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Study Of Wind Turbines

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ABSTRACT: There is huge activity in wind power, pan-India with the installed capacity increasing to 10,000 MW. India today has the fifth largest installed capacity of wind power in the world with 11087MW installed capacity and potential for on-shore capabilities of 65000MW. However the plant load factor (PLF) in wind power generation is very low, often in the single digits. The increase in interest in wind energy is due to investment subsidies, tax holidays, and government action towards renewable energy playing a big part in nation's energy system. There is a need to generate environment friendly power that not only raises energy efficiency and is sustainable too. The time has come for moving to generation based subsidies and understanding the drawbacks associated with wind power in India. The capital cost of wind power is third higher than conventional thermal power; further electrical problems like voltage flicker and variable frequency affect the implementation of wind farm. However advances in technologies such as offshore construction of wind turbines, advanced control methodologies, and simulation of wind energy affecting overall grid performance are making a case for wind energy.

I.INTRODUCTION

A **wind turbine** is a rotating machine which converts the wind kinetic energy into mechanical energy. If the mechanical energy is then converted to electricity, the machine is called a **windgenerator**, **wind turbine**. Wind turbines can be separated into two types based by the axis in which the turbine rotates as Horizontal Axis Wind Turbines and Vertical Axis Wind Turbines. The former are more commonly used due to several inherent advantages, the latter being used in small scale.

Figure 1: Horizontal Axis Wind Turbine

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II. WIND TURBINE GENERATOR UNITS

Turbine subsystems include:

- Rotors which convert wind energy into mechanical energy of the shaft ;
- Nacelle (enclosure) which contains all the conversion equipment, generator ,gear shaft etc.
- Tower, to increase the height of the turbine systems so that higher wind speeds are captured.
- Control equipment, Cables and other Civil works.

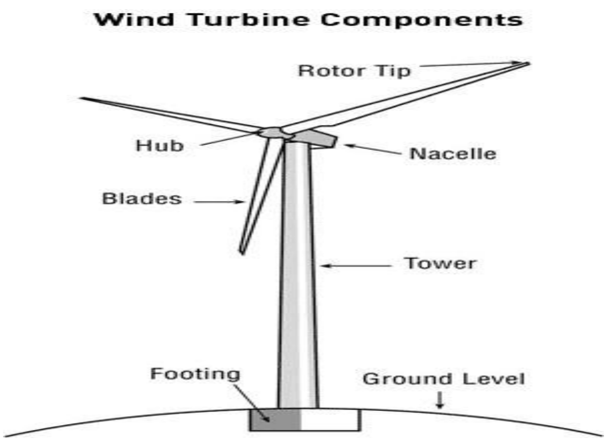

Figure 2: HAWT components

III. HORIZONTAL AXIS WIND TURBINES (HAWTS)

Horizontal-axis wind turbines (HAWT) get their name from the fact that their axis of rotation is horizontal. They have the main rotor shaft and electrical generator at the top of a tower, and are pointed into the wind. The variability of wind distribution and speed brings up the requirement of a gear system connected to the rotor and the generator. The gear system enables a constant speed of rotation to the generator thus enabling constant frequency generation. Turbine blades are made stiff in order to prevent the blades from being pushed into the tower by high winds. Downwind machines have also been built, as they no longer require a yaw mechanism to keep them facing the wind, and also because in high winds the blades can turn out of the wind thereby increasing drag and coming to a stop. Most of the HAWTs' are upwind as downwind systems cause regular turbulence which may lead to fatigue.

IV. HAWT ADVANTAGES

- Variable blade pitch, which gives the turbine blades the optimum angle of attack. Changing the angle of attack provides greater control over power generated and enables maximum efficiency.
- As wind energy increases with height, the tall tower in the HAWT gives access to higher wind speed. In some cases increase of even 10m height leads to increase in wind speed by 20 % •In HAWTs' the blades move horizontally that is perpendicular to the wind and hence have minimum drag and they receive power throughout the rotation.

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V.HAWT DISADVANTAGES

•Due to inherent large structures, construction costs are very high and so are transportation costs.

•Civil construction is costly due to erection of large towers.

•Wind turbine operation often leads to production of electronic noise which affects radar sites.

- In case of downwind HAWTs' the regular turbulence produced leads to structural failure.
- HAWTs require an additional yaw control mechanism to turn the blades toward the wind.

VI.MONO-BLADE HORIZONTAL AXIS WIND TURBINE (HAWT)

A.Features:

1. They have lighter rotor and are cheaper.
2. Blade are 15-25 m long and are made up of metal, glass reinforced plastics, laminated wood, composite carbon fiber/ fiberglass etc.
3. Power generation is within the range 15 kW to 50 kW and service life of plant is 30 years.

B.Advantages:

1. Simple and lighter construction.
2. Favorable price
3. Easy to install and maintain.

C.Disadvantages:

1. Tethering control necessary for higher loads.
2. Not suitable for higher power ratings.

D.Applications:

1. Field irrigation
2. Sea-Water desalination Plants
3. Electric power supply for farms and remote loads.

E.Twin-Blade HAWT

1. They have large sizes and power output in range of 1 MW, 2 MW and 3MW.
2. These high power units feed directly to the distribution network.

