

AEONSPHERE: OMNIDIRECTIONAL BLADELESS RENEWABLE HYBRID ENERGY SYSTEM

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1. ABSTRACT

The increasing demand for sustainable energy and the environmental impact of fossil fuels have driven the development of innovative renewable energy systems. Conventional wind turbines, although widely used, suffer from limitations such as noise, mechanical wear, high maintenance, and poor performance under low and turbulent wind conditions. This paper presents the design and development of an AeonSphere, an omnidirectional bladeless wind energy system that operates based on aerodynamic pressure differentials rather than rotating blades.

The proposed system utilizes an O-shaped hollow annular structure with a leaf-shaped internal geometry that enables wind capture from all directions. The pressure difference created within the structure generates rotational motion, which is converted into electrical energy using a geared generator. Additionally, a hybrid approach integrating a solar panel ensures continuous power generation during low wind conditions. The system includes real-time monitoring using an ESP32 microcontroller, along with voltage and current sensors. The results demonstrate that the proposed system is safe, cost-effective, low-maintenance, and suitable for urban environments. This research contributes to the development of compact and efficient renewable energy solutions.

Keywords:

Bladeless Wind Turbine, Omnidirectional Wind Energy, Hybrid Renewable System, ESP32, Pressure Differential Energy Harvesting, Wind Energy Conversion System, Vortex-Induced Vibrations.

2. INTRODUCTION

2.1 Background & Motivation:

The continuous rise in global energy demand, along with increasing environmental concerns due to fossil fuel consumption, has accelerated the transition toward renewable energy sources. Among these, wind energy has emerged as a widely adopted solution due to its sustainability, scalability, and low carbon emissions. Conventional wind energy conversion systems (WECS) primarily rely on horizontal-axis and vertical-axis wind turbines that utilize rotating blades to extract kinetic energy from wind. Despite their widespread deployment, traditional blade-based wind turbines present several limitations. These include aerodynamic noise, mechanical wear and tear, structural complexity, and high maintenance requirements. Moreover, their efficiency significantly decreases under low wind speeds and turbulent flow conditions, which are commonly observed in urban and semi-urban environments. Additionally, conventional turbines require specific wind direction alignment and large installation spaces, making them less suitable for densely populated areas. To address these challenges, recent research has explored alternative bladeless wind energy harvesting techniques. However, many existing bladeless systems are based on vibration mechanisms such as vortex-induced vibration (VIV) and aeroelastic effects, which operate efficiently within limited wind speed ranges and often require precise resonance tuning. This motivates the development of a novel approach that overcomes the limitations of both conventional and existing bladeless systems. The proposed **Aeon Sphere: Omnidirectional Bladeless Renewable Energy System** is designed to harness wind energy using aerodynamic pressure differentials within a hollow annular structure. Its omnidirectional capability allows it to capture wind from any direction without requiring alignment mechanisms, making it highly suitable for real-world urban conditions. Furthermore, integrating a hybrid solar energy system ensures continuous power generation even during low wind conditions, enhancing reliability and efficiency.

2.2 Problem Statement:

Conventional wind energy systems rely on rotating blades, which are unable to efficiently operate under low and turbulent wind conditions. As wind direction and speed continuously change throughout the day, the performance of these systems varies significantly, resulting in reduced energy capture and lower power generation. Additionally, many existing systems lack real-time monitoring and control capabilities, making it difficult to track performance and ensure optimal operation. Furthermore, blade-based systems introduce noise, safety concerns, and higher maintenance requirements, limiting their use in urban environments. Therefore, there is a need for an efficient and intelligent bladeless energy system that can operate in all wind directions while also providing real-time monitoring and control features to improve energy utilization and system reliability.

2.3 Objectives:

The main objectives of the proposed AEONSPHERE: Omnidirectional Bladeless Renewable Hybrid Energy System are:

- I. To design and develop an O-shaped bladeless wind turbine that operates using aerodynamic pressure differentials instead of conventional rotating blades.
- II. To enable efficient wind energy capture from all directions by implementing an omnidirectional structural design suitable for low and turbulent wind conditions.
- III. To convert the generated mechanical energy into electrical energy using a geared generator along with rectification and filtering circuits..
- IV. To integrate a hybrid wind-solar system for continuous power generation..
- V. To implement real-time monitoring using an ESP32-based system.

