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Review on Vertical Axis Wind Turbine

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ABSTRACT

Focus on the use of renewable sources of energy for generation of electrical power is gaining momentum. This is partly due to the emergence of Global warming as well as latest technological advancements in fields related to material science, nanotechnology, Finite Element Analysis and Computational Fluid Dynamics software, etc. Wind energy has high potential to be exploited for power generation along with solar energy. India has current installed capacity of 32.17 GW which is the fourth largest installed capacity in the world. Also, National Institute of Wind Energy has projected India's wind power potential from 49,130 MW to 302,000 MW. For now, most of the wind farms are located at remote places since they require large footprint of installation, produce noise pollution and cannot operate with high structures around them which obstruct wind flow. Hence, these factors make them absolute in an urban setup. We explore the applicability of Vertical Axis Wind Turbine in these urban areas. VAWT have inherent advantages over HAWT like less space requirement, operation in any direction of wind flow, easy construction and installation. Solar energy utilization is prominent in households. However, the biggest disadvantage of current Solar Energy Generation Systems is their inability to provide energy during night time. Wind energy is at its peak during night time due to temperature difference between sea temperature and land temperature. VAWT can be used in tandem with these SEGS to provide electricity during day as well as night time. In this paper, we have reviewed the history of VAWT, their major types and advantages over Horizontal Axis Wind Turbine.

KeyWords: *Wind Energy, VAWT, Savonious, Darrieus*

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1. WIND ENERGY

Wind is the flow of air. It is caused due to pressure difference between two regions. There are mainly two types of winds:

i. Planetary winds
ii. Local winds

Planetary winds are caused due to uneven heating of the surface of the Earth. Equatorial region gets heated more than the polar regions due to higher amount of incident sunlight. This temperature difference cause flow of air or wind, from equator to poles of the Earth. Hence, it can be said that wind energy is an indirect form of Solar energy. Local

winds are caused due to regional temperature difference. For example, the air over sea is cooler than the air over the land during night time. This causes flow of air from sea to land causing local wind currents.

Figure -1 Planetary Winds

As of 2012, the total world electricity production using wind power was 534.3 TWh. [1] The inherent advantages of wind power are that it is cheap, clean, reliable and available in plenty. A lot of research is being carried out to improve efficiency of current wind energy systems. HAWTs are widely used for this purpose.

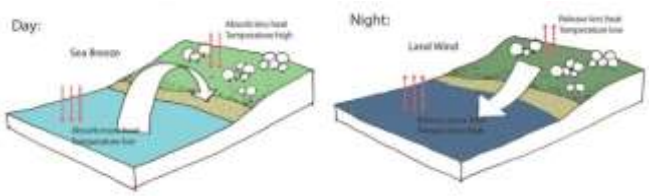

Figure 2 Local Winds

Focus on use of renewable sources of energy for generation of electrical power is gaining momentum. This is partly due to the emergence of Global warming as well as latest technological advancements in fields related to material science, nanotechnology, FEA and CFD software, etc. Wind energy has high potential to be exploited for power generation along with solar energy. India has current installed capacity of 32.17 GW which is the fourth largest installed capacity in the world. [2][3][4] Also, NIWE has projected India's wind power potential from 49,130 MW to 302,000 MW. [5] For now, most of the wind farms are located at remote places since they require large footprint of installation, produce noise pollution and cannot operate with high structures around them which obstruct wind flow. Hence, these factors make their use absolute in an urban setup.

2. VERTICAL AXIS WIND TURBINE

Vertical Axis Wind Turbines [VAWTs] are a type of wind turbines in which the axis of the rotor is perpendicular to the direction of wind flow. R&D on VAWTs started in early 1980s. [6] A lot of research has gone into determining the feasibility of VAWTs in current electricity production systems. [7]

There are mainly two types of Vertical Axis Wind Turbines:

i. Lift type

ii. Drag type

Lift type VAWTs use the aerodynamic lift force to run the blades of the wind turbine. Lift is defined as that component of the total aerodynamic force perpendicular to the force direction. They use blades of aerofoil cross-sectional profile.

