ISSN: 2582-7219

International Journal of Multidisciplinary Research in Science, Engineering and Technology

(A Monthly, Peer Reviewed, Refereed, Scholarly Indexed, Open Access Journal)

Impact Factor: 8.206

Volume 8, Issue 4, April 2025

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© 2025 IJMRSET | Volume 8, Issue 4, April 2025| DOI:10.15680/IJMRSET.2025.0804528

ISSN: 2582-7219 | www.ijmrset.com | Impact Factor: 8.206| ESTD Year: 2018|

International Journal of Multidisciplinary Research in Science, Engineering and Technology (IJMRSET)

(A Monthly, Peer Reviewed, Refereed, Scholarly Indexed, Open Access Journal)

Performance analysis of Vertical axis wind turbine in highways using IOT

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ABSTRACT: Due to the high emissions from the consumption of natural fossil fuel resources, developing and commercializing the sustainable and environment-friendly renewable energy systems are highly demanding topics. The wind turbines are commonly used to convert wind kinetic energy into electric energy. The induced wind along the highways has a great potential to be harvested through the wind turbines on the sideways. In this paper, the aerodynamic effect of traffic along the highway is analyzed to generate the induced wind profile in estimating the potential energy generation. Computational fluid dynamics (CFD) analysis is used to measure the wind velocity profiles generated through the vehicles in different scenarios. Based on these wind velocity profiles energy that can be captured from the harvesting units are estimated. Feasibility of the system is tested to power highway lighting apparatus.

I. INTRODUCTION

In recent years, the consumption of all forms of energy around the world increased rapidly due to the increasing population, urbanization, and development of the living standards. Around 42% of globalـ ଶ emission in 2013 was the by-product of electricity and heat mainly from fossil fuel resources . Over-utilizing the fossil fuel resources cause volatility in fuel prices, and serious environmental problems such as acid rain, global warming, and desertification. Thus, research and development in environmentally friendly renewable energy systems are very crucial. In 2014, global wind power capacity expanded to 369,553 MW. Currently, at least 84 countries around the world are using wind power in their energy portfolio to fulfill their energy demands which makes 4% of worldwide electric power usage .

The amount of energy available from the wind is highly related to the wind speed which is higher at high altitude and coastal areas. However, the wind energy generated from lowspeed wind can also be a source of energy, especially for the distributed energy needs. The turbulence due to the traffic on the roadways is a source for low-speed wind generation that would be considered for energy harvesting . Before investing in this technology, it is very crucial to estimate or measure the wind profile through the vehicle wake from the highways and the amount of energy that could be harvested through the wind turbines systems.

The research in this area is limited and constrained to a specific consideration. In , the induced wind speed of a heavy-duty vehicle was only measured from the bridge overthe highway to get the wind profiles. Researchers in [7] conducted a CFD analysis which is limited to a single vehicle model.

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BLOCK DIAGRAM

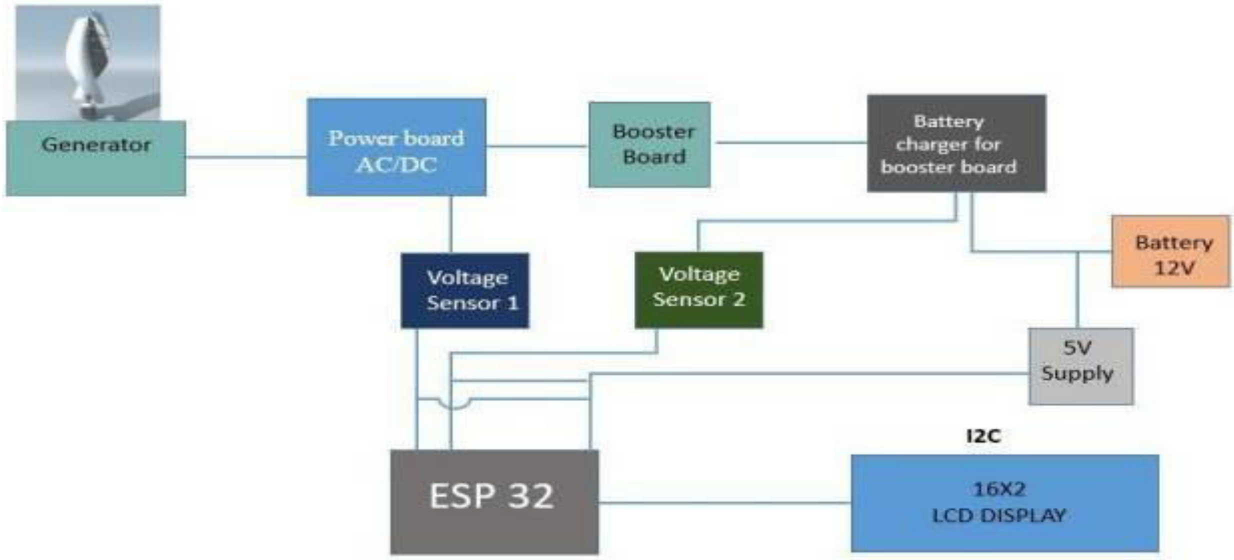

Fig 1: Block Diagram

II. LITERATURE REVIEW

Chiarelli et al. A specially created lift-based VAWT's performance is contrasted with that of a multi-blade wind turbine. • Work Carried out :Contrasted the performance of a specially created lift- based VAWT with a multiblade wind turbine. • Information gathered relevant to our project Shows the differences in efficiency and effectiveness between the two turbine designs.