3. LITERATURE & SURVEY

Several studies have explored alternative wind energy harvesting technologies to improve efficiency and adaptability under varying environmental conditions. Researchers have developed different bladeless wind turbine mechanisms using vibration-based techniques and embedded control systems. Many existing designs rely on vortex-induced vibrations and aeroelastic effects to generate energy from wind flow. Bladeless systems have been shown to reduce noise and mechanical complexity compared to conventional turbines. Recent developments include hybrid renewable energy systems and IoT-based monitoring, where parameters such as voltage, current, and power are tracked in real time. However, many existing systems lack efficient omnidirectional energy capture and reliable performance under low and turbulent wind conditions. This project addresses these limitations by introducing a pressure-differential-based bladeless design integrated with a hybrid energy system and real-time monitoring.

Recent advancements in renewable energy systems have led to the development of alternative wind energy harvesting technologies beyond conventional blade-based turbines. Several researchers have explored bladeless wind turbines based on vortex-induced vibration (VIV) and aeroelastic principles.

A study by **Kang et al. (2024)** proposed a bladeless wind turbine using vortex-induced vibrations, where wind flow around a cylindrical structure that generates oscillatory motion that is converted into electrical energy. The study highlighted that such systems can operate without rotating blades but are limited to a narrow wind speed range due to dependence on resonance conditions.

Further work by **Kang et al. (2026)** focused on optimizing bladeless turbines using a resonance control mechanism. Their research introduced a stiffness-tuning module that adapts to varying wind speeds, improving energy harvesting efficiency. However, the design increases system complexity due to additional control components.

Saba et al. (2026) developed a bladeless turbine model using vortex-induced vibration combined with a cylindrical cam mechanism to convert oscillatory motion into rotational output. Their findings demonstrated suitability for low-wind-speed urban environments, but the system still relies on vibration-based energy conversion methods..

In earlier research, **Bahadur (2022)** investigated the dynamic modeling of vortex bladeless wind turbines and emphasized the importance of tuning system parameters such as structural stiffness and damping to achieve optimal performance. The study revealed that system efficiency strongly depends on maintaining resonance with wind flow conditions.

Similarly, **Elsayed and Farghaly (2022)** presented a theoretical and numerical analysis of vortex bladeless turbines, showing that energy generation is based on oscillations induced by vortex shedding around a bluff body. Their work validated the feasibility of vibration-based systems but highlighted limitations in output power and scalability.

Experimental studies by **Ketata et al. (2025)** analyzed different materials and configurations of vortex bladeless turbines in wind tunnel conditions. The results showed that material selection and structural dimensions significantly influence vibration amplitude and energy output.

Overall, existing research primarily focuses on vibration-based bladeless wind energy systems, which depend on resonance and operate efficiently only within limited wind speed ranges. Very limited work has been carried out on pressure-differential-based bladeless designs that can provide continuous and omnidirectional energy capture. This research gap motivates the development of the proposed AeonSphere system, which utilizes aerodynamic pressure differences instead of vibration mechanisms for energy generation. In addition to the identified research gap, there is a growing need for renewable energy systems that are compact, safe, and suitable for urban environments. Existing solutions often face issues such as directional dependency, complex mechanical structures, and inconsistent performance under varying wind conditions. The proposed AeonSphere system addresses these challenges by combining a pressure-differential-based bladeless turbine with hybrid wind-solar integration and real-time monitoring, ensuring improved reliability and practical usability.

4. METHODOLOGY

4.1 System Overview:

The AeonSphere system is a hybrid energy setup that combines a bladeless wind turbine and a solar panel to ensure continuous power generation. Wind energy is converted into electrical energy using a generator, then rectified and filtered before being stored in a 12V battery. The solar panel, regulated by a charge controller, supports power generation during low wind conditions.

The stored energy is used to power loads such as LEDs and bulbs. An ESP32-based monitoring system, along with voltage, current, and IR sensors, tracks system performance. Real-time data is displayed on an LCD, and a buzzer provides alerts for abnormal conditions. During testing, the wind turbine alone generated approximately 6V under moderate wind conditions. The combined hybrid system (wind + solar) produced around 10V, showing improved output stability. These observations confirm the effectiveness of integrating multiple energy sources for consistent power generation.

