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Development of Vertical Axis Wind Turbines and Solar Power Generation Hybrid System

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Abstract: *Solar-wind power generation is an emerging approach in countries like the United States, the United Kingdom, and others, where efforts are being made to harness both solar and wind energy simultaneously. This hybrid system is recognized as a clean, sustainable, and independent energy solution. Despite its potential, many nations have yet to adopt it widely. Solar-wind hybrid systems are predicted to play a vital role in meeting future power demands, thanks to their ability to generate several megawatts of electricity with zero emissions. This study focuses on designing and developing a hybrid solar-wind energy system to enhance energy efficiency by integrating solar panels with wind turbines. The goal is to provide a robust alternative to traditional energy sources such as oil, gas, and coal, which are not only polluting but also increasingly scarce. The system includes an improved Vertical Axis Wind Turbine (VAWT) design. Two types of VAWT structures both vertical windmill-shaped are analyzed for performance and efficiency. Additionally, two solar panels are incorporated to supplement power generation, particularly during sunny days when wind speeds may be low. This hybrid design aims to ensure a more reliable and continuous power supply by leveraging the complementary nature of wind and solar energy.*

Keywords: Arduino, Horizontal axis wind turbine (HAWT), Photovoltaic (PV), Pulse width modulation (PWM),Vertical axis wind turbine (VAWT).

I. INTRODUCTION

This system utilizes a Vertical Axis Wind Turbine (VAWT) to generate energy for an inverter. A VAWT has its main rotor shaft positioned perpendicular to the wind, with essential components located at the base of the turbine. The setup is controlled by an Arduino and includes a vertical axis windmill, DC motor, 12V battery, DC inverter, LCD display, and transformer. As wind flows through the turbine, the windmill produces mechanical energy, which is converted into electrical energy by a dynamo. The generated power values are displayed on the LCD. The windmill blades convert wind energy into kinetic energy, which is then used to charge the 12V battery. Once the battery is activated, the inverter converts the stored DC power into AC. The step-up transformer then increases the voltage to a suitable level required to operate external devices. This system offers a compact, efficient method of wind energy conversion.

II. LITERATURE SURVEY

The literature survey reviews multiple studies on hybrid renewable energy systems that combine Vertical Axis Wind Turbines (VAWT) with solar power to improve energy efficiency and reliability. One study examines energy generation along highways using VAWTs and solar panels, focusing on aerodynamics, structural design, and energy conversion efficiency. It concludes that such systems are feasible, environmentally friendly, and cost-effective. Another study compares the performance of Horizontal Axis Wind Turbines (HAWT) and VAWTs in hybrid systems, highlighting that VAWTs are more efficient under low wind conditions. Key design factors like blade shape, rotor attachment, and energy storage were evaluated. A third study investigates a VAWT-solar hybrid model, analyzing different turbine types and environmental factors such as wind speed, direction, and solar irradiance. It emphasizes

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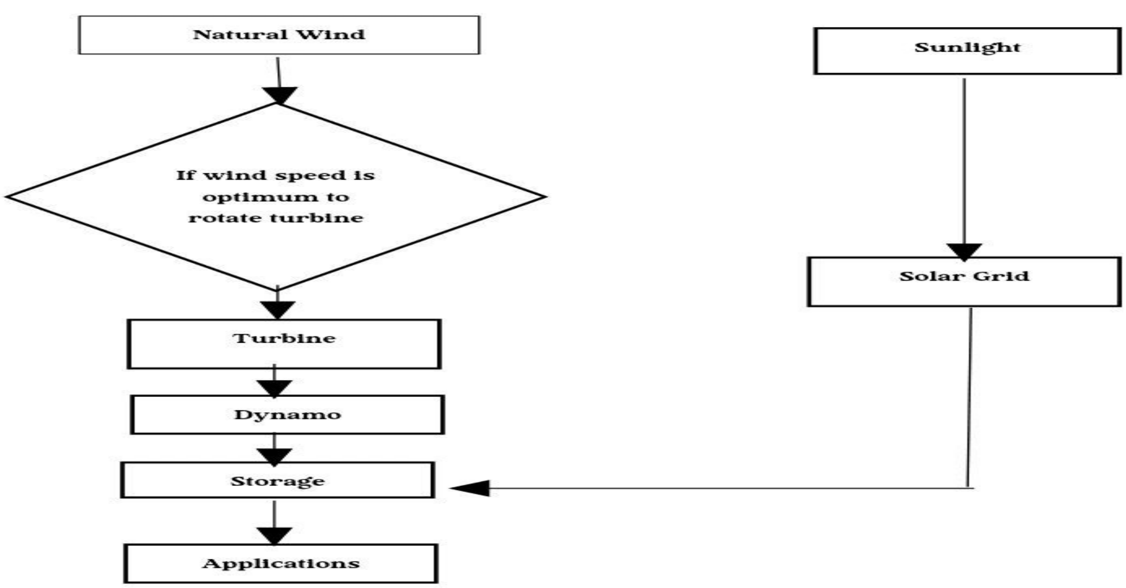
optimizing energy output and adaptability to varying conditions. Overall, the research underscores the potential of hybrid VAWT-solar systems as sustainable and efficient solutions for renewable energy generation.

