ELECTRICAL ENERGY IN WIND

Praveen Kumar Choudhary, Deepak Jangid and Mohit Rathi
B.Tech Students, Department of Electrical Engineering, SLBS Jodhpur
royalpkc121@gmail.com djangid171998@gmmail.com mohit.rathi9723@gmail.com

***Abstract*— The paper deals with the technical details involved in the generation of power through wind technology. It discusses the factors responsible for generation of wind power. This paper also include the principle of wind energy, types of wind turbine, parts of turbine, benefits and wind power in India.**

I. Introduction

WIND energy is a form of solar energy. Wind energy (or wind power) describes the process by which wind is used to generate electricity. Wind turbines convert the kinetic energy in the wind into mechanical power. A generator can convert mechanical power into electricity. Mechanical power can also be utilized directly for specific tasks such as pumping water.

Wind is caused by the uneven heating of the atmosphere by the sun, variations in the earth's surface, and rotation of the earth. Mountains, bodies of water, and vegetation all influence wind flow patterns. Wind turbines convert the energy in wind to electricity by rotating propeller-like blades around a rotor. The rotor turns the drive shaft, which turns an electric generator. Three key factors affect the amount of energy a turbine can harness from the wind: wind speed, air density, and swept area.

Wind speed

The amount of energy in the wind varies with the cube of the wind speed, in other words, if the wind speed doubles, there is eight times more energy in the wind. Small changes in wind speed have a large impact on the amount of power available in the wind.

Density of the air

The more dense the air, the more energy received by the turbine. Air density varies with elevation and temperature. Air is less dense at higher elevations than at sea level, and warm air is less dense than cold air. All else being equal, turbines will produce more power at lower elevations and in locations with cooler average temperatures.

Swept area of the turbine

The larger the swept area (the size of the area through which the rotor spins), the more power the turbine can capture from the wind. Since swept area is A= pi*r^2, where r = radius of the rotor, a small increase in blade length results in a larger increase in the power available to the turbine.[3]

Wind power generation capacity in India has significantly increased in recent years. As of the end of March 2017 the total installed wind power capacity was 32.17 GW, mainly spread across the South, West and North regions. By the end of 2015, India had the fourth largest installed wind power capacity in the world.

Wind power accounts nearly 9.87% of India's total installed power generation capacity and generated 46,011 million kWh in the fiscal year 2016-17 which is nearly 3% of total electricity generation.[5]

The main principle of wind energy conversation is that when wind strikes an object, it exerts a force in an attempt to move it out of the way. Some of the winds' energy is transferred to the object, in this case the windmill, causing it to move..

II. Wind Energy

Wind results from air in motion due to pressure gradient that is caused by the solar energy irradiating the earth.

Wind possesses energy by virtue of its motion .Any device capable of slowing down the mass of moving air can extract part of the energy and convert into useful work.

Following factors control the output of wind energy converter: -

- The wind speed
- Cross-section of the wind swept by rotor
- Conversion efficiently of rotor
- Generator
- Transmission system

Theoretically it is possible to get 100% efficiency by halting and preventing the passage of air through the rotor. However, a rotor is able to decelerate the air column only to one third of its free velocity.

A 100% efficient wind generator is able to convert maximum up to 60% of the available energy in wind into mechanical energy. In addition to this, losses incurred in the generator or pump decrease the overall efficiency of power generation to 35%.[6]

Why wind power?

1. The project is environment friendly.
2. Good wind potential to harness wind energy.

3. A permanent shield against ever increasing power prices.
4. The cost per kWh reduces over a period of time as against rising cost for conventional power.
5. The cheapest source of electrical energy. (On a levelled cost over 20 years.)
6. A project with the fastest payback period.
7. A real fast track power project, with the lowest gestation period; and a modular concept.
8. Operation and Maintenance (O&M) costs are low.
9. No marketing risks, as the product is electrical energy

A project with no investment in manpower(4)

III. THE PRINCIPLE OF OPERATION

Wind is simply defined as moving air. When the earth heats up from sunrays it releases wind, this is a balanced reaction meant to cool the earth. The sun heat is felt more on dry land than on the sea. The air expands and easily reaches maximum high altitudes, then cool air drops down and moves as wind.

Wind energy is generated by converting kinetic energy through friction process into useful forms such as electricity and mechanical energy. These two energy sources are put in to use by humans to achieve various purposes. In the past, people constructed wind mills to generate energy meant for grinding rains. They also constructed mechanical wind pumps to be uses to pump large amounts of water into the farms.

Egyptians also used wind to sail their ships. Wind mills were constructed later with propeller blades for generating electricity. This was a great development and electricity was even used in remote areas. Because of the current shortage of oil and its cost today, wind electricity has become the preferred source of energy in most countries worldwide

Electricity Generation

Wind turbines use wind energy to produce electricity. The wind turbines are machines that have a rotor with three propeller blades. These blades are specifically arranged in a horizontal manner to propel wind for generating electricity. Wind turbines are placed in areas that have high speeds of wind, to spin the blades much quicker for the rotor to transmit the electricity produced to a generator.

