Design and Performance Analysis of Helical Wind Turbine

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ABSTRACT

This report describes about the wind power and its potential that can be harnessed in the future to meet the current energy demand. With detailed description of the wind turbine and the wind generator focus has been given on the interconnection of the generators with the grid and the problems associated with it. The shape of the blades is changed to helical so that it can rotate continuously at any direction of wind. Hence the efficiency of the turbine is improved and also the stresses are minimized. Conclusions were made about the behavior of the wind in urban location. Thereafter, the helix angle of the blade is changed and the best angle of operation is analyzed.

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1. INTRODUCTION

A **windmill** is a mill that converts the energy of wind into rotational energy by means of vanes called sails or blades. Centuries ago, windmills usually were used to mill grain, pump water, or both. Thus they often were gristmills, wind pumps, or both. The majority of modern windmills take the form of wind turbines used to generate electricity, or wind pumps used to pump water, either for land drainage or to extract groundwater. A wind turbine is a device that converts kinetic energy from the wind into electrical power. The term appears to have migrated from parallel hydroelectric technology(rotary propeller). The technical description for this type of machine is an airfoil- powered generator.

The two main types of wind turbine are based on the direction/effect of the wind flow:

- Horizontal Axis Wind Turbine (HAWT)
- Vertical Axis Wind turbines (VAWT)

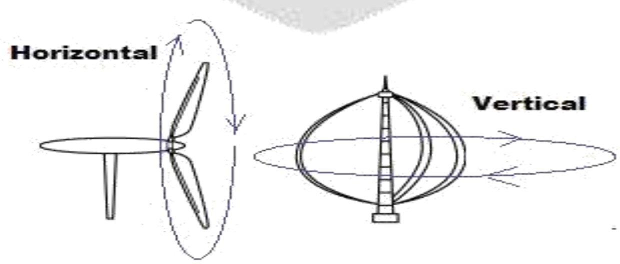

Figure 1.
Horizontal and Vertical Turbines

2. DESIGN AND TYPES OF THE HELICAL BLADE WIND TURBINE

Typically, helical wind turbines are designed along a vertical axis. Vertical axis wind turbines are generally gaining popularity for residences and urban settings because they can be placed lower to the ground and on rooftops. Another advantage of the helical wind turbine is that it generally can be used in areas with higher wind speeds where bladed turbines would need to be shut down for safety reasons. In recent years, manufacturers of utility scale horizontal axis bladed wind turbines have come under fire for killing birds especially in migratory paths. Helical wind turbines are also less susceptible to problems with crosswinds than bladed turbines and they require no tail-fan to keep them pointed in the optimal direction.

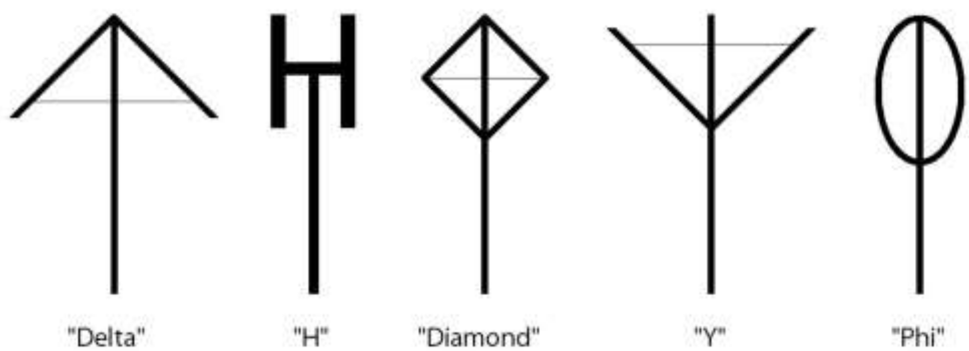

Figure 2. Different shapes of vertical turbines

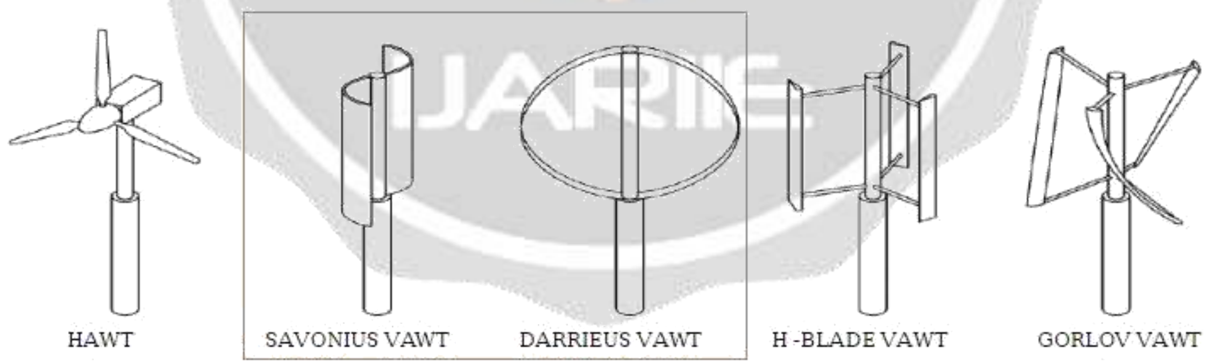

Figure 3. Different blade types for vertical wind turbines

3. FEATURES

- The turbine is self-starting.
- They are omni directional and do not require pointing in the direction of the wind.