TABLE-I: Literature Survey

Paper Title	Methodology	Study Area	DataSet	Contribution / Findings
Power genera- tion on highway by using Vertical windmill and Solar System	Systematic lit- erature review. A combination of vertical axis turbine and solar energy.	Aerodynamics, Energy Conver- sion Efficiency, Structural De- sign	Solar Irradiance Data, Books, Journals, Manu- als	Energy Generation Feasibility, Environmental Impact Reduction, Economic Analysis.
Development of a wind turbine fora hybrid solar-wind power system	A HWAT generates less electricity as compared to VAWT HAWT are Blades, Rotor attachment, Hub, Nacelle, DC motor, Base plate and Booster circuit	Blade Shape and Size, Material Selection, Wind Flow Optimization	Rotation Speed, Energy Storage Efficiency, Panel Efficiency	Adaptability for Low Wind Speeds,
Hybrid Model of vertical axis Wind Turbine Solar Power Generation	The wind turns the blades, which spina shaft, which connects to a generator and makes electricity..	Type of turbine, Size of turbine	Wind Speed, Wind Direction, solar Irradiance	Optimized Energy Production, Adaptability for Low Wind Speeds.

III. PROPOSED METHODOLOGY



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IV. BLOCK DIAGRAM

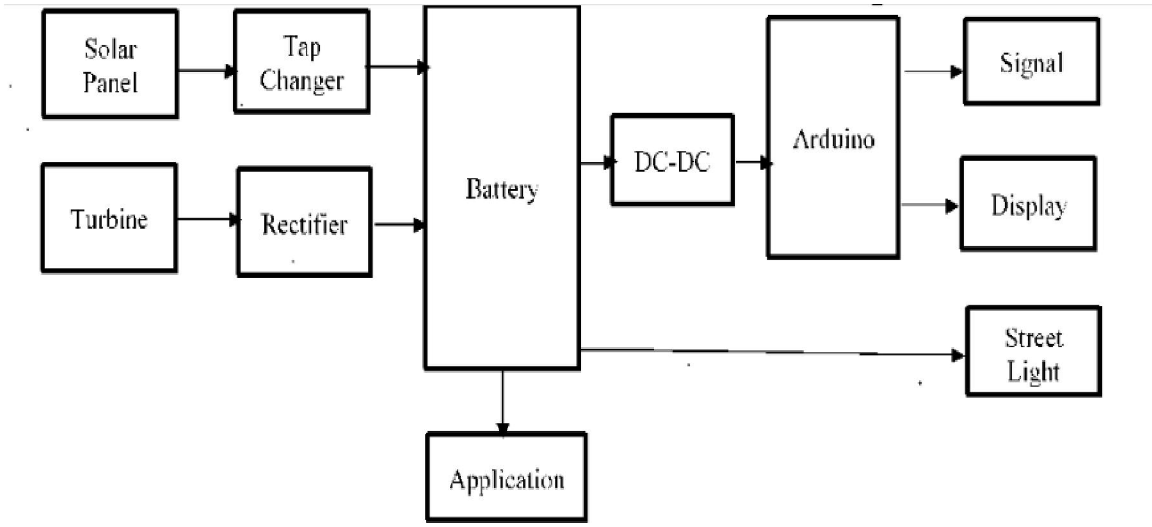

Figure 1: Block Diagram

This is a hybrid system which is used to generate an electricity through solar panel and Wind turbines. This system make utilization of vertical axis wind turbine, solar panel, 12v battery, Arduino. Wind turbine is used to generate an electricity through air, which is produced from the vehicle that passing through that system. When turbine starts rotating then generator generates an electricity and stored in 12volt battery. Solar panel is also generate an electricity through the sun rays and stored in 12volt battery.

