dynamo mechanism

The primary objective is to create a self-sufficient charging system that reduces dependence on external charging facilities, thus improving efficiency and operational range. This system is especially beneficial for commuting over short to medium distances in both urban and rural environments.

II. MATERIAL AND METHODS

This section describes the materials used and the methodology for developing the dual-source renewable-powered electric bicycle. The goal was to utilize renewable energy sources efficiently, safely, and cost-effectively.

2.1 Materials

The following components were integral to the creation of the dual-source renewable-powered electric bicycle.

- Electric Motor: A 250W PMDC motor that provides propulsion assistance.
- Battery: A 12V, 7.2Ah rechargeable battery for energy storage.
- Solar Panel: A 40W photovoltaic panel that converts solar energy into electrical energy.
- Dynamo: A rear-wheel mounted 36V Dynamo that generates electricity from mechanical motion.
- Bicycle Frame: A modified frame designed to accommodate additional components.

- Support Structure: Steel rods used to securely mount the solar panel.
- Wiring and Connectors: Essential for establishing electrical connections among the components.

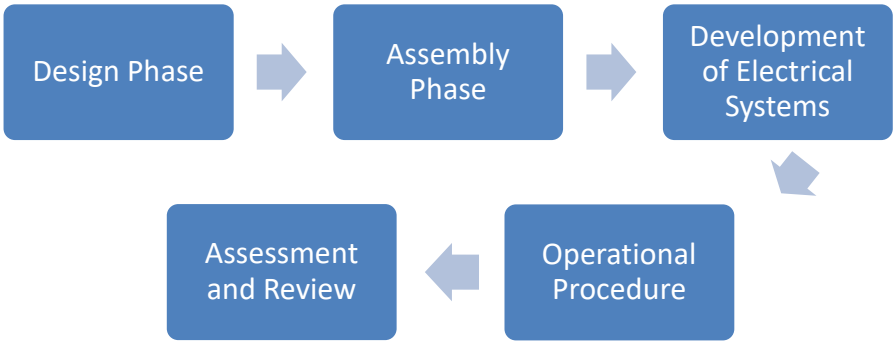
2.2 Purpose of the Components

The need for eco-friendly transportation is growing, and a new type of electric bicycle using two energy sources is becoming popular. Traditional electric bicycles rely on grid electricity, which isn't always from renewable sources [2]. This bicycle system gets its power from solar energy and a dynamo. The solar panel collects energy during the day, while the dynamo generates electricity while the bicycle is moving [1], [5]. This ensures the bicycle always has power.

This system makes the bicycle more efficient, extends battery life, and works well in areas with limited electricity access. It is an environmentally friendly way to travel, especially in cities and suburbs.

2.3 Methods

The system was developed through a step-by-step process.



Design Stage: The placement of the solar panel and other components was optimized using Computer-Aided Design (SolidWorks) to ensure proper weight distribution, structural strength, and aerodynamic efficiency.

Figure 1: SolidWorks Model of Dual Source Renewable Powered Electric Bicycle

Assembly Stage: The solar panel was attached to a metal support structure above or behind the seat for maximum sunlight exposure. The batteries were secured inside the bicycle frame for stability and safety.

Figure 2: Complete Model of Dual Source Renewable Powered Electric Bicycle

Electrical System Development: The solar panel and dynamo were connected to the battery through a charge controller that enables simultaneous charging from both sources [6]. Proper insulation and wiring ensured safe operation.

Operational Procedure: The solar panel generates electricity when exposed to sunlight, and the dynamo generates electricity when the bicycle is moving. Both sources charge the battery, which powers the motor to assist pedaling.

Assessment and Testing: The system was tested under various conditions to evaluate charging rates, battery performance, motor efficiency, and structural integrity. Results were used to optimize the system [1], [5].

2.4 Calculations and Considerations

1. System Overview

Component	Specification
Solar Panel	40W, 18V
Boost Converter Output	27.9V
Battery	2 × 12V (24V system), 7.2Ah
Motor	250W PMDC, 3000 RPM
Reduction Ratio	9.78

2. Solar Panel Current

$$I = \frac{P}{V} = \frac{40}{18} = 2.22 \text{ A}$$

3. Boost Converter Output (85% efficiency assumed)

$$P_{out} = 40 \times 0.85 = 34 \text{ W}$$

$$I_{out} = \frac{34}{27.9} = 1.22 \text{ A}$$

4. Battery Charging Voltage Range: 26–29V (27.9V output is suitable for 24V battery system)

5. Battery Energy Storage

$$E = V \times Ah = 24 \times 7.2 = 172.8 \text{ Wh}$$

6. Charging Time (Solar Only)

$$t = \frac{172.8}{34} \approx 5.1 \text{ hours}$$

7. Motor Current

$$I = \frac{P}{V} = \frac{250}{24} = 10.4 \text{ A}$$

8. Motor Torque (Angular speed ω = 314 rad/s)

$$T = \frac{P}{\omega} = \frac{250}{314} \approx 0.8 \text{ Nm}$$

9. Speed Calculation

$$\text{Wheel RPM} = \frac{3000}{9.78} \approx 306 \text{ RPM}$$
$$\text{Theoretical Speed} \approx 38 \text{ km/h}$$
$$\text{Practical Speed} \approx 20\text{–}25 \text{ km/h}$$

10. Runtime Estimate

- Battery capacity: 172.8 Wh
- Estimated runtime: 40–50 minutes depending on load and solar assistance

III. RESULTS AND DISCUSSION

The dual-source renewable energy system enhances the electric bicycle's performance and efficiency. By combining solar power with dynamo-driven energy production, the system ensures a steady energy supply. A key benefit is simultaneous charging from two sources, resulting in improved energy efficiency and reduced waste.

Key Advantages:

Advantage	Description
Reduced Grid Dependence	Partial self-charging while in use, unlike traditional e-bikes requiring plug-in charging
Extended Range	Battery drains more gradually, ideal for daily commuting
Environmental Benefits	Utilizes renewable energy, minimizes pollution
Reliability	Solar panel works in sunlight; dynamo works during motion

Limitations:

Limitation	Description
Weather Dependence	Solar panel performance reduced in cloudy/rainy conditions
Speed Dependence	Dynamo produces less energy at low speeds
Added Weight	Additional components slightly increase bicycle weight

IV. CONCLUSION

The dual-source renewable energy electric bicycle offers a groundbreaking approach to eco-friendly transportation. Combining solar and dynamo-based power systems decreases dependence on traditional energy sources, enhancing both efficiency and usability.

Key Findings:

1. The 40W solar panel and dynamo can charge the 24V/7.2Ah battery system in approximately 5.1 hours (solar only)
2. The 250W motor provides assistance for 40–50 minutes of continuous operation
3. Practical speed of 20–25 km/h is suitable for urban commuting
4. The hybrid system reduces grid dependency and operational costs

This research shows that hybrid renewable energy systems can significantly contribute to sustainable transportation. With continued improvements, this concept could be broadly implemented as an effective solution for current transportation challenges.

Future Work:

- Integration of maximum power point tracking (MPPT) for improved solar charging efficiency
- Lightweight materials to reduce overall bicycle weight
- Regenerative braking system to capture additional energy
- Smart battery management system for optimized charging

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interest regarding the publication of this research paper.

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