Erfort et al. According to an experimental investigation by Eriksson and Bernhoff , when torsional vibrations in the design of the VAWT are taken into account, a directly driven synchronous generator is favored over a geared induction generator. Work carried out :Investigated torsional vibrations in VAWT design, favoring a directly driven synchronous generator over a geared induction generator. • Information gathered to our project Emphasized the importance of generator selection for minimizing torsional vibration effects.

Kang et al .the spiral rotor's maximum torque coefficient is higher than that of the conventional rotor • Works Carried out:Found that the spiral rotor's maximum torque coefficient is higher than that of a conventional rotor. • Information gathered relevant to our project Provided insight into rotor Design improvements for better torque performance.

The 2013 paper by Rolland et al., titled "Benchmark experiments for simulation of a vertical axis wind turbine" in Applied Energy, provides an in-depth exploration of benchmark experiments for the simulation of Vertical Axis Wind Turbines (VAWTs). • Work Carried Out: based on the areas this study likely explores, as it assesses experimental and simulation methods related to VAWT performance and modeling. • Information gathered relevant to our project , Benchmarking data it is essential for researchers and engineers developing or testing simulation models.and Experimental Setup and Conditions, like turbine specifications.

The study by Kang et al. (2010), the authors explore the design modifications and aerodynamic performance of a spiral rotor Savonius turbine in comparison to a traditional Savonius turbine. • Work carried out of this study would typically cover the evolution of Savonius turbines, the significance of torque in turbine performance, and previous studies that have investigated performance optimization for vertical-axis wind turbines (VAWTs), especially those focusing on Savonius-type designs. • Information gatherd relevant to our project ,This paper gives the idea about Size and Shape of the turbine and also performance of savonius wind turbine.

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III. METHODOLOGY OF PROPOSED SURVEY

By active driving mode, a technique for VAWT wind tunnel testing is established. Small-scale and selfstarting challenges are resolved by the developed technique.

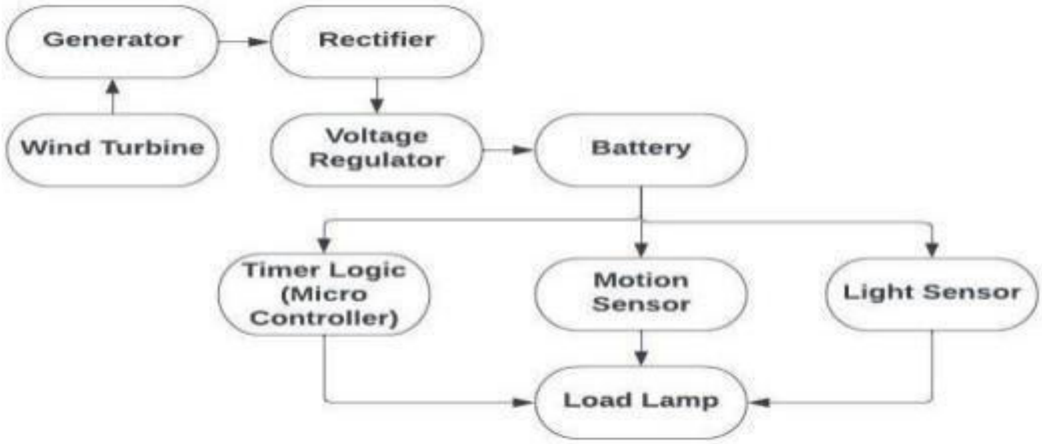

Figure 2. ENLIL schematic representation

VAWT mechanism

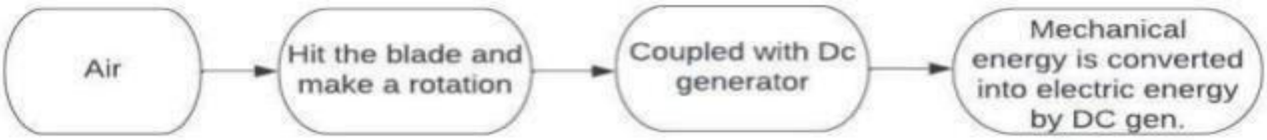

Figure 3. Flow chart of VAWT mechanism

IoT and ThingSpeak Integration

ThingSpeak is an open-source IoT platform that allows users to collect, visualize, and analyze sensor data in real-time. In this application, sensors measure wind speed, turbine RPM, voltage, and current. These values are transmitted via microcontrollers (e.g., ESP8266 or Arduino) to the ThingSpeak server using Wi-Fi. ThingSpeak's MATLAB analytics integration allows for automated calculations, trend analysis, and anomaly detection, greatly enhancing system responsiveness.

IV. CONCLUSION AND FUTURE WORK

In conclusion, highways present themselves as the most suitable location for deploying the turbine system due to several favorable factors. The open environment of highways allows for consistent airflow, which is essential for maintaining the operational efficiency of the turbine. Additionally, the moderate to high levels of vehicle traffic contribute to the generation of wind gusts, a critical factor in ensuring that the turbine can harness energy effectively. The project has been designed with a clear focus on utilizing low RPM turbulent winds and vehicle-induced wind currents, making highways an ideal environment to test and deploy this system. However, the success of the turbine depends not only on its efficiency but also on its placement in an environment that aligns with its design principles. Testing in real-world conditions will play a vital role in analyzing the system's performance and validating its capability to meet the project's goals. A carefully chosen location, coupled with rigorous testing, will ensure the turbine operates at its full potential, fulfilling the objective of harnessing wind energy from highway traffic effectively.

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