4.2

SPECIFICATIONS:

4.3

Table :1 Component And Specifications

1	Bladeless Wind Turbine	Captures wind energy from all directions using a bladeless structure. Generates mechanical motion based on pressure differences.
2	Generator	Converts mechanical energy from the turbine into electrical energy. Produces AC output based on shaft rotation.
3	Rectifier	Converts alternating current (AC) into direct current (DC). Ensures the output is suitable for storage and electronic circuits.
4	Capacitor Filter Bank	Smooths the pulsating DC output from the rectifier. Reduces voltage fluctuations and ripple.
5	12V Battery	Stores the generated electrical energy for later use. Provides a stable power supply to loads and system components.
6	Solar Panel	Converts sunlight into electrical energy. Acts as an additional power source in low wind conditions.
7	Solar Charge Controller	Regulates voltage and current from the solar panel. Protects the battery from overcharging and damage.
8	LED Load	Demonstrates direct power usage from the system. Represents low-power output applications.
9	Bulb Load	Utilizes stored energy to provide lighting output. Validates real-world power consumption capability.
10	Sensors	Voltage, Current, and IR Sensors – Monitor system output and system power generation through object detection.
11	LCD Display (16×2)	16×2 LCD Display – Displays system parameters such as voltage, power, and object detection.
12	ESP32 Controller	Processes sensor data and controls system operations. Supports real-time monitoring and IoT-based features.
13	Buzzer	Produces alert sounds during abnormal conditions. Indicates faults or threshold limit exceedance.

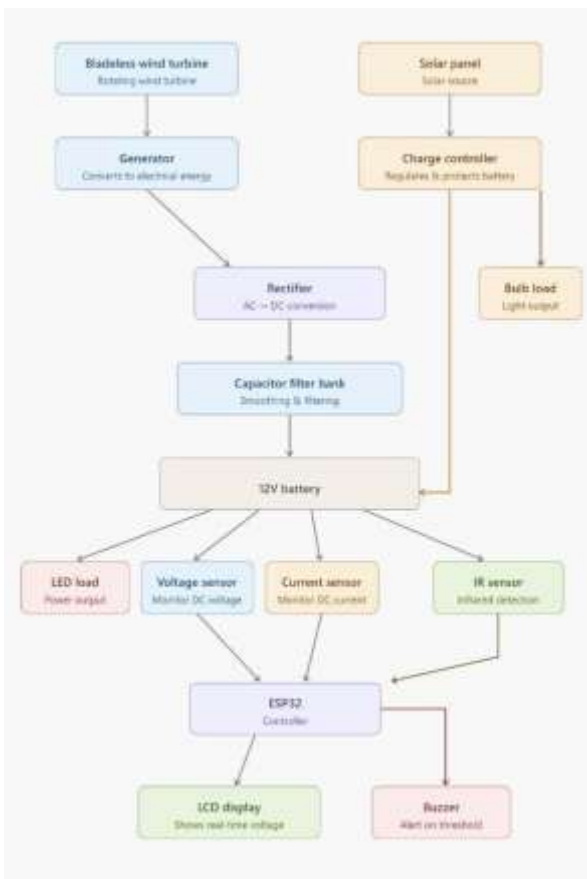


Figure 4.1. Block Diagram of AeonSphere

4.4 HARWARE IMPLEMENTATION:



Figure 4.2 : Real-Time Hardware Implementation of Aeonsphere

The hardware implementation of the AEONSPHERE system involves the integration of renewable energy sources, power conditioning units, and a control system.

A bladeless wind turbine is mechanically coupled to a DC generator to convert wind energy into electrical energy. The generated AC output is converted into DC using a rectifier and then smoothed through a capacitor filter bank to ensure stable voltage.

A solar panel is integrated as a secondary energy source, connected through a charge controller to regulate charging and protect the battery. Both wind and solar outputs are combined to charge a 12V battery, which acts as the main energy storage unit.

The system includes voltage and current sensors to monitor electrical parameters in real time. An IR sensor is used for detection-based control. All components are interfaced with an ESP32 microcontroller, which processes sensor data and manages system operations.

An LCD display is used to show real-time voltage values, while a buzzer provides alerts when predefined thresholds are exceeded. The entire hardware setup ensures efficient energy conversion, storage, and intelligent monitoring.

4.4.1 Working of Hardware System:

The AEONSPHERE system operates by combining wind and solar energy to provide a continuous power supply. When wind flows, the bladeless wind turbine rotates and drives the generator to produce electrical energy. This output is converted from AC to DC using a rectifier and then smoothed by a capacitor filter.

Simultaneously, the solar panel generates DC power from sunlight, which is regulated by the charge controller. Both energy sources are used to charge the 12V battery, ensuring energy availability even when one source is not active.

