SYNERGY OF SUN AND WIND ENERGY: A HYBRID POWER GENERATION SYSTEM WITH DUAL AXIS SOLAR PANELS AND VAWT

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Keywords:

Hybrid Power Generation, Dual Axis Solar Panels, Vertical Axis Wind Turbine (VAWT), Microcontroller-Based System, Real-Time Environmental Responsiveness, Energy Optimization, Sustainable Power Solution, Cost-Effectiveness, Renewable Energy Integration.

Introduction:

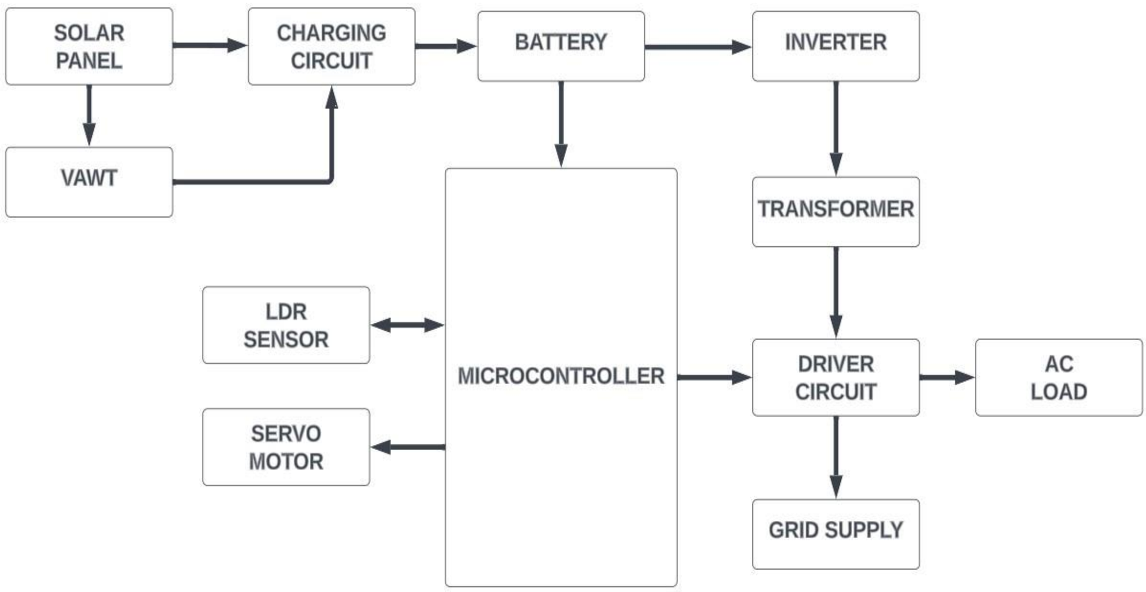
The quest for sustainable energy solutions has led to the innovation of hybrid power systems that combine the strengths of solar and wind energy. This project introduces a **microcontroller-based hybrid power generation system,** integrating dual-axis solar panels with a Vertical Axis Wind Turbine (VAWT). The system is designed to maximize energy capture by dynamically adjusting to environmental conditions, using advanced microinverter technology and integrated sensors[3]. The project aims to contribute to the renewable energy landscape by enhancing efficiency, reducing reliance on fossil fuels, and promoting sustainability. It represents a significant step towards the development of scalable and responsive power generation systems, paving the way for a future powered by clean and renewable energy sources. The hybrid system's adaptability makes it suitable for various applications, including remote power supply, rural electrification, and environmental monitoring. This innovative approach not only addresses the immediate energy needs but also supports the global transition towards a greener and more resilient energy infrastructure. The literature survey reveals various studies on the integration of solar and wind energy systems. Dr. Himabindu Bantikatla et al. proposed a solar "tree" that combines PV panels with a wind turbine, potentially boosting output by 50.8% compared to flat systems. Mr. Adhiya N et al. focused on dual-axis solar tracking systems to enhance solar system efficiency, particularly for rural electrification. Mr. Abhishek Gothe et al. designed a hybrid system tested with Proteus software, aiming to provide a consistent power supply. Mr. Uday Bhasker et al. emphasized the eco-friendly and cost-effective nature of a hybrid system combining solar tracking and a vertical axis wind turbine. Dr. Hao Wang et al. introduced a Wind-Solar Energy Harvester with an Airflow Enhancement Mechanism for isolated railway-side equipment. Dr. Arif Ahmed et al. discussed the benefits of a Hybrid Power Generation System for rural areas with minor power needs, highlighting its sustainability and economic advantages.

