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PDESIGN AND DEVELOPMENT OF ROOF TOP DOMESTIC WIND TURBINE

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Abstract : This project focuses on designing and developing a small rooftop wind turbine to generate electricity for household use. Design parameters are carefully tailored to power ten household appliances based on daily average consumption. The NACA series profile is selected for blade design to maximize lift and aerodynamic efficiency.

The project analyzes various operating conditions at different RPMs, resulting in a specific power curve for the turbine. Future plans include installing these turbines on different rooftops with unique conditions. Additionally, the project explores the correlation between wind speed and power generation to understand adaptability and efficiency in diverse environments.

Overall, the project provides insights into rooftop wind energy for sustainable household power solutions.

IndexTerms - **design, development, rooftop, domestic, wind turbine.**

I. INTRODUCTION

Wind turbines represent a remarkable feat of technology, efficiently transforming the kinetic energy of wind into electrical power. With a history spanning over a millennium, these devices remain vital contributors to energy generation. Known as Wind Energy Conversion Systems (WECS) or Wind Turbine Generators (WTGs) when configured for electricity production, they exist in two primary forms: Horizontal Axis Wind Turbines (HAWTs) and Vertical Axis Wind Turbines (VAWTs).

Small Horizontal Axis Wind Turbine Design:

This project centers on the intricate design of small Horizontal Axis Wind Turbines (HAWTs), tailored specifically for rooftop installations. The objective is to effectively harness electrical energy from wind kinetic power. Utilizing advanced design methodologies, we have meticulously optimized the coefficient of lift (CL) for the turbine blades to ensure peak performance. The project integrates a fundamental kinetic energy formula to calculate the electrical energy available in the wind:

Formula: Energy available in the wind = $0.5\ \rho\ A\ U^3$

Here, A represents the Span Area, D is the Rotor Diameter, ρ denotes Air Density, U signifies Wind Velocity, and Cp is the Coefficient of Performance.

Wind Turbine Blade Evaluation:

The culmination of our meticulous design process involves assessing the performance of wind turbine blades. This evaluation entails comparing actual performance data with theoretical calculations, visually presenting the results through graphical representations. These visuals offer insights into blade efficiency across various wind speeds.

II. DESIGN OF SMALL HORIZONTAL WIND TURBINES:

Small-scale turbines feature blades typically measuring 1.5 to 3.5 meters in diameter, producing 1 to 10 kW of power at optimal wind speeds. Prioritizing lightweight construction, some models are designed for portability and easy installation. They offer flexible output options, including direct current for battery charging and power inverters to convert electricity back to alternating current (AC) while maintaining a constant frequency for seamless grid connection.

Future Implications:

This project sets the stage for a future where small horizontal axis wind turbines adorn rooftops, seamlessly blending into urban environments. Despite their compact size, these turbines represent a significant stride towards decentralized energy generation. Figure 1 illustrates the proposed model, offering a glimpse into the innovative solutions that could revolutionize domestic wind energy utilization. By delving into wind turbine design intricacies and performance analysis, we pave the way for sustainable, efficient, and visually discreet household power generation.

Fig.1 – Turbine Model

Horizontal Wind Turbine:

The Horizontal Wind Turbine operates akin to an airplane wing, utilizing propeller-like blades to harness wind energy. As wind blows, a low-pressure pocket forms on one side of the blade, creating a force called lift that pulls the blade towards it, causing the rotor to spin. Notably, the power generated by lift surpasses the wind's force against the blade's front side, known as drag. The combined effect of lift and drag propels the rotor, similar to a propeller's motion.

Vertical Wind Turbine:

In contrast, the Vertical Wind Turbine employs a design focused on drag to capture wind energy. The rotational energy produced by the turbine rotates the generator, ultimately generating electricity. This design is particularly advantageous in situations with space limitations or variable wind directions.

