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Solar-Wind: Integrated Dual power Generation System

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Abstract: *Wind turbine efficiency improvements can greatly increase power generation while lowering the demand for costly and environmentally harmful power sources. More efficient use of wind could result in lower energy costs for regular consumers because it is a renewable and free resource. Wind energy is a clean substitute for fossil fuels because it emits little to no pollution. Households may experience a significant reduction in their electricity costs with the development of turbine technology and wider adoption. Early windmills were invented in Persia, and people have been using wind power since the 7th century. Grain grinding, irrigation, and milling were the main functions of these early devices, which is probably where the word "windmill" came from. The use of windmills had expanded throughout Europe by the 12th century, with areas like the Netherlands seeing the most growth. Where massive wind farms started to play a crucial role in the generation of energy. But the first windmills weren't very effective. They produced slow, torque-focused machines because they only used half of each sail's rotation and had low tip speed ratios. Notwithstanding their drawbacks, these windmills served as a precursor to the highly engineered, contemporary turbines of today.*

Keywords: Wind turbine efficiency, renewable energy, wind power, clean energy, energy cost reduction, pollution reduction

I. INTRODUCTION

The latest vertical wind turbines combined with photovoltaic (PV) solar panels offer a powerful hybrid solution for reducing dependency on expensive grid electricity. These hybrid systems are supplying consistent, clean energy everywhere, from apartment buildings to street lighting. Since vertical turbines require less infrastructure and space than traditional horizontal turbines, they are particularly well suited for urban and low-wind environments.

Windmills are controlled by two basic designs: horizontal and vertical axes. Bernoulli's Principle, that differences in air pressure over curved blades create rotation, is the foundation of lift in horizontal axis windmills, as in the traditional Dutch design.The goal of modern horizontal turbine tuning is to maximize lift and minimize drag.

Vertical axis windmills, such as the Savonius or Darrieus, on the other hand, use drag to capture wind energy. But they are generally less effective. They have an edge in windy conditions and are easier to maintain. Windmills are used for many purposes, including friction heating, electricity generation, and water pumping.

Over the years, advancements like gearboxes, hinged blades, air brakes, and the fantail (created in 1745) have significantly revolutionized control and performance. Modern wind turbines are always changing, combining cutting-edge technology with traditional creativity to create a more sustainable world.

II. LITERATURE REVIEW

Hybridizing vertical axis wind turbines (VAWTs) with photovoltaic (PV) solar panels has received a great deal of interest as a green way of minimizing the use of conventional grid electricity. This review examines the architecture, operation, and deployment of such hybrid systems.

Numerous applications, including transportation and precision systems, have been studied for the concept of magnetic levitation, or Maglev. Post (1994) [1] introduced a magnetic levitation system for moving objects, laying the groundwork for frictionless, extremely effective systems. Kim and Trumper (1998) [6] extended this with a high-precision magnetic levitation stage for photolithography, showcasing the potential of Maglev in precision engineering and clean energy systems such as vertical axis wind turbines (VAWTs).

Mashyal and Anil [2] emphasized the potential of using wind generated by fast-moving vehicles in their design and analysis of a highway windmill electric generation system. This innovative use demonstrates how underutilized wind resources along highways can be leveraged to support decentralized power generation.

Similarly, Ramesh and Aravind [3] examined the design aspects of blade shape and placement in Maglev-based VAWTs, showing how aerodynamically optimized blade configurations improve structural efficiency and stability.

The aerodynamic modeling of Savonius turbines, a type of drag-based VAWT, has also seen significant progress.Diaz et al. [4] designed a computational model that provided valuable information for low-wind and urban conditions in an attempt to evaluate their performance. Mohamed et al. [9] also designed obstacle-based shielding methods in an attempt to improve Savonius turbine performance by increasing energy capture and lowering drag on the returning blade.

There has also been a lot of interest in hybrid renewable energy systems' dependability and effectiveness. A techno-economic analysis of a solar-wind hybrid system was conducted by Hongxing et al. [5], who optimized component selection and sizing to make energy production economical. According to their research, integration strategies are important for off-grid and rural electrification projects.

In-depth evaluations of turbine designs have also been conducted. Eriksson et al. [7] emphasized the suitability of vertical axis designs for specific environmental conditions in their assessment of different wind turbine concepts. A more comprehensive analysis of wind energy technologies was provided by Herbert et al. [8], who discussed the history, advantage, and disadvantage of different turbines.

Lastly, aerodynamic performance models for Darrieus-type straight-bladed VAWTs were explored by Islam et al. [10]. In addition to resolving the issues created by dynamic stall, their work provided modeling frameworks that enhance the accuracy of turbine performance predictions under real conditions.

III. METHODOLOGY

The initial step towards creating the Solar-Wind Integrated Dual Power Generation System was to identify the type of wind turbine blade that could function in regions with low wind speeds. Several blade designs were considered based on their aerodynamic efficiency, material needs, and strength structure.

