Advantages and disadvantages for wind energy engineering essay

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Man has always been depending on Mother Nature for his every need. From clothing to even shelter he is directly or indirectly debts on her. In order to pursue the thrust for development, he has been using various methods to achieve his goal. It was the turn of oil to be the fuel for development during the 20 and 21st century. As Economic scientists said

He realized that oil can no longer help in his movement to prosperity after a decade. So the search for new energy sources began as a result. Thus non renewable energy sources were given a strict watch and studies were conducted on it.

Non renewable energy sources included wind, tidal, sunlight, and biomass .

Man has been using wind energy in one form or another for thousand years. The earliest use was for the propulsion of ships but nearly two thousand years ago in Persia , China and Japan , windmills are believed to have been used widely.

Windmills. jpeg

A traditional wind mill in Natherlands

The first ‘ modern’windmills were developed in the late nineteeth century for pioneer agricultural use in Australia and the United states. These were originally developed for water pumping and were generally of mult-bladed type still familiar in many parts of the world.

Some small wind mills were used for electricity production ahead of rural electrification programmes but the development of the internal combustion

engine and steam cycle for electricity production led, in the use of the wind as a source of power in most parts of the world. This occurred in spite of a growing appreciation of the aerodynamic principles of windmill construction , largely originating from the development of windmill construction , largely originating from the development of aircraft technology during the First World War. A notable exception to this general trend occurred in Denmark where La Cour developed windmills for electricity production. To overcome the variations in output , La Cour stored energy by electrolysing water to produce hydrogen which was then used to light his laboratory . At the turn of the century , a Royal Commission was set up in Denmark to develop windmills for agricultural use .

Source of the wind

The driving force for wind is the solar radiation incident on the earth’s atmosphere and , in particular , the pattern of heat transfer between the surface and the atmosphere. Unequal heating of the surfaces establishes a pressure gradient and the air is thus subject to a force leading to acceleration in the direction of its gradient. The rotation of the earth is also playing a major role in establishing global patterns of air flow. The Coriolis force resulting from these factors acts at right angles to the direction of air flow, and in the northern hemisphere this tends to establish clockwise rotation of the flow.

Power and Energy in the wind

The energy contained in the wind is its kinetic energy. The kinetic energy of any particular mass of moving air is equal to half the mass, m, of the air with square of its velocity, V

i. e. kinetic energy = 1/2mV2

Where m is in kilograms (kg) while V is in metres per second (ms-1)

We can calculate the kinetic energy in wind, by assuming wind to be flowing through a circular ring having an area, A of 100m2 at a velocity, V of 10m/s and the ring is having a length of 10m. Therefore calculating the volume of air flowing through the ring each second is 100 * 10 = 1000 cubic metres (m3). Density of air is p, which at sea level is 1. 2256 kgm-3.

Therefore, mass of air is calculated as the product of air density to volume of air flowing per second.

I. e. mass (m) of the air = air density * area *length of cylinder of air flowing per second

= air density * area *velocity

i. e. m = pAV.

Therefore kinetic energy per second = 0. 5 p A V3 (joules per second)

Power is also equal to energy per unit of time, then power in the wind, P (watts)= kinetic energy in the wind per second (joules per second)

I. e. P = 0. 5pAV3

Principle of Wind Energy capturing

The power in the wind at any moment is the result of a mass of air moving at speed in some particular direction. To capture this power – or a fraction of it, since it is not practicable to extract the whole – it is necessary to place in the path of the wind some machine which retards it and so brings about a transfer of power from the wind to the machine. Wind power being proportional to the cube of the wind speed, reduction of this diminishes the power in the wind; the power output of the machine is that lost by the wind except for the inevitable losses which must occur in the process of transference. The machine must either move along with the wind against a back pressure as in a sailing ship or, remaining stationary, must be caused to rotate on an axle carrying a load which exerts a breaking effect.

Classes of Wind driven machines

Two main classes of machines which may be distinguished are:

Machines having the effective moving surfaces of their rotors moving in the direction of the wind.

Machines whose rotors move in a plane, or planes, perpendicular to the direction of the wind.

Class (a) Machines: These usually have rotors which run about a vertical axis and which respond equally to all wind directions though there have been exceptions to these general rules. They are characterized by simple construction and by a lower power coefficient than class (b) machines. The maximum possible power coefficient for such a machine, sometimes called

panemones, is . Other disadvantages of wind driven machine constructed on this principle are

That the moving surface must always move at less than the speed of the wind.

The surfaces, which move with the wind during one half of the revolution about their vertical axis, must move against the wind during the other half revolution and this involves a further considerable loss of power.

Although these may prove useful, and of economic construction, in small sizes, these are not likely to be applicable to large scale power production. They are low power coefficient would necessitate the use of very large surfaces to obtain the required power. Not only would this expensive in material for the blades but the machines would be difficult to construct with sufficient strength the high wind pressures encountered on very windy sites.

Class (b) Machines: In these machines the active surfaces are placed at a very small angle to the relative wind instead of being perpendicular to it, and the driving force, instead of being displaced in the direction of the relative velocity, makes an angle with it.

