# General Overview Of Wind Energy As A Renewable Energy Resource


## Abstract:

Here in this paper we will discuss about a well known renewable energy resource, Wind energy. And along with this we will focus on the design and installation consideration of wind turbine. Tip speed ratio, blade pitch angle, solidity these are some important parameters to get maximum power from the environment by a wind turbine. Very slow winds are useless because there has no possibility of power generation.


## Introduction:

The kinetic energy associated with movement of large masses of air is called wind energy. It is clean, cheap, and eco-friendly renewable source. A wind turbine coupled with a generator is known as aero-generator. On the planetary level, great mountain massifs influence the circulation of air currents. Wind energy is harnessed as mechanical energy with the help of wind turbine.

## Theory:

### Wind turbine power calculation:

Under constant acceleration, the kinetic energy E of an object having mass m and velocity v is equal to the work done W, i.e E=W=F.s ; where F= force and s= displacement.

According to Newton’s law, F=ma Hence E=mas

Now using the third equation of motion, v2=u2+2as where v=wind speed (m/s) ;

We get, a= (v2-u2)/2s ; since the initial velocity u=0; so, a=v2/2s ;

So kinetic energy becomes E=mv2/2

The power in the wind is given by the rate of change of energy: P=dE/dt= (dm/dt)(v2/2)

As mass flow rate is given by dm/dt = ?A(dx/dt) Where A= swept area (m2)

dx/dt= v ;

So we get, dm/dt= ?Av ; Hence the power can be written as P = ?Av3/2 ;

And also A = ?r2 ; where r= radius of the rotor (m)

So extracted power from wind turbine, P = ? ?r2v3/2

The instantaneous power can be estimated by the formula: P = ½ ? ACpNgNbV3

Where Ng is the generator efficiency and Nb is the bearing efficiency, V is air density.

## Maximum power extraction from wind:

Betz's and Carnot law: Betz's law suggests that a heat engine cannot extract all the energy from a given hot reservoir of energy and must reject parts of input to the environment. But Carnot cycle efficiency can be expressed in terms of Kelvin heat input temperature T1 and Kelvin heat rejection temperature T2,

Efficiency= (T1-T2)/T1= 1-(T2/T1)

Betz's equation deals with the upstream from the turbine wind speed u0 and downstream wind speed u2. The stream tube area of constant air mass is A0 upstream which expands to A1 while passing through the rotor and become A2 downstream as shown in fig below.

So the air mass flow rate, F=mu0-mu2 ; So P= Fu1 =m(u0-u2) u1

The power is also equal to the kinetic energy. Hence P= m(u02-u22)

Now we have u1=( u0+ u2)/2 ; As an external case, u2 is 0 so u1= u0/2

An interference factor a is defined as a=(u0-u1) u0 or, u1=(1-a) u0 or, a=(u0-u2)/2u0

Power extracted by the turbine, PT= 4a(1-a)2(?A1u03/2) or, PT= CPP0

Where CP= 4a(1-a)2 So the criterion for maximum power extraction, i.e, CPmax=16/27 is called Betz criterion.

Solidity: Blade solidity is very important design parameter for the axial flow. It is defined in terms of the ratio of blade chord length to pitch. Blade Solidity = c/s where c=chord length and s=pitch. And s=2?rm/nb where rm= mean radius and nb= blade number.

Rotor solidity is completely different from blade solidity. Rotor solidity is the ratio of the total area of the rotor blades to the swept area of the rotor.

Blade pitch angle: The output of a turbine is also greatly influenced by blade pitch angle. Blade pitch control is a very effective way to control the output power, speed or torque.

## Effect of rotor blade numbers on rotor design:

The blade number is very important in turbine. Number of blades affects the speed and efficiency of turbine. Generally wind turbines use three blades.

1. Power drawn from each blade: Each blade draws certain power from the wind. Higher the number of blades drawing of energy from the wind will be more.
2. The interference effect of each blade on another: Lesser the interference of blade one

another higher the efficiency of blade.

### Effect of wind speed:

For constant wind speed the power extraction by a turbine will decrease if

- The blades are so close together, or rotating so rapidly that a blade moves into the turbulence created by a preceding blade.
- The blades are so far apart or rotating so slowly that much of the air passes through the cross section without interacting with the blades.

Thus for a particular wind speed there exists an optimum turbine speed to produce maximum output. It is important to match the rotational frequency of the turbine to the corresponding wind speed.

The preferable site selection criteria for wind turbine installation:

The 5 most important characteristics for good wind site are

- A high average wind speed
- Sufficient separation from noise sensitive neighbors
- Good grid connection
- Wind turbines are large and heavy so larger area is needed.
- The area must not be special bird designation area.

## Wind energy as renewable resource:

### Advantages:

- Unlimited source of wind in our environment
- Most environmental friendly resource
- Reduces fossil fuel consumption
- Generates cheap electricity
- It can provide power for remote location
- Low maintenance
- Low running cost

### Disadvantages:

- Wind fluctuates
- Installation is expensive
- Creates noise pollution
- Also creates visual pollution

## Conclusion:

So we have seen that wind energy also have some pros and cons. But it definitely helps to keep environment cleaner than other non-renewable energy sources. And we have seen that wind

energy is very much eco-friendly and it is quite easy to power up the remote areas by using it. And there has certain parameters to look after at the time of designing turbines to get maximum extracted power and high efficiency value.