The optimal type of blade was selected based on an intensive analysis. The selected blade was then modeled using SolidWorks, which is a 3D modeling software that performs the task of generating a precise and detailed model of the blade. Apart from providing a simulation testing platform, this virtual model helped to imagine the final structure. Performance of the blade for various wind conditions, such as stress distribution, tip speed ratio, and overall energy conversion efficiency, was studied by means of simulations. based on the simulation results, necessary modifications were made to optimize the design before fabrication.

Light and stiff materials such as wood or PVC were utilized in fabrication, which ensured proper performance and simplicity in manufacturing. Once the blade was fabricated, the wind turbine unit was constructed by placing it on a support stand and securing it to the turbine hub. Then, this unit was connected to a generator capable of converting the mechanical energy of the turbine to electrical energy. A solar panel was also provided as the aim of the project was to create a hybrid power generation unit.

In selecting the solar panel, efficiency, dimensions, and capability of the solar panel to complement the output of the wind turbine were considered. The two power sources were joined by using a charge controller. In regulating the supply of power from the solar panel and wind turbine, this device regulated the voltage.

Each variable of the solar panel's efficiency, size, and capability of supporting the production of the wind turbine was also considered in selection. A charge controller was utilized to bring together the two energy sources. It managed the voltage by controlling the solar panel and wind turbine power supply.

The inverter, which transforms the stored DC power into usable AC output, was then connected to the system. After the hybrid system was fully assembled, it underwent a series of tests. Performance was assessed under various environmental conditions to gauge the integrated setup's power output, efficiency, and dependability. The system's ability to continuously provide electricity even in the event that one of its sources—either solar or wind—was not

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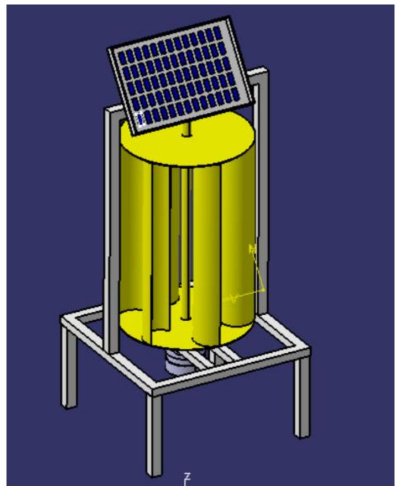
operating was one of its key performance indicators. According to the test, integrating both renewable energy sources resulted in a cleaner and more stable power supply, increased overall dependability, and more effective use of natural resources. Thus, it was guaranteed that a suitable hybrid renewable energy system would be developed, designed, and validated successfully for continuous and economical power generation.

IV. SCHEMATIC REPRESENTATION



V. ANALYSIS AND CALCULATIONS

Total weight of our turbine = 2.3 kg

AREA OF TUEBINE

Surface area = $2\pi r2 + 2\pi rh$

= 2 x 3.14 x 225 + 2 x 3.14 x 15 x 50

=1413 + 4,710

=6,123 〖cm〗^2

VOLUME OF TURBINE

There is special formula for finding the volume of a cylinder. The volume is how much space takes up the inside of a cylinder. The answer to a volume question is always in cubic units.

Volume = $\pi r2h$

= 3.14 X 225X50

=35,325 〖cm〗^3

We know,

Kinetic Energy =½(MV)^2

The volume of air passing in unit time through an area A, with speed V is AV and its mass M is equal to the Volume V multiplied by its density ρ so:

M= ρAV

Substituting the value of M in equation above we get:

Kinetic Energy=1/2 (ρAV) V^2

Kinetic Energy=1/2 ρAV^3

To convert the energy to kilowatts, a non-dimensional proportionality constant k is introduced where,