- The lower blade rotational speeds imply lower noise levels.
- Perceived as being more aesthetically pleasing.
- The increased blade configuration solidity and torque assists the machine in self-starting.
- Eliminating the risk of the blade reaching equilibrium during start-up rotation by using 3 blades or more.
- Reduced cyclic loading and power pulsation and fluctuation by using more than 2 blades.
- Easy access to all mechanical and structural elements of the machine.
- A direct drive, permanent magnet generator is used and there are no gear boxes with the machine having only one moving part.

4. FEASIBILITY IN INDIA

The gradual depletion of the fossil fuels along with their adverse implications on the global environment is a matter of increasing concern. To add to this further, the future progress and development of any country is judged by its capacity to harness the renewable sources of energy like wind, solar and geothermal energy. Of the various forms of renewable energies available, wind energy happens to be the cleanest. Though India is still primarily dependent on coal and petroleum as major sources of energy, it has become one of the major players in the production of wind power energy mainly due to the tremendous support from the Government of India and also of the huge coastal stretch. Currently it ranks third in the world in the production of wind power energy with wind energy accounting for 70% of the total energy supplied by nonconventional energy sources. This is more so important as energy demand is likely to increase by three times between 2005 to 2030 [1]. Keeping in mind that much remains to be done before its full potential is to be attained, the current paper attempts to present a brief review of the wind energy potential of India, its challenges, and possible suggestions to improve its present capacity.

The range of wind speeds that are usable by a particular wind turbine for electricity generation is called productive wind speed. The power available from wind is proportional to cube of the wind's speed. So as the speed of the wind falls, the amount of energy that can be got from it falls very rapidly. On the other hand, as the wind speed rises, so the amount of energy in it rises very rapidly; very high wind speeds can overload a turbine. Productive wind speeds will range between 4 m/sec to 35 m/sec. The minimum prescribed speed for optimal performance of large scale wind farms is about 6 m/s. Wind power potential is mostly assessed assuming 1% of land availability for wind farms required 12 MW/ha in sites having wind power density exceeding 200 W/sq.m. at 50 m hub-height.[2]

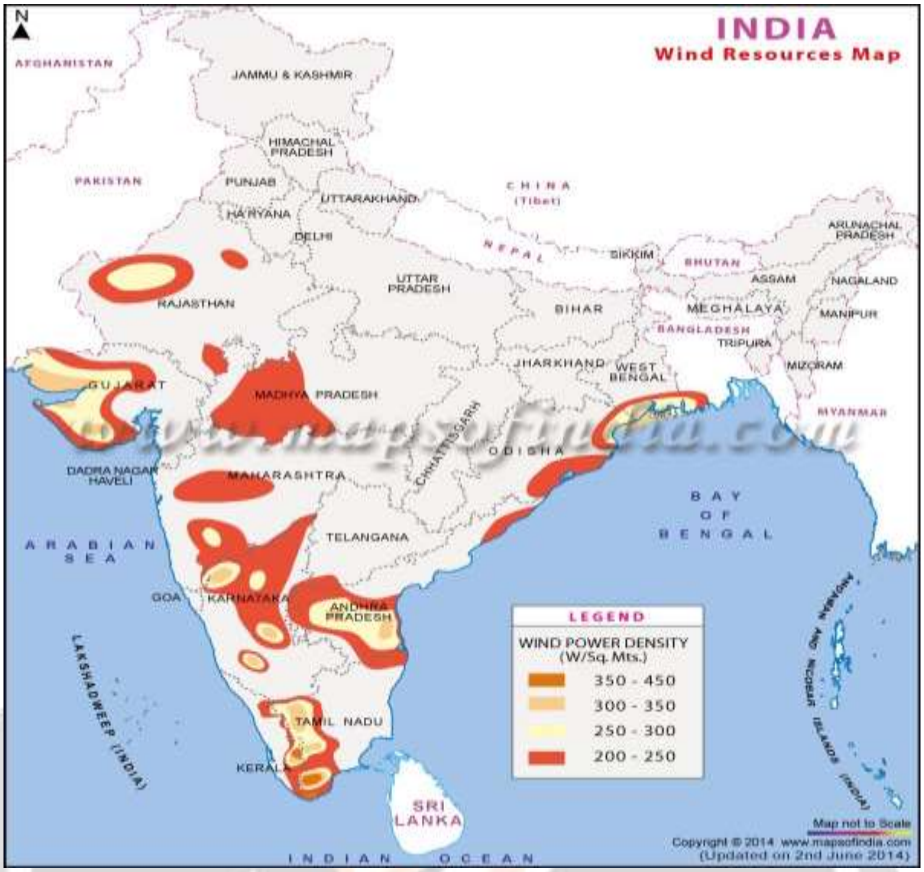

Figure 4. Wind Resource Map Of India[3]