The stored energy in the battery is supplied to loads such as LED and bulb. The voltage and current sensors continuously monitor system parameters and send data to the ESP32 microcontroller. The ESP32 processes this data, displays it on the LCD, and activates the buzzer if any abnormal conditions like overvoltage or overcurrent occur.

Thus, the system ensures efficient hybrid energy generation, storage, and smart monitoring.

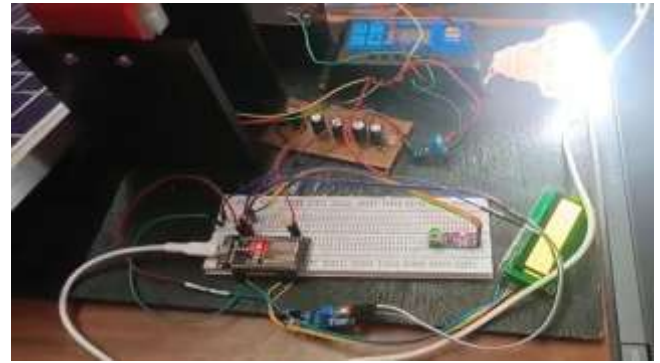


Figure4.3: Hardware Working Model

5. RESULTS & DISCUSION

The performance of the proposed AeonSphere system was experimentally evaluated under real-time environmental conditions to analyze its efficiency, stability, and practical applicability. The system was tested in two different operating modes: wind-only operation and hybrid wind-solar operation.

Case 1: Wind Turbine Only



In the first case, the system was operated using only the bladeless wind turbine. Under moderate wind conditions, the generator produced an output voltage of up to approximately 6V. The output was observed to fluctuate with variations in wind speed and turbulence, as the energy generation depends directly on airflow characteristics.

Although the system successfully demonstrated energy generation without the use of blades, the voltage level was relatively low and inconsistent. This limited output is mainly due to the dependence on natural wind conditions, which are often irregular, especially in urban environments. As a result, the wind-only configuration is suitable for low-power applications but may not ensure continuous energy supply.

Case 2: Hybrid Wind-Solar System



In the second case, the system was operated in hybrid mode by integrating the solar panel along with the wind turbine. Under similar environmental conditions, the system produced an output voltage of approximately 10V. The solar panel provided an additional and more stable energy source, which compensated for fluctuations in wind energy.

The hybrid system showed improved voltage stability and better overall performance compared to the wind-only setup. Even when wind speed was low, the solar panel maintained energy generation, ensuring a more reliable output. This demonstrates the advantage of combining multiple renewable sources to enhance system efficiency.

DISCUSSION:

The AEONSPHERE system demonstrates an effective approach to hybrid renewable energy generation by combining wind and solar sources. The integration of a bladeless wind turbine with a solar panel improves energy reliability, as power can be generated under varying environmental conditions.

The use of a rectifier and capacitor filter ensures stable DC output, while the charge controller protects the battery and enhances its lifespan. The 12V battery acts as a reliable storage unit, enabling continuous power supply to the loads even during low energy generation periods.

The incorporation of sensors and the ESP32 microcontroller enables real-time monitoring and intelligent control of system parameters. Features such as LCD display and buzzer alerts improve user interaction and system safety.

Overall, the system is cost-effective, environmentally friendly, and suitable for small-scale applications. However, efficiency depends on environmental conditions, and future improvements can include enhanced energy optimization and IoT-based remote monitoring.

6. CONCLUSION & FUTURE SCOPE

The proposed AeonSphere system demonstrates an innovative approach to renewable energy generation by integrating a bladeless wind turbine with a solar energy source. The system effectively utilizes aerodynamic pressure differences to generate power without rotating blades, making it safer and more suitable for urban environments. Experimental results indicate that the wind-only configuration produces up to 6V, while the hybrid system enhances the output to approximately 10V, improving stability and reliability. The integration of hybrid energy sources along with an ESP32-based monitoring system ensures efficient performance and real-time tracking of system parameters. The compact design, low maintenance requirements, and adaptability make the system suitable for small-scale and off-grid applications. In the future, the system can be further improved by optimizing the turbine design and enhancing aerodynamic efficiency to increase power output. The inclusion of IoT-based monitoring and control can enable remote access and better system management. Additionally, scaling the system for larger applications such as street lighting and smart energy systems, along with the use of advanced control techniques, can significantly enhance its performance and practical usability.

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