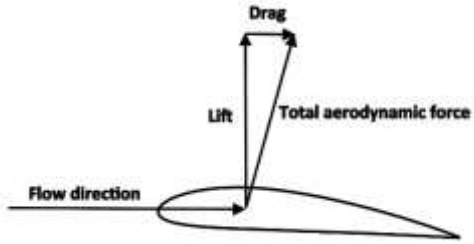

Fig.-3 Lift and Drag Force

Drag type VAWT use drag force to run the blades of the wind turbine. Drag is defined as that component of the total aerodynamic force parallel to the force direction. They allow use of non-aerofoil blade profiles to be used, thereby reducing manufacturing costs.

2.1 Savonius VAWT

In order to fabricate Savonius rotor, a hollow elliptical cylinder is sliced into two pieces and each of these halves fixed to a vertical axis with a fixed gap. It forms S-shape due to this Savonius type rotors are also called as **S-rotors**. Savonius vertical-axis wind turbines is a slow rotating, high torque machine with two or more scoops and are used in high-reliability low-efficiency power turbines. Most wind turbines use lift generated by airfoil-shaped blades to drive a rotor, the Savonius uses drag and therefore cannot rotate faster than the approaching wind speed.

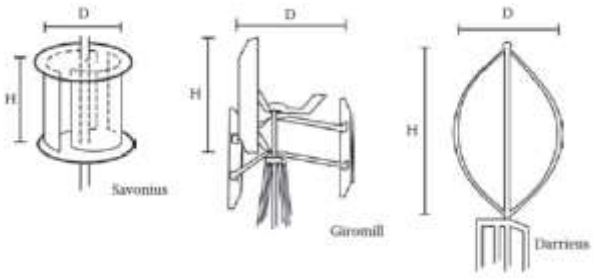

Fig.-4 Vertical Axis Wind Turbines

2.2 Darrieus VAWT

During the Cold War and energy crisis in 1970s, wind turbines were recognized and developed for its potential in power generation. Interest in developing wind energy technology had sprouted Darrieus VAWT out of the vacuum. Until recently, the only VAWT deemed as efficient as a HAWT was giromill with COP of about 0.5. [8] Darrieus VAWT was intensely studied and analyzed for about 20 years, mainly at National Research Council [NRC] in Canada,

Sandia National Laboratories [SNL] in US and the Carmarthen Bay Wind Energy Demonstration Centre in the UK. Several variations on both curved and straight blades configurations have been investigated. Novel variations have emerged to prove better performance. A recent investigation [9] using stereoscopic particle image velocimetry [PIV] shows the wake and vortices formed by a two-bladed H-rotor clearly. These vortices are used in the VAWT fish-schooling formation to harness more power in a given area.

2.3 Advantages of VAWT over HAWT

- Darrieus VAWT power generation cost is about 18-39% less than a HAWT counterpart. [8]
- Darrieus VAWT has better turbulence characteristics compared to HAWT, making it possible to arrange them in an array close to each other. This improves overall performance of the wind turbine.
- Vertical Axis Wind Turbines can operate in any direction of wind flow.
- Even though theoretically the efficiency of VAWT is less than HAWT, it is better than HAWT in L-σcriterion. [10]
- Manufacturing of VAWT devices with low technicity is sufficient to meet modest electrical needs of a household. This is not possible with HAWT since they require blades with airfoil profile to operate efficiently. [11]

4. CONCLUSION

From above review, it can be concluded that Vertical Axis Wind Turbines can play an important role in increasing utilization of wind energy in congested urban areas. Their advantages of running on lower wind speeds, ability to work in any direction of wind flow, compact construction and quite operation make them ideal for localized household power generation units.

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