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Comparison of Horizontal Axis Wind Turbines and Vertical Axis Wind Turbines

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***Abstract:* -** This paper gives a comparison between the horizontal axis wind turbines, or HAWTS, and the vertical axis wind turbines, or VAWTS. The two types of wind turbines are used for different purposes. Several models of both types are presented from previous research.

***Keywords:* -** *component, vawts; hawts, wind turbines.*

I. INTRODUCTION

There are generally two core types of wind turbines, which are the horizontal axis wind turbine (HAWT) and the vertical axis wind turbine (VAWT). The current work aims at presenting a comparison of both different types of these wind turbines.

II. WIND TURBINES

There are generally two different types of wind turbines. One type is built with the aim of generating electricity from wind with high speeds. On the other hand, the other type is built especially for areas with low wind speeds, such as Malaysia (Wahab et al. 2008). Wind turbines consist of a set of blades attached to a rotor hub, which together form the rotor; this rotor deflects the airflow, which creates a force on the blades, which in turn produces a torque on the shaft such and the rotor rotates around a horizontal axis, which is mainly attached to a gearbox and generator. These are inside the nacelle, which is located at the top end of the tower, along with several other electrical parts. The generator generates electricity, which is moved down from the tower and out to an available transformer, so that it can be converted from the output voltage (usually about 700V) to the some voltage for either the countrywide grid (33000V) or for any personal use (about 240V) [1].

The formal definition for a wind turbine is a type of device that transforms kinetic energy from the mainly from the wind into electric power [2].

The outcome of about a millennium of development and engineering in windmills, current wind turbines are produced in a broad range of both vertical and horizontal axis kinds. The small turbines are implemented for different applications such as battery charge for boats or power traffic signs. The more larger turbines may be implemented for the use of small contributions to a power supply while selling power that is unused to the supplier through the electric grid. Many large turbines, called wind farms, are currently becoming a more important renewable energy source and are implemented by numerous countries as a strategy to decrease use of fossil fuels.

III. VERTICAL AXIS WIND TURBINES

Before Although Vertical Axis Wind Turbines (VAWTS) are not considered in this work, they will be discussed briefly in order to point out the differences between VAWTS and Horizontal Axis Wind Turbines (HAWTS).

There are generally two core kinds of VAWTs, they are called the Savnoius and the Darrieus. The Savories functions similar to a water wheel that uses drag forces. On the other hand, the Darrieus makes use of blades similar to the blades used on HAWTS. VAWTs commonly function nearer to the ground, and has the benefit of enabling placement of heavy equipment, such as the gearbox and generator, close to the ground level and not in the nacelle. However, the winds are lower near ground level, hence for a similar wind and capture area, a less amount of power is generated [1].

Another benefit of a VAWT over the HAWT is that it does not need a yaw mechanism, because it can harness the wind from all directions. This benefit is outweighed by numerous other limitations, such as: time varying power output because of change of power in a single blade rotation, the requirement for guy wires to support the main tower and the fact that the Darrieus VAWTS are do not self-start like HAWTS.

VAWTs give many advantages when compared traditional horizontal-axis wind turbines (HAWTs). They may be packed very closer together inside the wind farms, and this allows more in any space. They are also quiet, they are omni-directional, and they also generate lower forces on the support structure. They also do not need as much wind in order to produce power, therefore permitting them to be nearer to the ground where the speed of the wind is lower. Because they are closer to the ground, this means they are easily controlled and can be implemented on tall structures [3].

A great deal of Research at Caltech has revealed that cautiously designing the wind farms using VAWTs may result in the generation of power output that is ten times greater than a HAWT wind farm that is the same size [3].

VAWTs are also more quieter than the HAWTs, with the dB levels at a ground level that is ten meters from the tower measured about 95 dB for a HAWT – this is about the sound of a highway with cars passing by – as compared to about 38dB for a VAWT– which is about the sound of whispered conversation. This is because of multiple reasons, starting with a lower tip speed of VAWTs.