Thereafter the electricity produced is supplied to different stations through the grid. One wind turbine can generate enough electricity to be used by a single household. A wind energy plant normally consists of many wind turbines that are 30 to 50m long each. According to the rule, the higher you go, the cooler it becomes and more air is circulated. This rule is applied by constructing turbines at high altitudes, to use the increased air circulation at high altitudes to propel the turbines much faster.

IV. TYPES OF WIND TURBINE

Wind turbines can be separated into two basic types determined by which way the turbine spins. Wind turbines that rotate around a horizontal axis are more common (like a wind mill), while vertical axis wind turbines are less frequently used (Savonius and Darrieus are the most common in the group).

Horizontal Axis Wind Turbines (HAWT)

Horizontal axis wind turbines, also shortened to HAWT, are the common style that most of us think of when we think of a wind turbine. A HAWT has a similar design to a windmill, it has blades that look like a propeller that spin on the horizontal axis.

Horizontal axis wind turbines

have the main rotor shaft and electrical generator at the top of a tower, and they must be pointed into the wind. Small turbines are pointed by a simple wind vane placed square with the rotor (blades), while large turbines generally use a wind sensor coupled with a servo motor to turn the turbine into the wind. Most large wind turbines have a gearbox, which turns the slow rotation of the rotor into a faster rotation that is more suitable to drive an electrical generator.

Since a tower produces turbulence behind it, the turbine is usually pointed upwind of the tower. Wind turbine blades are made stiff to prevent the blades from being pushed into the tower by high winds. Additionally, the blades are placed a considerable distance in front of the tower and are sometimes tilted up a small amount.

Downwind machines have been built, despite the problem of turbulence, because they don't need an additional mechanism for keeping them in line with the wind. Additionally, in high winds the blades can be allowed to bend which reduces their swept area and thus their wind resistance. Since turbulence leads to fatigue failures, and reliability is so important, most HAWTs are upwind machines.

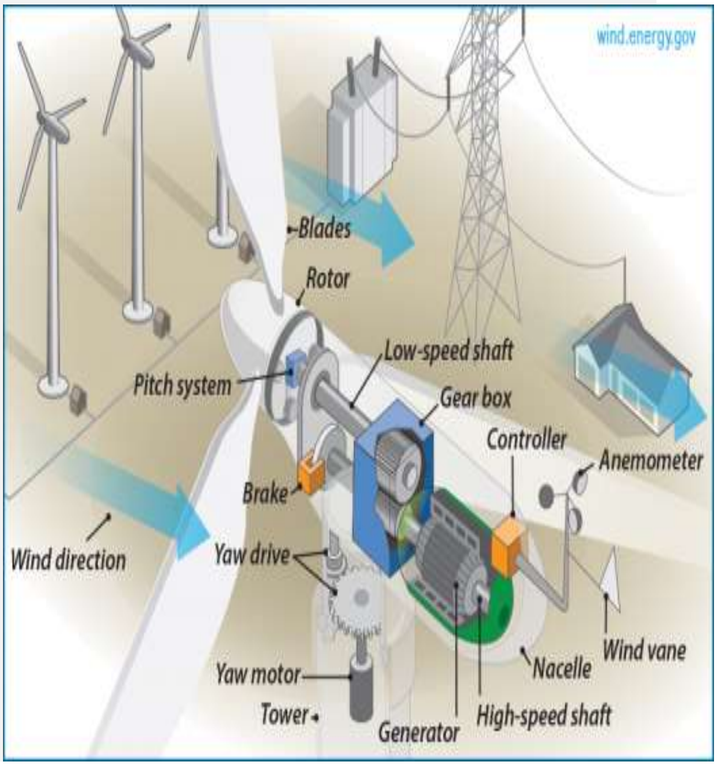
Vertical axis

Verticalaxis wind turbines, as shortened to VAWTs, have the main rotor shaft arranged vertically. The main advantage of this arrangement is that the wind turbine does not need to be pointed into the wind. This is an advantage on sites where the wind direction is highly variable or has turbulent winds. With a vertical axis, the generator and other primary components can be placed near the ground, so the tower does not need to support it, also makes maintenance easier. The main drawback of a VAWT generally create drag when rotating into the wind.

It is difficult to mount vertical-axis turbines on towers, meaning they are often installed nearer to the base on which they rest, such as the ground or a building rooftop. The wind speed is slower at a lower altitude, so less wind energy is available for a given size turbine. Air flow near the ground and other objects can create turbulent flow, which can introduce issues of vibration, including noise and bearing wear which may increase the maintenance or shorten its service life. However, when a turbine is mounted on a rooftop, the building generally redirects wind over the roof and this can double the wind speed at the turbine. If the height of the rooftop mounted turbine tower is approximately 50% of the building height, this is near the optimum for maximum wind energy and minimum wind turbulence.

V. PARTS OF WIND TURBINE

Part of wind turbine



Wind turbines harness the power of the wind and use it to generate electricity. Simply stated, a wind turbine works the opposite of a fan. Instead of using electricity to make wind, like a fan, wind turbines use wind to make electricity. The energy in the wind turns two or three propeller-like blades around a rotor. The rotor is connected to the main shaft, which spins a generator to create electricity. This illustration provides a detailed view of the inside of a wind turbine, its components, and their functionality.