F.3-Blade HAWT

1. 3 blade propeller type wind turbines have been installed in India as well as abroad.
2. The rotor has three blades assembled on a hub. The blade tips have a pitch control of 0 – 30 for controlling shaft speed.
3. The shaft is mounted on bearings.
4. The gear chain changes the speed from turbine shaft to generator shaft.

VII.VERTICAL AXIS WIND TURBINES

Vertical-axis wind turbines (or VAWTs) have the main rotor shaft arranged vertically as the plane of rotation is vertical. Blades are also vertical in this arrangement. The biggest advantage of VAWTs is they don't require a yaw control mechanism to be pointed into the wind. Thus these are useful in sites where wind direction is random or there is presence of large obstacles like trees, houses etc. Also VAWTs' don't require a tower structure and can be placed nearby a ground enabling access to electrical components. Some drawbacks are the low efficiency of wind production and the fact that large drag is created for rotating the blades in a vertical axis.

VIII.VAWT ADVANTAGES

- A massive tower structure is not required, as VAWTs' are mounted closer to the ground
- They don't require yaw mechanisms.
- These are located closer to the ground and hence easier to maintain.
- These have lower startup speeds than their horizontal counterparts. These can start at speeds as low as 10Kmph.
- These have a lower noise signature.

VAWT disadvantages

•VAWTs' have lower efficiency as compared to HAWTs' because of the additional drag produced due to rotation of blades.

• Even though VAWTs' are located closer to the ground, the equipment now resides at the bottom of the turbines structure thus making it inaccessible.

•Because of their low height they cannot capture the wind energy stored in higher altitudes.

IX.TYPES OF VAWTS

A.Persian Windmill:

1. The Persian windmill was the earliest windmill installed. (7th Century A.D. – 13th Century A.D. in Persia, Afghanistan, and China) 2. It is a vertical axis windmill.
3. This windmill was used to grind grains and make flour.

B.Savonius Rotor VAWT:

1. Patented by S.J. Savonius in 1929.
2. It is used to measure wind current.
3. Efficiency is 31%.
4. It is Omni-directional and is therefore useful for places where wind changes direction frequently.

C.Darrieus Rotor VAWT:

1. It consists of 2 or 3 convex blades with airfoil cross-section.
2. The blades are mounted symmetrically on a vertical shaft.
3. To control speed of rotation mechanical brakes are incorporated. Those brakes consist of steel discs and spring applied air released calipers for each disc.

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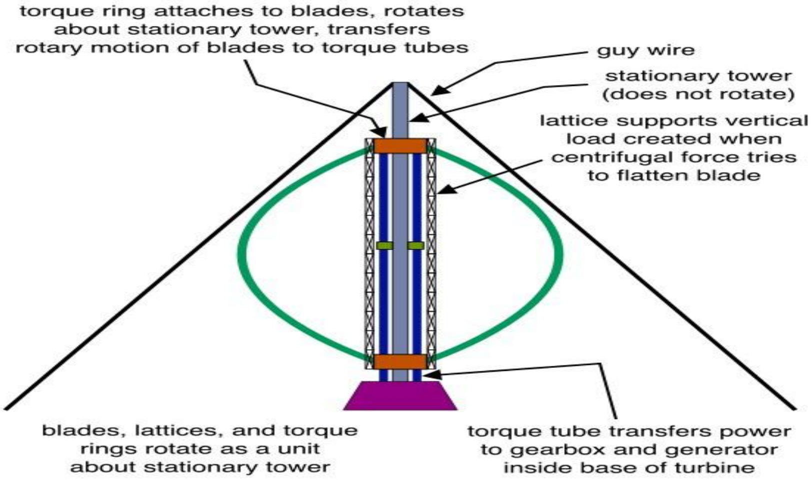

Figure 3: High Mechanical Efficiency Centrifugally Stable Darrieus Turbine

VAWT's Used in Practice:

X.WINDTERRA ECO 1200 1KW VAWT:

The aforesaid VAWT is developed by Windterracorporation. It is a technically superior product that can be used in both urban and rural areas.

Figure 4: Windterra ECO1200 VAWT

The following are the advantages of the Windterra VAWTs':

- **Omni-directional**: As in case of all VAWTs' this turbine is also omni-directional and can take in wind from any direction.
- **Turbulent-wind friendly**: Due to its omni-directional nature it a feasible product for urban areas where large obstacles such as trees and houses are there.
- **Low rotation speed**: Like all VAWTs' this rotates at lower speeds around 200rpm to 270rpm and thus produces lower noise signature.
- **Industry-leading annual output**: Due to aforesaid advantages. And the fact that this is specifically designed to operate at lower wind speed the output of the turbine is industry leading.
- **Roof-top mounting**: The VAWTs' is manufactured so as to be roof mountable without any fuss and also includes the generator etc in a complete package.

