

Design And Fabrication of a Stand Mounted Vertical Axis Wind Turbine Investigators

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Abstract- Nigeria's persistent fuel crisis and unreliable grid electricity have intensified dependence on petrol and diesel generator resulting in high operating cost and environmental pollution. This publication presents the design, fabrication and performance evaluation of a stand mounted vertical wind turbine integrated with a 600mm bicycle wheel transmission system automotive alternator, 100Ah battery storage, charge controller and 1.2 KVA inverter. The project was motivated by recurring fuel scarcity in Nigeria and aims to provide a low-cost locally fabricated renewable energy alternative. The turbine combines wind energy into mechanical rotation, amplified by a bicycle wheel drive system to power a car alternator. Generated DC power charges a DC 12V 100ah battery through a regulated charge controller. A 1.2 KVA inverter converts stored energy to 220 – 240V AC output for household application. Experimental evaluation under moderate wind condition demonstrated effective battery charging and reliable AC load operation.

Keywords: Vertical axis wind turbine, Nigeria fuel crisis, Renewable Charging, Automotive alternator, Battery storage inverter system, decentralized power.

I. INTRODUCTION

Energy access remains a major challenge in Nigeria. Despite being an oil producing nation, the country experience recurrent fuel shortages and unstable electricity supply. Petrol and diesel generator serves as the primary power source for household and small businesses. However, repeated fuel crisis has led to escalating fuel prices, business interruption, increased cost of living and even environmental degradation. These challenges have led to the urgent need for decentralized renewable and locally made energy solution. Wind energy offers a promising alternative. Vertical wind turbine is particularly suitable for urban and semi urban use because they capture wind from any direction, operate at a lower mounting height and have lower noise level.

This project is motivated by Nigeria's fuel crisis and aim to develop a practical, low-cost wind energy system capable of charging batteries and supplying AC power without fuel dependency.

II. LITERATURE REVIEW

Extensive research has been conducted on Vertical wind turbine aerodynamic optimization and modeling.

Sarneje et al. (2025) reviewed aerodynamic optimization and hybrid integration strategies across 80 peer-reviewed works. Their study summarized trends and research gaps but did not include practical implementation.

Morgan et al. (2025) investigated blade inclination and chord distribution, demonstrating significant influence on aerodynamic efficiency and structural load. Gupta et al. (2025) studied variable blade pitch systems, showing improved torque and lift under varying wind conditions.

Alina et al. (2025) used CFD analysis to compare Savonius, Darrieus, and spiral VAWT configurations, identifying optimal designs for low-wind urban environments.

Hameed and Afaq (2013) modeled blade parameters to achieve 1 kW output targets in small VAWTs.

Zakis et al. (2025) proposed improved blade shapes optimized for low wind speeds. Roga et al. (2025) demonstrated CFD simulations as cost-effective tools for evaluating VAWT performance.

Jin et al. (2015) highlighted advantages of Darrieus VAWTs compared to HAWTs. Zhang et al. (2024) investigated self-starting enhancement devices.

Srivastava (2022) reviewed aerodynamic challenges and computational tools. Mohammed et al. (2021) developed hybrid Darrieus–Savonius turbines integrated into buildings.

Rusianto et al. (2023) investigated generator integration in small VAWTs. Suet al. (2020, 2023) improved blade performance and noise reduction.

Huan Liu and James (2025) applied machine learning optimization achieving 30% performance improvement.

III. RESEARCH GAP IDENTIFICATION

Although prior studies emphasize aerodynamic optimization and computational modeling, limited research focuses on:

Low-cost fabrication using locally available materials. Integration of automotive alternators as generators. Mechanical speed amplification using bicycle wheel transmission.

Full off grid systems including battery storage and inverter output.

Socio economic motivation addressing fuel crises in developing countries.

Most research remains theoretical or simulation based. There is insufficient emphasis on deployable, cost-effective renewable systems for energy insecure communities. There is minimal research specifically targeting Nigeria's recurring fuel crises and decentralized renewable alternatives.

While Rusianto et al. (2023) studied generator integration, emphasis was placed on axial generators. The use of:

Locally available automotive alternators, Speed amplification using bicycle wheel transmission, Direct battery charging through conventional charge controllers has not been sufficiently explored in literature as a low-cost solution.

IV. RESEARCH GAP S COVERED BY THIS RESEARCH

While extensive literature exists on VAWT aerodynamics, blade optimization, wake modeling, and computational design, limited work addresses the urgent energy challenges of developing nations such as Nigeria. Most studies emphasize efficiency improvement rather than socio-economic applicability. The developed stationary stand mounted vertical wind turbine system fills this gap by offering a practical, low cost, fuel independent renewable energy solution tailored to Nigeria's fuel crisis context.

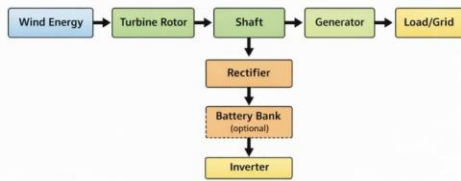
By integrating mechanical transmission, automotive alternator generation, battery storage, and inverter-based AC output, this work contributes a deployable model that extends beyond theoretical optimization toward real world impact.