Anemometer:
Measures the wind speed and transmits wind speed data to the controller.

Blades:
Lifts and rotates when wind is blown over them, causing the rotor to spin. Most turbines have either two or three blades.

Brake:
Stops the rotor mechanically, electrically, or hydraulically, in emergencies.

Controller:
Starts up the machine at wind speeds of about 8 to 16 miles per hour (mph) and shuts off the machine at about 55 mph. Turbines do not operate at wind speeds above about 55 mph because they may be damaged by the high winds.

Gear box:
Connects the low-speed shaft to the high-speed shaft and increases the rotational speeds from about 30-60 rotations per minute (rpm), to about 1,000-1,800 rpm; this is the rotational speed required by most generators to produce electricity. The gear box is a costly (and heavy) part of the wind turbine and engineers are exploring "direct-drive" generators that operate at lower rotational speeds and don't need gear boxes.

Generator:
Produces 60-cycle AC electricity; it is usually an off-the-shelf induction generator.

High-speed shaft:
Drives the generator.

Low-speed shaft:
Turns the low-speed shaft at about 30-60 rpm.

Nacelle:
Sits atop the tower and contains the gear box, low- and high-speed shafts, generator, controller, and brake. Some nacelles are large enough for a helicopter to land on.

Pitch:
Turns (or pitches) blades out of the wind to control the rotor speed, and to keep the rotor from turning in winds that are too high or too low to produce electricity.

Rotor:
Blades and hub together form the rotor.

Tower:
Made from tubular steel (shown here), concrete, or steel lattice. Supports the structure of the turbine. Because wind speed increases with height, taller towers enable turbines to capture more energy and generate more electricity.

Wind direction:
Determines the design of the turbine. Upwind turbines—like the one shown here—face into the wind while downwind turbines face away.

Wind vane:
Measures wind direction and communicates with the yaw drive to orient the turbine properly with respect to the wind.

Yaw drive:
Orients upwind turbines to keep them facing the wind when the direction changes. Downwind turbines don't require a yaw drive because the wind manually blows the rotor away from it.

Yaw motor:
Powers the yaw drive.

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VI. WIND POWER IN INDIA

Wind power generation capacity in India has significantly increased in recent years. As of the end of March 2017 the total installed wind power capacity was 32.17 GW, mainly spread across the South, West and North regions. By the end of 2015, India had the fourth largest installed wind power capacity in the world The development of **wind power in India** began in 1986 with the first wind farms being set up in coastal areas of Maharashtra(Ratnagiri), Gujarat (Okha) and Tamil Nadu (Tirunelveli) with 55 kW Vestas wind turbines. These demonstration projects were supported by the Ministry of New and Renewable Energy (MNRE).

The potential for wind farms in the country was first assessed in 2011 to be more than 2,000 GW by Professor Jami Hossain of TERI University, New Delhi. This was subsequently re-validated by Lawrence Berkley National Laboratory, US (LBNL) in an independent study in 2012. As a result, the MNRE set up a committee to reassess the potential and through the National Institute of Wind Energy (NIWE, previously C-WET) has announced a revised estimation of the potential wind resource in India from 49,130 MW to 302,000 MW assessed at 100 m hub height. Wind turbines are now being set up at even 120 m hub height and the wind resource at higher hub heights of around 120 m or more that are prevailing is possibly even more. In 2015, the MNRE set the target for Wind Power generation capacity by the year 2022 at 60,000 MW.[5]

VII. BENEFITS OF WIND ENERGY

1. Wind energy is cost competitive with other fuel sources.
2. Wind energy creates jobs
3. Wind energy is an indigenous, home-grown energy source that helps to diversify the national energy portfolio
4. Wind energy can provide income for farmers and ranchers, as well as economic benefits to communities.
5. Wind energy is an inexhaustible renewable energy source.
6. Wind turbines do not consume water
7. Wind energy is clean.
8. Wind energy systems have low operating costs
9. Wind energy can be used in a variety of applications.[4]

VIII. CONCLUSION

The people should be financially, mentally and physically able to support the improvement in the quality of their lives. We want the entire population to have access to uninterrupted supply of electricity. This puts a huge burden on the limited fossil fuel resources. The benefits of using wind power over other resources lies in its minimum operational cost. Depending on field of applications, various schemes can be adopted to get optimum output. Modern turbines are totally controlled by computers that are totally safe. Since wind is clean source of energy, the power conversion does not pose any environmental hazard.

REFERENCES

1. 22886372-Wind-Energy.ms word file
2. http://cleangreenenergyzone.com/working-principle-of-wind-energy/
3. http://en.openei.org/wiki/Wind_energy
4. http://www.nrel.gov/docs/fy15osti/62823.pdf
5. https://en.wikipedia.org/wiki/Wind_power_in_India
6. WIND POWER GENERATION TECHNOLOGY.pdf file