V. RESULTS AND FINDINGS

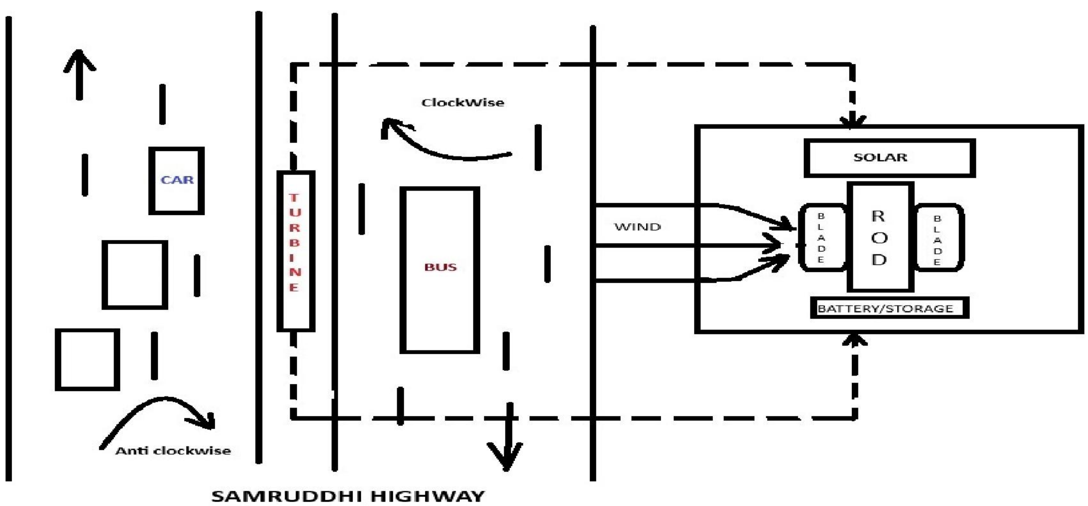

Figure 2: Simulation (Proteus Software)

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Figure 3: Output of Final System (Hardware)

This section illustrates the hardware design and simulation results of the proposed system. The experimental results show that the system was able to generate ample voltage and current for both the wind turbine and the two solar panels. The hybrid system implemented was able to generate maximum power, voltage and current. These results were mainly achieved when the sunlight intensity was ideal for solar power harvesting and optimum wind speed for power harvesting using the VAWT.

VI. CONCLUSION

In today's world, the focus is on creating machines that limit greenhouse gas emissions and promote the use of renewable energy sources over non-renewable ones Utilizing innovative ideas, renewable energy sources can be implemented in various applications to provide clean energy while reducing costs and minimizing environmental damage. Vertical Axis Wind Turbines (VAWTs) are a low-cost, environmentally-friendly option that can be used for small-scale operations and maintenance. Combining wind and solar energy on highways is an effective way to generate continuous power, providing an alternative to depleting energy sources. Grouping turbines on long strips of highways can produce significant amounts of energy to power street lights, rural areas, and public places, while also allowing for potential profits from selling excess power to the grid. For our project, we will install vertical turbines on highways to generate electricity from wind energy produced by passing vehicles. Additionally, solar panels will be placed to capture solar energy during the day and energy from vehicle headlights during the night. The power generated will be used to light up the streets at night using a smart energy conservation system that turns on the lights only when there is vehicle movement, saving up to 50 percent of energy. LDR sensors will detect day and night time to automatically turn the lights on and off. We will monitor power generation and consumption using a sensor network and upload the data to the cloud using IoT technology.

VII. ACKNOWLEDGMENT

With a deep sense of gratitude, we extend our heartfelt thanks to all who guided us throughout our project journey. We are especially thankful to Prof. Y.R. Shinde for his valuable suggestions, support, and continuous encouragement, which played a vital role in our progress. We also appreciate the guidance provided by various industry engineers and technicians, whose input helped us understand and complete the project thoroughly. Our sincere thanks go to our parents for their unwavering support and motivation. Lastly, we express our gratitude to our friends and everyone who contributed, directly or indirectly, to the successful completion of our project.

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BIOGRAPHIES

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