Objectives of the project:

- To reduces reliance on fossil fuels, mitigating emissions and promoting sustainability.
- To keep the solar photovoltaic panel perpendicular to the sun throughout the year in order to make it more efficient.
- To provide an alternative power solution for remote locations such as research areas and small villages and also the system can be used as a temporary power solution for locations affected by natural disasters.
- Cost savings are achieved by integrating both solar and wind energy.
- Installation in National Highway Dividers

Methodology:

Block Diagram:



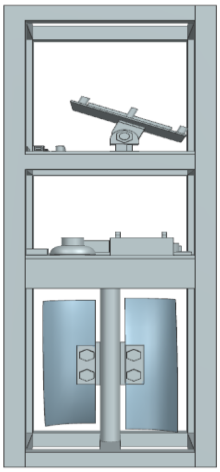
First the **light-dependent resistor (LDR) sensor** detects the ambient light level and sends a signal to the microcontroller. The **microcontroller** controls the system based on the input from the LDR sensor and controls the servo motor. By a **servo**

motor as a part of the control mechanism, possibly adjusting the position or orientation of solar panel based on sensor data. The **solar panel** converts sunlight into direct current (DC) electricity. Utilize a **VAWT (Vertical Axis Wind Turbine)** to harness wind energy. The **charging circuit** regulates the DC electricity from the solar panel and charges the battery. The **inverter** converts the DC electricity from the battery into alternating current (AC) electricity. The **battery** stores the AC electricity from the solar panel. The **transformer** steps up the voltage of the AC electricity from the inverter to match the grid voltage. Connect all components using **driver circuits** to ensure efficient flow and control of electricity. Integrate **grid supply** as an alternative or supplementary source of power, ensuring uninterrupted supply.

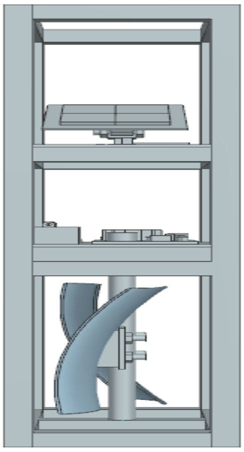
Materials Used:

Arduino UNO Microcontroller, Battery, Windmill Parts, Solar Panel, LDR Sensors, Servo Motor, Resistors, Capacitors, Transistors, Cables and Connectors, PCB and Breadboards, Inverter, Push Buttons, Cast Iron, Card Board, Digital Multimeter, Magnets, Bulb holder, Bulb

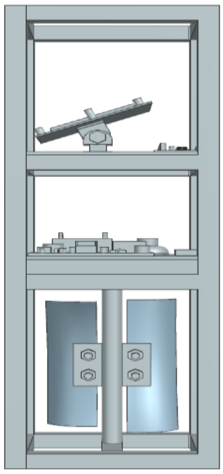
3D Model of Project:



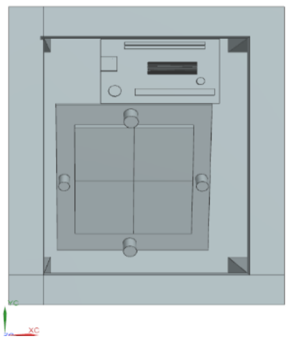
Left View



Front View



Right View



Top View

Results and Conclusion:

