

# Integrated multiple free energy System Using Solar, Wind, and Tidal Resources for Sustainable Power Generation

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**Abstract**—Rising global energy demands and environmental concerns have driven significant interest in the advancement of renewable energy technologies. However, individual renewable sources such as solar, wind, and tidal energy suffer from intermittency and variability due to environmental conditions. This paper presents the design, fabrication, and performance evaluation of a multiple renewable energy system capable of generating electricity using multiple renewable resources. The proposed system integrates photovoltaic (PV) panels, a vertical axis wind turbine (VAWT), and a tidal energy conversion mechanism using buoy-driven rack and pinion gear assembly connected to a DC generator. The hybrid system allows continuous power generation by utilizing complementary energy sources. The electricity generated from each subsystem is regulated through an Electrical Control Equipment (ECE) box which performs power conditioning and distribution. The experimental model demonstrates improved reliability and efficiency compared to standalone renewable systems. The above said system can be useful for remote locations, coastal regions, and off-grid applications requiring sustainable and reliable power generation.

**Keywords**— Solar, wind, tidal, vertical axis wind turbines, multiple free energy systems, and sustainable power production.

## I. INTRODUCTION

Energy demand across the world has been rapidly raising due to population growth, industrialization, and technological development. Conventional energy resources such as fossil fuels are finite and contribute significantly to environmental pollution and climate change. Therefore, renewable energy technologies are being widely explored as sustainable alternatives.

Among the various renewable resources, solar, wind, and tidal energy have emerged as highly promising sources for sustainable power generation. Solar energy is abundant and environmentally friendly but depends on daylight conditions. Wind energy is widely available but varies depending on wind speed and atmospheric conditions. Tidal energy is predictable and reliable but geographically limited to coastal regions.

An efficient way to get around the drawbacks of separate energy sources is through combined Non conventional energy systems. By integrating these free energy technologies, the reliability and efficiency of the overall system can be significantly improved. When one source is unavailable or weak, other sources can compensate for energy generation.

This research focuses on the development of a **Multiple Renewable Energy Resource (MRER) system** that combines solar, wind, and tidal energy into a single integrated model capable of generating continuous electricity.

## II. LITERATURE REVIEW

Numerous research studies have examined multiple free energy systems to enhance the reliability of power generation.

**Roy et al. (2023)** reviewed the recent advances in multiple free energy systems that combine solar photovoltaic and wind energy technologies. The study analyzed different system architectures, converter topologies, and optimization techniques used in hybrid systems. The authors concluded that integrating solar and wind energy with energy storage significantly improves system reliability and reduces intermittency problems in renewable power generation.

**Zhou and Li (2024)** performed a bibliometric analysis on hybrid solar-wind standalone systems to understand global research trends. The study revealed that hybrid Free energy systems are commonly used in off-grid applications because they can deliver a stable and continuous power supply. The authors emphasized the growing importance of hybrid technologies in rural electrification and sustainable development.

**Hu et al. (2024)** analyzed the thermal, electrical, and economic performance of a combined solar-wind-geothermal energy system in Germany. says that combining multiple free energy sources improves system efficiency and reduces greenhouse gas emissions. The outcomes also showed that hybrid systems can support long-term energy sustainability in residential applications.

**Huang et al. (2025)** developed a control-oriented modeling approach for hybrid wind-wave energy systems. The study proposed advanced control strategies to improve energy capture efficiency and ensure stable system operation. The authors concluded that accurate system modeling is essential for optimizing hybrid free energy performance.

**Ahmed and Haji (2025)** analyzed the techno-economic performance of offshore hybrid wind-wave energy systems. The research demonstrated that integrating wave energy converters with offshore wind turbines can reduce power fluctuations and decrease the levelized cost of electricity. The study highlighted the economic and operational benefits of hybrid offshore renewable energy platforms.



The outcomes of these investigations demonstrate that hybrid free energy systems can improve system reliability, ensure efficient resource utilization, and promote sustainable energy production. Therefore, the proposed MRER system is designed to integrate multiple renewable sources to ensure continuous electricity production.

### III. OBJECTIVES

The primary objective of this research is to develop a multiple free energy system capable of generating electricity using multiple renewable sources.

The specific objectives are:

- To design and fabricate a multiple free energy model integrating solar, wind, and tidal energy.
- To develop a system capable of continuous electricity generation using complementary energy sources.
- To evaluate the performance, efficiency, and feasibility of the hybrid system.