Wind power costs in India are decreasing rapidly. The levelized tariff of wind power reached a record low of ₹ 2.43 per kWh (without any direct or indirect subsidies) during auctions for wind projects in December 2017.[5]

5. WIND SPEEDS

Under optimal conditions, the efficiency of a wind generator in converting energy to electricity is about 45%, although research shows efficiency of 10–40% is more common in day-to-day operation.
Studies have found that average wind speeds in a particular location need to exceed at least 6–8 metres per second (m/s) for a small wind turbine to be economically viable. [6]

Average wind speed distribution for a typical site is shown at Table below:

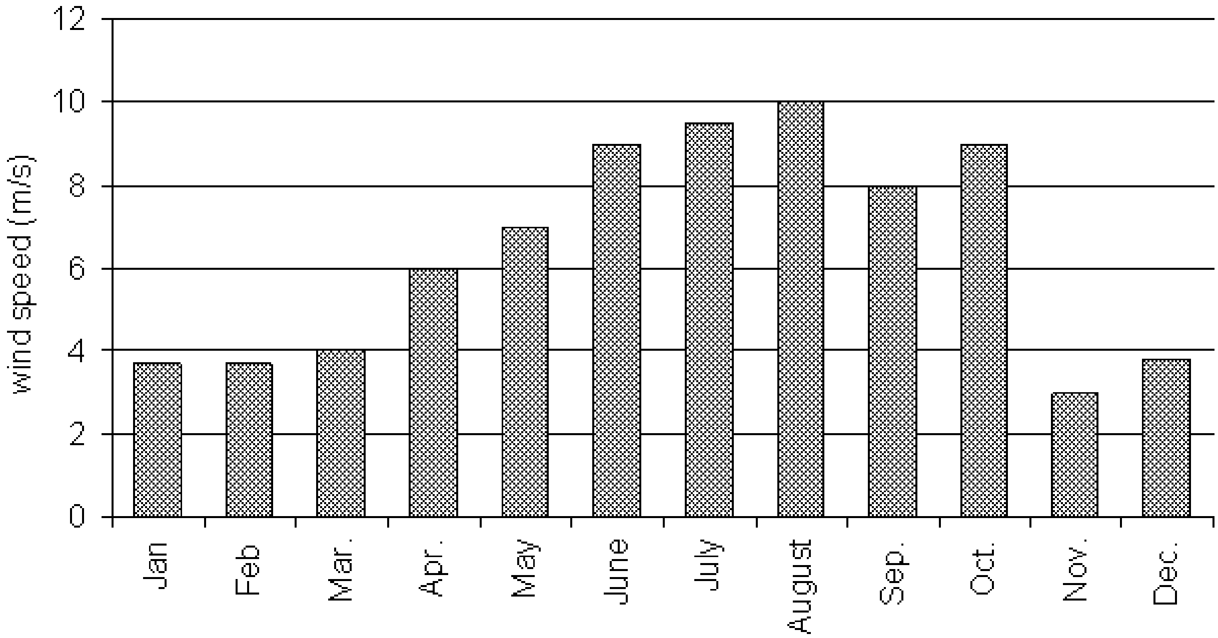

Figure 5. Average Wind Speed Across An Year In Typical City In India[7]

From above graph we can conclude that for most part of the year ie. from April to October a substantial amount of energy can be harnessed from wind.

6. CALCULATION FOR HELICAL WIND TURBINE

Calculating the energy available in the wind relies on knowledge of basic geometry and the physics behind kinetic energy. If the air mass is *m* and it moves with an average velocity *V*, the kinetic energy (KE) of the wind is:

$$KE = 1/2 \times m \times v^2 \text{ Joules} \quad (1)$$

The mass of air hitting our wind turbine (which sweeps a known area) each second is given by the following equation:

$$\textit{Mass hitting in wind turbine} = V \times A \times p \text{ / second} \quad (2)$$

Where V is velocity in meter per second, are in meter^2 , *p* is the density of air (which at sea level is 1.2256 kg m^{-3}). And therefore, the power in the wind hitting a wind turbine with a certain swept area is given by simply inserting the mass per second calculation into the standard kinetic energy equation given above resulting in the following vital equation:

$$\textit{Power density} = 0.5 \times p \times A \times V^3 \quad (3)$$

Where Power is given in Watts, the Swept area in square meters, the Air density in kilograms per cubic meter, and the Velocity in meters per second.

7. CONCLUSION

These turbines are comparatively easy to build and the investment is also well affordable when compared to the HAWTs. Since the turbines are smaller in size, they can be only used for low power applications such as for powering streetlights or the toll plazas. Moreover, they may also be used to power the advertisement hoardings. An advantage is that they can catch wind from all directions eliminating the need for yaw mechanism. In addition, they can be built lower so they are less visible and can withstand much harsher environments and do not need to be shut down at greater wind speeds.

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