They also come with disadvantages however. Some of the more important ones are explained. VAWTs sometimes do not function properly under winds that are gusty. They generate extremely low starting torque, and also have dynamic stability issues. The VAWTs are also very sensitive to the off-design conditions and possess a low installation height that limits operation to the environments with a low wind speed [2].

The blades that are attached to VAWT are vulnerable to types of fatigue because of the broad variation in applied forces with every rotation. The vertical types of blades implemented in early models became bent with every spin, and this caused them to have cracks. With time, blades broke, and this led failure of the turbine. This makes VAWTs less reliable.

Numerous research work has focused on solving issues and inefficiencies that come with VAWTs by enhancing turbine placement in wind farms. Even though they are at low elevations, the scaling of the physical forces that exist forecast that wind farms that contain VAWTs may be constructed with the use of cheap materials, manufacturing processes, and also maintenance than can be possible with existing wind turbines"[4].

IV. HORIZONTAL AXIS WIND TURBINES

A horizontal wind turbine has currently been modernized from the traditional windmill designs that have been around for many centuries. A nacelle installed perpendicular to the turbine tower and horizontal in terms of the ground shows the name of the turbine. Most common models for drawing energy from wind, the horizontal wind turbines offer a great amount of advantages [4]. The core components of a horizontal wind turbine are as shown below:

- The main rotor shaft
- The electrical generator
- The gearbox to increase the rotation speed of the blades
- Turbine blades, with stiffness to avoid contacting the post

A wind vane is used to point the turbines, while a wind sensor is implemented for a large horizontal wind turbine. Figure 1 shows the different parts of a HAWT.

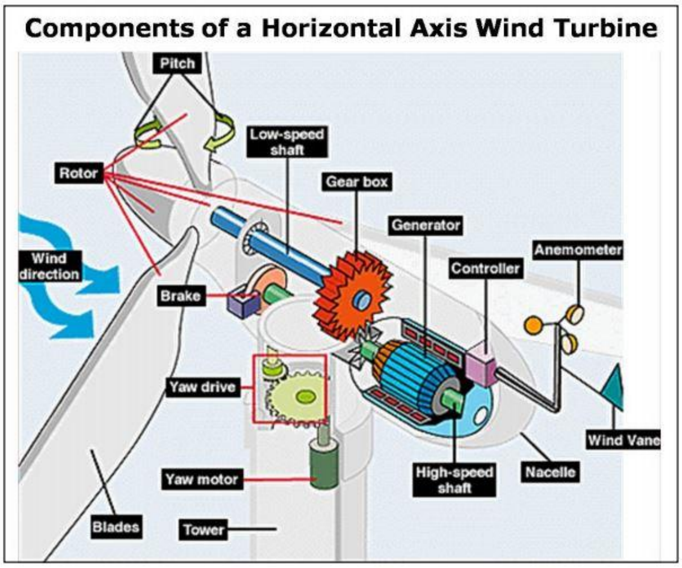

Figure 1. Components of Horizontal Axis Wind Turbine

These Horizontal Axis Wind Turbines have to always be pointed in the right direction (into the wind, or away from the wind, based on the type) so they can have max efficiently. Those that are positioned away from the wind , which are called downwind turbines ("downwind" because of the location of the turbine relative to the tower) and are pushed into the accurate orientation. In conventional and smaller upwind based turbines, accurate orientation is obtained via the use of a simple wind vane; large turbines include a yaw motor and yaw meter. The yaw meter picks up the accurate direction of the wind, and the yaw motor moves the turbine to ensure it is always positioned into the wind [2].