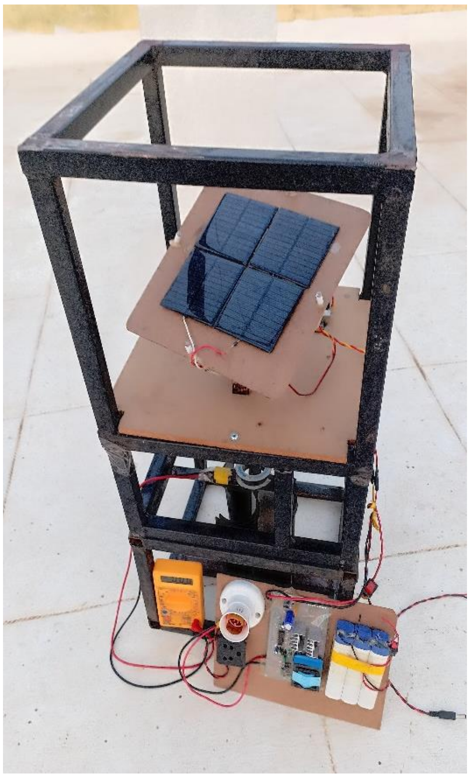
Real Time field analysis of the Hybrid Solar Wind Power Generation System to assess its performance was conducted in roof of the house. Under this assessment, we have carried out separate, full-scale tests upon both solar and wind components of the hybrid system. They are explained below.

Solar Panel Energy Calculations:

Capacity of Unit: 10 W/h
Volts: 12V Period for which Solar Panel is exposed to Sun in Summer
(Ts): 9 hrs. Period for which Solar Panel is exposed to Sun in Winter
(Tw): 7hrs Total Power per Day
(Ps): 90W /day If Losses are included, (The rated power of Solar Panel* the no. of hrs. of Sunshine* Dust, Weak Radiation * Efficiency of Charge Controller)
Power (Ps)= 10*9*0.90*0.85= 64.8Watts/Day)

Wind Power Generation Unit Calculations:

Kinetic Energy of Wind: P=1/2*ρ*A*V3 (P=Power, ρ=density, A= swift area, V= velocity of wind)
P = 1/2 * 1.125 *0.04575 * 53 = 3.21 kg m2 /s3
Multimeter Reading: I = 0.2 amps/min
Power (P) = V*I =12*0.2
Power (P) =2.4 W/min (if Wind Flow is continuous and V =5 m/s)



Innovation in the Project:

The project presents a pioneering hybrid power generation system that ingeniously combines dual-axis solar panels with a Vertical Axis Wind Turbine (VAWT). This integration capitalizes on the complementary nature of solar and wind energies, ensuring a more consistent and reliable power output. The system's core innovation lies in its advanced microinverter technology, which dynamically optimizes energy capture by precisely aligning the solar panels and adjusting the VAWT blade angles in response to real-time environmental conditions. Integrated sensors, including Light Dependent Resistors (LDRs), empower the system to track sunlight and adapt to varying wind patterns, while servomotors drive these adjustments to maintain peak efficiency

Scope for future work:

- **Performance Optimization**: Further research can be conducted to enhance the efficiency of the dual-axis solar panels and the VAWT, ensuring maximum energy capture and conversion.
- **Material Advancements**: Investigating new materials and technologies that can improve the durability and performance of the system components, especially in varying environmental conditions.
- **Energy Storage Solutions**: Developing advanced energy storage systems to ensure a stable and reliable power supply during periods of low wind or solar irradiance.
- **Scalability Studies**: Exploring the scalability of the system for larger applications, such as community power generation or industrial use.
- **Integration with Smart Grids**: Examining the potential for integration with smart grid technology to optimize energy distribution and management.
- **Cost-Benefit Analysis**: Conducting a comprehensive cost-benefit analysis to determine the economic viability of the system for widespread adoption.
- **Environmental Impact Assessment**: Assessing the long-term environmental impacts of the system, including its carbon footprint and potential benefits to ecosystems.
- **User Interface Development**: Creating user-friendly interfaces and monitoring systems to allow easy operation and maintenance of the hybrid system.
- **Policy and Regulatory Framework**: Analysing the policy and regulatory implications of deploying such hybrid systems and advocating for supportive measures.
- **Educational Outreach**: Utilizing the project as an educational tool to promote awareness and understanding of renewable energy technologies among students and the general public.