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A)Internal Components of a Wind Turbine

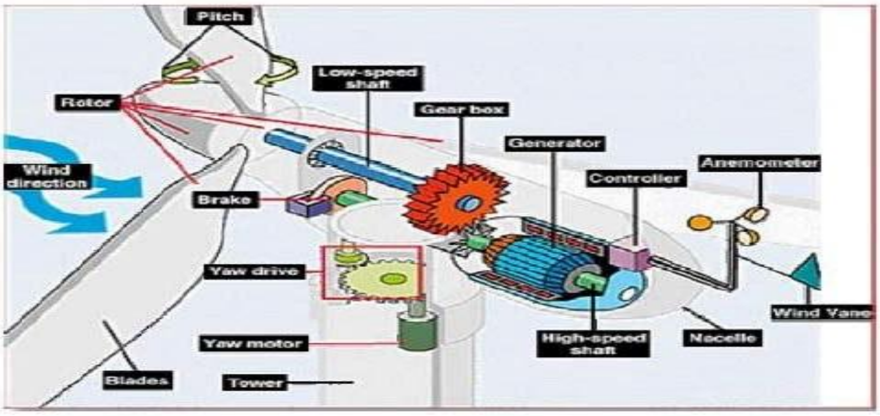

Figure 5: Internal Components of a Wind Turbine

- ❖ **Anemometer:** This device is used for measurement of speed. The wind speed is also fed to the controller as it is one of the variables for controlling pitch angle and yaw
- ❖ **Blades:** These are aerodynamically designed structures such that when wind flows over them they are lifted as in airplane wings. The blades are also slightly turned for greater aerodynamic efficiency.
- ❖ **Brake:** This is either a mechanical, electrical or hydraulic brake used for stopping the turbine in high wind conditions.
- ❖ **Controller:** This is the most important part of the turbine as it controls everything from power output to pitch angle. The controller senses wind speed, wind direction, shaft speed and torque at one or more points. Also the temp of generator and power output produced is sensed
- ❖ **Gear box:** This steps-up or steps down the speed of turbine and with suitable coupling transmits rotating mechanical energy at a suitable speed to the generator. Typically a gear box system steps up rotation speed from 50 to 60 rpm to 1200 to 1500 rpm
- ❖ **Generator:** This can be a synchronous or asynchronous Ac machine producing power at 50Hz ❖**High-speed shaft:** Its function is to drive the generator.
- ❖ **Low-speed shaft**: The rotor turns the low-speed shaft at about 30 to 60 rotations per minute.
- ❖ **Nacelle:** The nacelle is the housing structure for high speed shaft, low speed shaft, gear box, generator, converter equipment etc. It is located atop the tower structure mostly in the shadow of the blades.
- ❖ **Pitch:** This is basically the angle the blades make with the wind. Changing the pitch angle changes weather the blades turn in or turn out of the wind stream. ❖**Rotor:** The hub and the blades together compose the rotor.
- ❖ **Tower:** Towers are basically made up of tubular steel or steel lattice. Taller the towers greater is the amount of power generated as the wind speed generally goes on increasing with height.
- ❖ **Wind direction:** Generally erratic in nature, hence the rotor is made to face into the wind by means of control systems.
- ❖ **Wind vane:** Basically the job of a wind sensor, measuring the wind speed and communicating the same to the yaw drive, so as to turn the turbine into the wind flow direction.
- ❖ **Yaw drive:** This drive controls the orientation of the blades towards the wind. In case the turbine is out of the wind, then the yaw drive rotates the turbine in the wind direction ❖**Yaw motor:** Powers the yaw drive.

XI.CONCLUSION

The potential of wind power generation is immense, a historical source of energy, wind can be used both as a source of electricity and for irrigation and agricultural uses. In today's world, where a greener source of energy is the need of the hour, wind energy is a promising resource, waiting to be harnessed to its true potential. The study of wind turbine and its characteristics showed that how it can be properly designed and used to get the maximum output, even with the variable wind speeds. The development of offshore wind farms, which have both a better energy density and lesser interference with the local systems, is a definite step forward in realization of the wind potential. The Indian scenario is agog with Suzlon making rapid strides, and a lot of multinationals investing heavily.The study of Aggregation technique, being used in the UK, has shown us a path forward towards a realization of an independent wind farm. The analysis of different sites in the country shows how the wind energy density varies from place to place. The following table puts things into perspective regarding the varying energy densities:

Place	April 30	May 3rd	May 4th	May 5th	Average
Bhubaneswar	0.1079	0.1359	0.1733	0.1901	0.1518
Chennai	0.1392	0.1131	0.2440	0.1457	0.1605
Delhi	0.1307	0.1985	0.0794	0.1612	0.14245
Mumbai	0.1774	0.0944	0.1141	0.1186	0.126125

❖ **Table 1: Comparison of Energy densities th**

All the energy density values are in kWh/m^2/day, from the above table it is clear that the energy density of Chennai being the highest, it makes more sense to setup a wind farm near Chennai than near Mumbai.

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