V. METHODOLOGY

The developed wind energy System consist of several Integrated mechanical and electrical component that work together to convert wind energy into usable electrical power. Each component performs a specific role in the energy Conversion process. Vertical axis wind turbine is the primary energy capture device. It Converts the Wind energy into rotational mechanical motion through its curved blades mounted around a vertical shaft. Unlike horizontal turbine, It Can capture wind from any direction without needing orientation mechanism.

VI. CHART FLOW ANALYSYS

The vertical wind turbine converts wind energy (as shown in the flow chart) into mechanical rotation through the turbine rotor and shaft. This mechanical motion drives the generator, which produces electrical power. The output passes through a rectifier, also called a charge controller, where AC is converted to DC and the battery charging process is regulated. The power may then be stored in the battery bank and later converted by the inverter into AC supply for the load or grid.



VII. THE STRUCTURAL STAND

The structural stand provides mechanical Support and stability to the turbine assembly. It elevate the turbine above ground level to allow better exposure to wind flow while ensuring the system remains balanced and vibration resistant during operation.

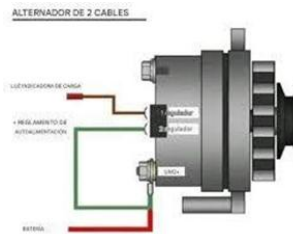


VIII. BICYCLE WHEEL TRANSMISSION SYSTEM

The bicycle wheel function as a mechanical Transmission mechanism. It help transfer rotational motion from the turbine shaft to the alternator while also increasing rotational speed through pulley into amplification, enabling the alternator to operate efficiently.

IX. AUTOMOTIVE ALTERNATOR

The Car alternator serves as the electrical generator in the System. It converts mechanical rotational energy from the turbine into electrical energy. Alternators are capable of producing regulated DC output suitable for charging Battery.



X. CHARGE CONTROLLER

The charge Controller regulates the electrical currents flowing from the alternator to the battery. It prevents battery over charging, stabilizes voltage, and improves the safety and longevity of the storage system.



XI. 100 AH BATTERY STORAGE

The Battery acts as the energy storage unit of the System. It stores electrical energy generated during period of sufficient wind and supplies power when

wind speed drops or when electricity is required for load.



13;1 Battery Capacity, $E = V \times Ah$ $E = 12V \times 100ah = 1200Wh$
 $E = 1.2KWh$
 Depth of discharge; $0.8 \times 1200Wh = 960W$

XII. 1.2 KVA INVETER

The Inverter converts the stored direct current (DC) from the battery into the alternating current. This conversion allows conventional household electrical appliances that operates on AC power to be used-



XIII. INVERTER

1.2VA Inverter converts DC to 220-240v AC
 Assuming 0.8 power factor
 Real power = 960W

XIV. WIND TURBINE DESIGN AND PARAMETER USED

A Three blade vertical axis turbine Configuration with Curved blade was used for this research. This

design improves the torque generation and enhances salt, starting ability, particularly in moderation wind condition typical in many parts of Nigeria.

The blade height of 1.2m was designed and this determine the vertical dimension of the turbine and influences the amount of wind energy captured. Taller blades Increases the swept area and improves energy harvesting capability.



XV. SHAFT MATERIAL

The central shaft is made from mild steel to ensure adequate strength, durability and resistant to mechanical stress during turbine rotation.



XVI. BEARING

Bearing are installed at both the top and bottom of the shaft to reduce friction during rotation. This helps ensure turbine movement and extends the Life span of the mechanical component.



XVII. BATTERY INDICATOR

The battery indicator in the wind turbine system shows the battery charge level and charging status. It helps monitor whether the battery is charging, full, or low, and prevents overcharging or deep discharge, ensuring safe and efficient energy storage.



PERFORMANCE EVALUATION

WIND CONDITIONS

Tested wind speeds: 3–7 m/s.

CHARGING PERFORMANCE

Observed charging voltage:

13.5–14.2 V

Charging current:

5–15 A

Estimated charging time from 50% depth of discharge: 3–6 hours under steady wind.

LOAD TESTING

Powered successfully:

6 LED bulbs (60 W total)

1 standing fan (75 W)

Phone charging devices

Total load tested: 150–250 W

System operated quietly without fuel consumption.

XVIII. DISCUSSION

Contribution Beyond Literature

This study differs from previous research because:

It integrates full mechanical-electrical-storage chain.

Uses locally available automotive alternator.

Employs bicycle wheel transmission.

Addresses Nigeria's fuel crisis directly.

Demonstrates real-world deployment rather than simulation.

SOCIO ECONOMIC IMPACT

The system provides:

Fuel-free electricity Reduced operating cost

Environmental sustainability Improved energy resilience

LIMITATIONS

Wind variability

Alternator inefficiency at low RPM Limited battery capacity

Future improvements may include:

MPPT controller

Permanent magnet generator Hybrid solar integration

Larger battery bank

CONCLUSION

This study presented the design and development of a stand-mounted vertical axis wind turbine integrated with a 600 mm bicycle wheel transmission, automotive alternator, 100 Ah battery storage, charge controller, and 1.2 kVA inverter. Motivated by Nigeria's recurring fuel crises, the system provides a practical and low-cost renewable alternative to petrol generators.

Experimental results confirm effective battery charging and AC load operation under moderate wind conditions. Unlike prior research focusing primarily on aerodynamic modeling, this work demonstrates a complete, deployable off-grid wind energy solution tailored for developing economies.

The system contributes to decentralized renewable energy deployment and offers a scalable model for reducing fuel dependency in Nigeria.

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