III. VERTICAL AXIS WIND TURBINES (VAWTS):

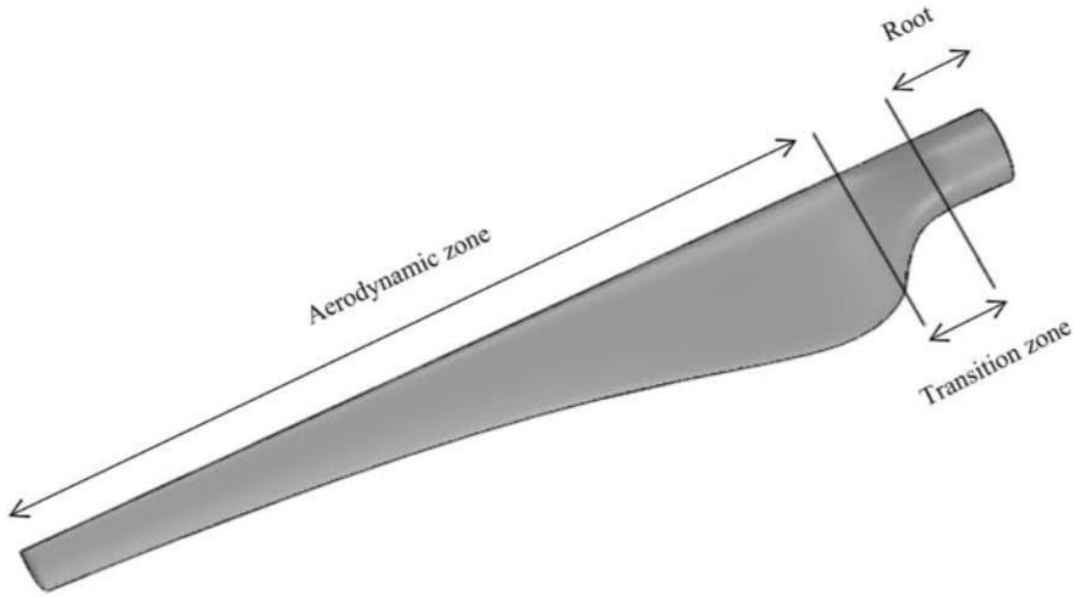
VAWTs are engineered to operate closer to the ground, making them well-suited for capturing lower-speed winds in residential and urban areas. Key characteristics include:

1. Rotor Rotation Around a Vertical Axis: Blades rotate around a vertical axis, enabling them to harness wind from any direction without requiring a yaw mechanism.

2. Wind Direction Adaptability: VAWTs can generate electricity regardless of wind direction, enhancing their suitability for areas with variable wind patterns.

3. Lower Maintenance Requirements: In comparison to Horizontal Axis Wind Turbines (HAWTs), VAWTs generally entail less maintenance, making them appealing for residential and commercial applications. This reduced maintenance demand contributes to their attractiveness for homeowners seeking sustainable solutions.

The methodology of rooftop wind power projects integrates innovative blade design, airflow optimization, and careful selection of wind turbine types. Emphasis on optimizing wind speed calculations and choosing appropriate turbine designs ensures efficient energy generation in diverse environments, addressing the unique challenges presented by urban and residential settings. This approach not only reduces carbon footprints but also aligns with the practical requirements of homeowners and businesses seeking sustainable and effective energy solutions.



Advantages of Micro Wind Turbines for Home Use:

1. Space Efficiency: Micro Wind Turbines are crafted with a compact footprint, making them ideal for residential setups where space is at a premium.

2. Versatility: Offering both horizontal and vertical designs, homeowners can select the configuration that aligns best with their location and energy needs.

3. Sustainability: By harnessing wind power, micro turbines promote eco-friendly energy practices, diminishing reliance on traditional power sources and cutting carbon emissions.

4. Decentralization: Micro Wind Turbines empower homeowners to generate their electricity, fostering energy autonomy and reducing reliance on centralized power grids. This self-sufficiency enhances energy security and resilience.