K = 2.14×10^−3

Therefore,

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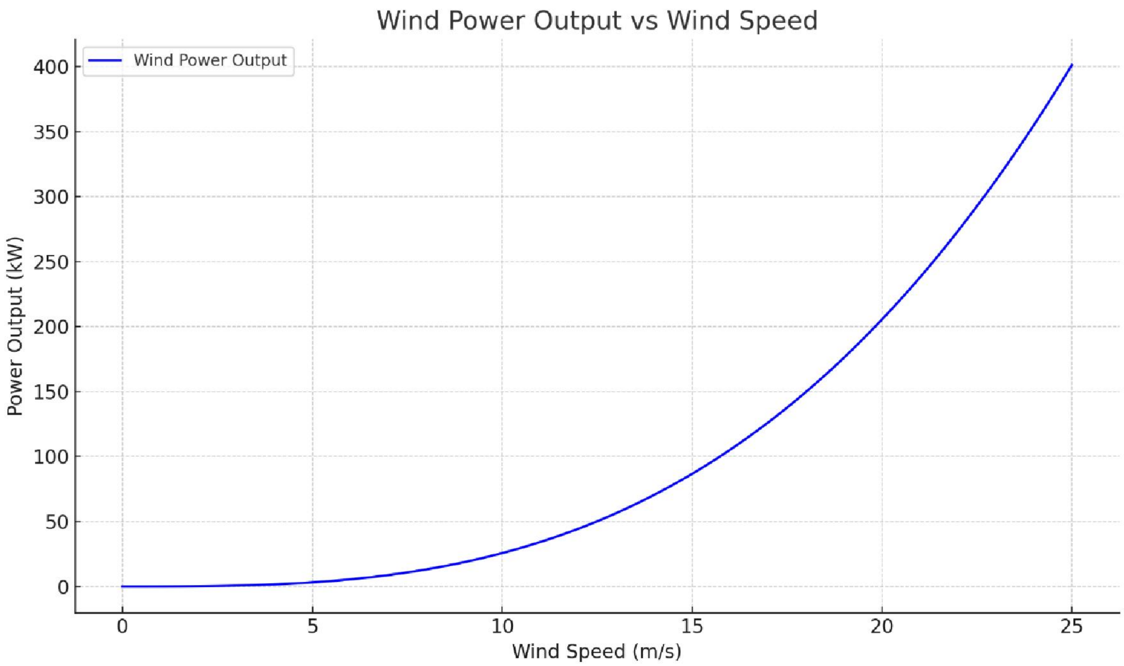
Power in KW (P) = 2.14ρAV3×10^−3
Where:
Air Density (ρ) = 1.2 kg/ 3/2.33x 10^−3 slugs/f 3
Area (A) = Area swept by the blades by the turbine
Velocity (V) = wind speed in m/s



VI. RESULT AND DISCUSSION

The testing and development of the hybrid system involving solar panels and vertical-axis wind turbines were done successfully. The wind turbine was designed to perform well at low wind speeds with the aid of solar power for ensuring uninterrupted generation of power. The system produced a significant level of energy and thus suitable for small-scale applications such as charging batteries or powering small devices. Safe and balanced charging and discharging of the battery storage system were enabled through the use of a charge controller. The dual-source system is able to complement each other well and reduce dependency on grid electricity, especially in remote or off-grid locations, as was demonstrated by the functional prototype.

VII. CONCLUSION

The project is able to effectively demonstrate how a hybrid power generation system using solar and wind power can serve as an affordable, eco-friendly, and sustainable alternative to conventional sources of electricity. The system capitalizes on the weaknesses of each renewable resource by complementing their strengths; the wind turbine will operate whenever there is wind, and the solar panels will perform optimally during daytime.Apart from producing energy more reliably, the configuration also makes the system energy independent and less environmentally harmful.The system is a perfect fit for rural electrification and small city usage since it is economical, easy to install, and scalable. Smart tracking systems, the newest materials, and large-scale uses for increased energy production are a potential future development.

REFERENCES

[1] "Magnetic Levitation System for moving objects", R. F. Post, 1994, United States Patent (Patent No: 5,722,326).

[2] "Design and analysis of highway windmill electric generation", S. Mashyal and Dr. T. R. Anil, American Journal of Engineering Research, Volume-03, Issue-07, pp-28-32.

[3] "Design Aspects of Blade Shape and Position for the MAGLEV Vertical Axis Wind Turbine", G.P. Ramesh and C.V. Aravind, Power Electronics and Renewable Energy Systems, Lecture Notes in Electrical Engineering Volume-326, pp-933-940.

[4] "Computational model of Savonius turbine",A.P Diaz, G. J Pajaro and K. U Salas, Ingeniare. Revistachilena de ingeniería, Volume-23, pp. 406-412.

[5] "Optimal design and techno-economic analysis of a hybrid solar–wind power Generation system", Y. Hongxing, Z.Wei, L. Chengzhi, Energy Volume 86, Issue 2, pp-163–169.

[6] "High-precision magnetic levitation stage for photolithography", W Kim and D. L. Trumper, Precision Engineering, volume-22, Issue 02, pp-66–77.

[7] "Evaluation of different turbine concepts for wind power",S. Eriksson, H. Bernhoff, M. Leijon, Renewable and Sustainable Energy Reviews , Volume- 12, pp- 1419–1434.

[8] "A review of wind energy technologies", G.M. Herbert, S. Iniyan, E. Sreevalsan, S. Rajapandian, Renewable and Sustainable Energy Reviews, volume-11, pp- 1117–1145.

[9] "Optimization of Savonius turbines using an obstacle shielding the returning blade", M.H. Mohamed, G. Janiga, E. Pap, D. Thévenin, Renewable Energy, volume-35,pp- 2618-2626.

[10] "Aerodynamic models for Darrieus-typestraight-bladed vertical axis wind turbines", M. Islam, D. S. Ting, A. Fartaj, Renewable and Sustainable Energy Reviews, volume-12, pp-1087–1109