Since it is possible for the turbine to push yaw in the same direction for numerous turns, moving the cables, turbines contain a cable twist counter that makes the system to yaw back around to ensure the cables untwist, as soon as they have reached a particular number of turns in one certain direction. The overall shape of the blades is extremely important in controlling the turbine. The shape has to be designed to give lift so that the rotor will turn properly. They have an airfoil shape (like that of an airplane's wing), but for large wind turbines the blades are always in the form of a twist. From the perspective of the blade, the wind will be coming from a greatly steeper angle as it moves towards the root of the blade. Because the blade will stop giving lift if the blade is contacted at an angle of attack that is too steep, the rotor blade has to be twisted to obtain an optimum angle of attack throughout the length of the blade.

While going back in history of horizontal axis wind turbines, there are three main types, used in different time periods:

- A 12th century horizontal wind turbine includes four blades, and were implemented to grid grain and pump water. Currently, this kind of wind turbine was implemented in European countries for electricity generation.

The 19th century horizontal windmill was made use of to pump water, for railroad tanks and for power generation in rural areas. These wind turbines include multiple numbers of blades. One may still find these wind turbines used in areas where power generation commercially is costly [4].

Motor wind turbines are the recent form of horizontal turbines that are used to generate electricity at commercial levels. These are mainly 3-blade turbines and make use of computer monitored motors for functioning [5].

Currently high speed propeller wind turbines are commonly used as horizontal axis turbines because of their excellent aerodynamic efficiency [6]. Among the vertical axis wind turbines, however, the Darrieus rotor is the more efficient than the Savonius rotor, but the main limitation of the Darrieus rotor is that it does not have the capability to self start. The Savonius rotor is simple and cheap, but its efficiency is much less than the Darrieus rotor. Figure 1 shows the different types of advanced wind turbines [4][7].

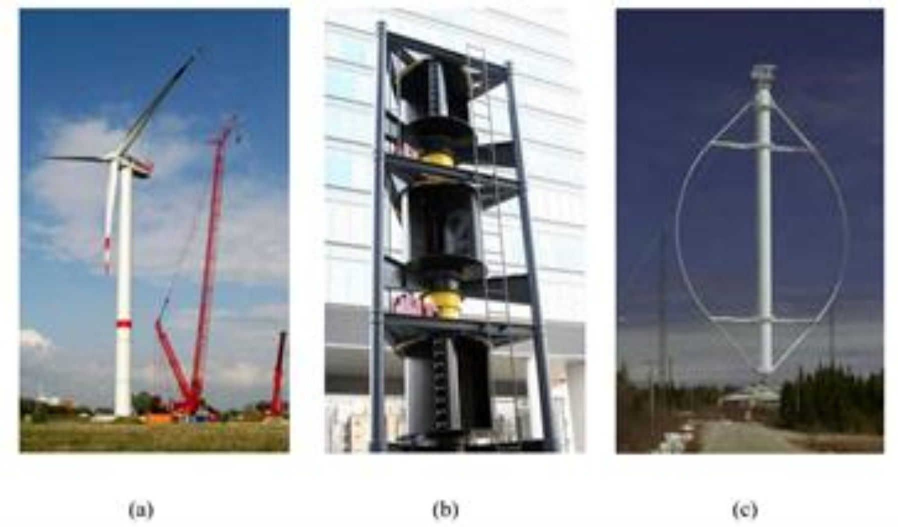

Figure 2. (a) Horizontal axis based high speed wind turbine (b) Savonius (c) Darrieus

There are a number of advantages to use HAWTS. First of all, variable pitch of blades used for horizontal wind turbine allows it to collect maximum amount of energy form wind. Second is higher efficiency is offered by a horizontal wind turbine as it has blades in perpendicular to the direction of wind and hence receives more power for rotation. Third is the traditional designs allow easy installation and easy maintenance as well. Finally, from home usage to application in hybrid systems, the horizontal wind turbines are popular options as sources of energy.

V. CONCLUSION

Both types of turbines, whether VAWTs or HAWTs, are used for generating electrical power from the wind. This work has compared both types, and also presented the advantages and disadvantages of both types. Each type has its applications. It depends on the wind speed and place to be fixed on. Any way the horizontal axis with propeller blades is the most common one, since its efficiency is about 60%.

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