The system aims to reduce dependence on fossil fuels and promote sustainable energy solutions

### IV. SYSTEM DESIGN AND CAD MODELING

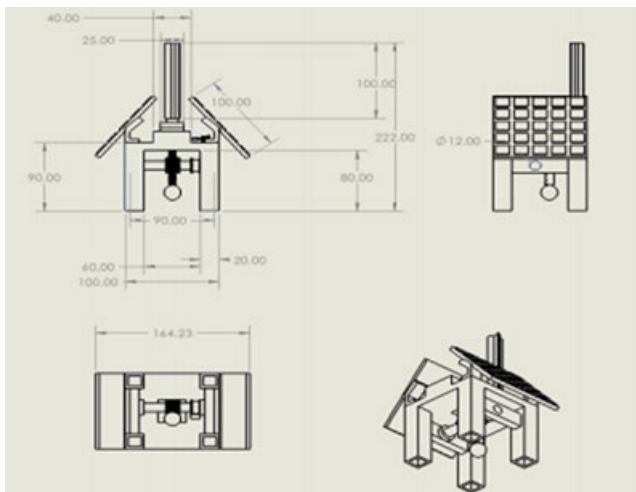


Fig. 1. CAD Drawing

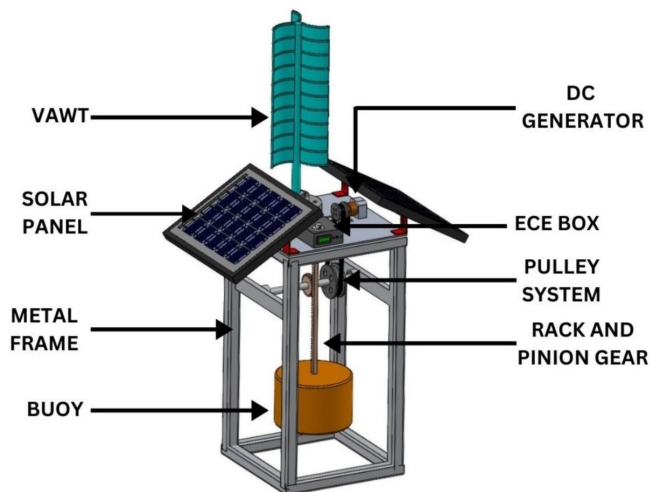


Fig. 2. Assembled work model

The proposed multiple free energy system was designed using computer-aided design tools to integrate solar photovoltaic modules, a vertical axis wind turbine, and a buoy-based tidal mechanism. The CAD model helped determine structural dimensions, component placement, and mechanical integration prior to fabrication.

### V. MATHEMATICAL MODELING OF ENERGY SOURCES

#### A. Solar Energy Model

The power generated by the photovoltaic panel can be expressed as

$$P_{\text{solar}} = A \times G \times \eta_{\text{pv}}$$

Where:

$P_{\text{solar}}$  = Solar power output (W)

$A$  = Area of the solar panel ( $\text{m}^2$ )

$G$  = Solar irradiance ( $\text{W}/\text{m}^2$ )

$\eta_{\text{pv}}$  = Efficiency of photovoltaic module

For standard test conditions:

$$G = 1000 \text{ W}/\text{m}^2$$

The electrical output voltage from the solar module is given by

$$V = N_s \times V_{\text{cell}}$$

Where:

$N_s$  = Number of cells connected in series

$V_{\text{cell}}$  = Voltage of individual PV cell

#### B. Wind Energy Model

The power available in wind is determined by the equation:

$$P_{\text{wind}} = 1/2 \times \rho \times A \times V^3$$

Where:

$P_{\text{wind}}$  = Wind power (W)

$\rho$  = Air density ( $1.225 \text{ kg}/\text{m}^3$ )

$A$  = Swept area of turbine blades ( $\text{m}^2$ )

$V$  = Wind velocity (m/s)

The actual mechanical power extracted by the turbine is:

$$P_{\text{turbine}} = C_p \times P_{\text{wind}}$$

Where:

$C_p$  = Power coefficient of the wind turbine (typically 0.3–0.45)

For a Vertical Axis Wind Turbine (VAWT), the swept area is calculated as

$$A = H \times D \times A$$

Where:

$H$  = Height of the turbine

$D$  = Diameter of the turbine

### C. Tidal Energy Model

The tidal energy subsystem uses a buoy mechanism that converts vertical wave motion into rotational mechanical energy.

The potential energy available from tidal motion can be approximated by:

$$P_{\text{tidal}} = 1/2 \rho A V^3$$

Where:

$\rho$  = Water density (1025 kg/m<sup>3</sup>)

A = Cross-sectional area of tidal turbine

V = Velocity of tidal flow

Since the system uses wave-induced buoy motion, the mechanical power generated can be expressed as

$$P = F \times v$$

Where:

F = Force exerted by buoy movement

v = Velocity of buoy displacement

The rack-and-pinion mechanism converts this linear motion into rotational motion to drive the generator.