IV. FUTURE INTEGRATION:

As we peer into the future, the incorporation of Micro Wind Turbines into residential environments heralds a promising transition towards sustainable and self-reliant energy solutions. Their versatility, coupled with the capacity to harness electricity from natural wind resources, positions them as pivotal components in the evolution towards a greener and more sustainable energy ecosystem for homes.

V. ROOFTOP WIND ENERGY:

Conventional wind turbines, renowned for their imposing and sturdy designs, have traditionally epitomized eco-friendly power generation. Operating both on land and offshore, these turbines have unquestionably played a significant role in providing abundant and renewable

VI. CALCULATION:

Using the provided formula with the given assumptions:

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$$5kW = \underline{1} \times 1.225 \times A \times (13^3) \times 0.4$$

This yields:

- Length of the blade = 1.11 m
- Blade diameter = 2.22 m

POWER CALCULATION

Considering 10 household appliances with an average power consumption of 1.75 kW, the theoretical power for this project is fixed at 5 kW.

Calculating daily power consumption:
Average Power = 42000 watts per hr.

= 1750 watts

Thus, the theoretical average electrical energy consumption is 1750 watts per day for one house.

TIP SPEED RATIO

The Tip Speed Ratio (\(J\)) is defined as the ratio of the product of the rotational speed of the blade and the radius of the wind turbine blade to the wind speed:

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$$\frac{\Omega\times\square}{\square}$$

Where:

- J = Tip Speed Ratio
- Ω = Rotational Speed
- r = Radius of The Wind Turbine Blade
- V = Free Stream Velocity

VII. CONCLUSION:

- In conclusion, the development and utilization of micro wind turbines for residential purposes signify a significant advancement towards sustainable energy practices. With their compact size, versatility, and ability to harness wind power efficiently, micro turbines offer homeowners a viable means of generating electricity on-site while reducing reliance on traditional energy sources.

- Moreover, the integration of micro wind turbines into residential settings not only promotes energy decentralization but also contributes to environmental conservation by reducing carbon emissions. By harnessing the natural power of the wind, homeowners can take proactive steps towards creating greener, more self-sufficient communities.

- As we embrace this transition towards renewable energy solutions, it is essential to continue investing in research, development, and infrastructure to further enhance the efficiency and affordability of micro wind turbine technology. By doing so, we can pave the way for a more sustainable future, where clean energy is accessible to all, and our planet's natural resources are preserved for generations to come.

VIII. REFERENCES

1. F.C. Emejeamara, A.S. Tomlin, A method for estimating the potential power available to building mounted wind turbines within turbulent urban air flows,
2. Renewable Energy, 2020
3. Zinat Tasneem a , Abdullah Al Noman a, An analytical review on the evaluation of wind resource and wind turbine for urban application: Prospect and challenges,
Developments in the Built Environment, 2020

4. N.A. Ahmed, A novel small scale efficient wind turbine for power generation,

Renewable Energy, 2013

5. Qiong Zou a , Zhengnong Li b, A study on the characteristics of roof wind field by wind tunnel test, Journal of Building Engineering, 2021

6. Ronit K. Singh, M. Rafiuddin Ahmed, Blade design and performance testing of a small wind turbine rotor for low wind speed application, Renewable Energy, 2012

7. Francesco Calise , Francesco Liberato Cappiello , Dynamic modelling and thermoeconomic analysis of micro wind turbines and building integrated photovoltaic panels, Renewable Energy, 2020

A.D. Peacock a , D. Jenkins b, Micro wind turbines in the UK domestic sector,

Energy and Buildings, 2007

8. Marco Bortolini a , Mauro Gamberi b, Performance and viability analysis of small wind turbines in the European union, renewable energy, 2013

9. Q.S. Li a , Z.R. Shu a, Performance assessment of tall building-integrated wind turbines for power generation, Applied Energy,2016

10. Firoz Alama , Abdulkadir Alia, Status of power generation by domestic scale wind turbines in Australia, Procedia Engineering, 2012