### VI. HYBRID POWER MANAGEMENT SYSTEM

The power generated from each renewable source is directed to the Electrical Control Equipment (ECE) unit.

The ECE unit performs the following functions:

Voltage regulation

Power conditioning

Energy storage management

Load distribution

The total hybrid power generated is expressed as:

$$P_{\text{total}} = P_{\text{solar}} + P_{\text{wind}} + P_{\text{tidal}}$$

### VII. ELECTRICAL OUTPUT ANALYSIS

The experimental prototype produced the following outputs from individual energy sources.

Energy Source	Voltage Output
Solar Panel	10 V
Wind Turbine	7–8 V
Tidal System	4–6 V

When all three sources operated simultaneously, the combined output ranged between:

$$V_{\text{total}} = 25V \text{ to } 65V$$

This output is sufficient for powering low-power electrical loads or charging battery storage systems.

### VIII. EFFICIENCY ANALYSIS

The overall efficiency of the hybrid system can be calculated as

$$\eta_{\text{system}} = \frac{P_{\text{output}}}{P_{\text{input}}} \times 100$$

Where:

$P_{\text{output}}$  = Total electrical power generated

$P_{\text{input}}$  = Total renewable energy available

Hybrid systems generally provide higher reliability and improved energy utilization compared to single-source renewable systems.

### IX. CONCLUSION

The study proposes the design and implementation of a multiple free energy system capable of producing electrical power by integrating solar, wind, and tidal resources. The system effectively integrates three renewable energy technologies to ensure continuous and reliable power generation.

The experimental model demonstrates that hybrid renewable systems can significantly improve energy reliability while reducing environmental impact. Future work may involve large-scale implementation, advanced energy storage systems, and smart grid integration.

#### A. Research Contributions of the Study

- Design of a compact multiple free energy system.
- Integration of solar, wind, and tidal energy sources within a single framework.
- Validation of continuous power generation using complementary renewable resources.
- Proposed cost-effective solution for rural and coastal electrification.

#### B. Future Research Scope

Future improvements may include:

- Integration with MPPT (Maximum Power Point Tracking) controllers.
- Use of advanced battery energy storage systems.
- IoT-based monitoring of renewable energy parameters
- Large-scale deployment in microgrid applications

### REFERENCES:

- [1] Zhang, X. Liu, and X. Cao, "Assessment of structural stability and power performance for a hybrid wind-solar-wave energy system," Scientific Reports, vol. 16, 2026.
- [2] S. Hazra, D. Datta, and C. Paul, "Electric vehicle integrated tidal-solar-wind-hydro-thermal systems for strengthening microgrid sustainability," Scientific Reports, vol. 15, 2025.
- [3] M. Shamoushaki and S. C. L. Koh, "Solar cells combined with wind power systems for improved environmental sustainability," Communications Earth & Environment, vol. 5, 2024.
- [4] L. Cui et al., "Synergistic hybrid marine renewable energy harvest system," Energies, vol. 17, no. 5, 2024.
- [5] S. Syama et al., "Hybrid methodology for wind speed and solar irradiance forecasting using optimized machine learning," Scientific Reports, vol. 14, 2024.
- [6] A. Albarrak, G. M. Sowilam, and T. A. Kawady, "Hybrid solar-wind energy systems integrated with hydrogen fuel cell storage," Journal of Umm Al-Qura University for Engineering and Architecture, 2025.
- [7] P. Roy, J. He, and T. Zhao, "Recent advances of wind-solar hybrid renewable energy systems for power generation: A review," IEEE Industrial Electronics Technology News, 2023.
- [8] J. Jia, G. Zhang, and Z. Shi, "Joint dispatch of wind, solar, hydro and thermal power systems for improved reliability," Frontiers in Energy Research, vol. 12, 2024.
- [9] A. Ahmed and M. Haji, "Techno-economic and dynamic performance analysis of hybrid wind-wave renewable energy systems," Renewable Energy Research, 2025.

- [10] S. Bayat, J. Zuo, and J. Sun, "Modeling and dynamic simulation of a hybrid wind-wave system on a semi-submersible offshore platform," *Renewable Energy Systems Research*, 2025.
- [11] F. P. Andrinirinaimalaza et al., "Improvement and stabilization of output voltages in vertical tidal turbines using intelligent control strategies," 2025.
- [12] I. Rahman, F. Suha, and A. Ahmed, "Optimal sizing of hybrid renewable energy microgrid systems using optimization algorithms," 2024.