Vertical Axis Turbine Rotors

Vertical axis turbine at New Mexico , USA http://t3. gstatic. com/images? q= tbn: 87T3xU-VxnuMnM: http://www. arge-biogasanlagen. at/upload/vetikal. jpg&t= 1

These are wind driven machines having a vertical axis and bearing some superficial resemblance to a water turbine. Claims have been made that the simple construction, avoidance of speed control mechanisms and acceptance of winds from any direction without orientation, make it superior to the horizontal axis turbine.

These machines can be distinguished because the operating forces are produced by wind which strikes the moving surfaces, not perpendicularly, but at a small angle.

Advantages of a Vertical Axis Wind Turbine

These types of turbine are easier to maintain:-As generator is near the ground.

Due to large surface area very less wind is required to turn the rotor blades to generate power.

There is no need for Yaw and hence weight is reduced.

Being near the ground allows turbine to collect extra energy from wind that bounces off a forty-five degree slope from the base of the turbine to the ground. So when the wind hits the ground and is directed up the slope, around twenty percent more power is added to the wind turbine.

Disadvantages of a Vertical Axis Wind Turbine

Because of large surface area the windmill can suck birds and other objects.

There is a height of limitation, i. e. how high a vertical axis wind turbine can be

built.

It needs flat region.

There is instability as the main centre of gravity being in the airfoil. Strong support

at the base is required.

Expensive.

Horizontal axis Turbine Rotors (HAWTs)

These Turbines have either two or a large e number of blades. The latter appears to be virtually a solid disk covered by many solid blades made up of slightly cambered sheet metal . They include the multi-blade wind turbines used for water pumping on farms.

The swept area of wind turbines with two or three blades is largely void and only a small fraction of this area appears to be solid. These are referred to be low-solidity devices. Modern low -solidity HAWTs are of same gene from the olden windmills. They have their rotors resemble the propellers of aircrafts and are the common type of wind turbines available now a day. Their rotors have two or three wing like blades and are generally used for generating electricity.

A three bladed horizontal axis wind turbine. horizontal axis wind turbine

Components of a Windturbine

http://www. alternative-energy-news. info/images/technical/wind-turbine. jpg

The cross section of a typical Wind Turbine is shown above. The main components are:

1. Blades – They form the core of the wind turbine. Blades convert the wind motion to mechanical energy. It is made of wide variety of materials as exposed to harsh weather conditions.

2. Gear box – It helps the generator to achieve a constant speed all the time irrespective of varying wind speeds.

3. Generator – As the name suggests it produces electricity by converting the mechanical energy provided by the blades of the turbine.

Materials used in wind turbines

In order to determine which kind of material is to be used for building wind turbines, it is essential to know about the loads and stresses expected, the existence of effects such as resonances and instabilities and most importantly the environment to which the machine will be subjected , that is , offshore mills or onshore mills.

Most designs of large wind turbines are extensively analysed to calculate the static and dynamic loads which various components will experience. Although the stresses arising from the aerodynamic, gravitational and centrifugal loads on blades and gravitational loads on the tower are relatively small, many fatigues can be accumulated in a short time. In a life time of 30years, the blades of a large wind turbine will rotate more than 108

times. So, considering all these facts in the design process sophisticated computer programmes have been developed which makes the calculation easier.

Designs must also be analysed for instabilities. These involve an interaction between degrees of freedom, reinforced by an external source of energy which builds the interaction up to high values. A number of possible mechanisms which are reinforced by the wind can be identified in the blades

The choice for towers is too low. It is always steel lattice, thin steel lattice or concrete. Stiffness in towers can be varied and it is always useful in avoiding resonances. Particular attention must be given to the weld quality and to the areas surrounding the holes which are used to fasten lattice tower cross members.

Blades are the only structures which are exposed to the wind. Therefore it must withstand the pressure of wind also. So, a special attention must be given in selecting the material as well as its design. Various materials are available for the construction of turbine according to the different conditions in which it is to be used. Some materials which are used for blades are listed below:

Aluminium and aluminium alloy- problems of fatigue are often seen on these materials but it does not appear if they are used for a long term.

Steel- it is widely used and performs well in dry conditions. Coatings must be provided if it is used in marine environments. Steel blades are usually heavy.

Titanium and titanium alloy- They do posses high specific strength, stiffness, good fatigue properties and good corrosion resistance. Titanium is always used for strategic purposes and is quite expensive.

Composites- They have good specific strengths, fatigue properties and corrosion resistance. So they are gaining quite a good favour. Stiffness, which is an important criterion in case of blades, can be varied with the choice of fibre type and content. Once considered to be more expensive but now costs are coming down and it makes the production of large blades possible.

Wood- Pre modern era wind mills used wooden blades. Moisture absorption which leads to crack formation backfires them while using in offshore.

Energy conversion

“ Energy can neither be created nor destroyed”. We can only change its forms, using appropriate energy-conversion processes. The ability to convert mechanical energy to electrical energy has often decided the progress of nations. The most efficient way of exploiting Wind power is by converting it to electrical energy. The biggest challenge in the design of a low cost low speed wind turbine system is the perhaps the design of the energy conversion system. The mechanical energy in the wind is converted into electrical energy using a Generator.

Most windmills incorporates either a synchronous or an induction generator, although other options like hydraulic or AC/DC conversions with thyristor control are sometimes employed.

Types of wind farms

Wind farms can divide into 2 types according to their site of operation. They are

Onshore

Offshore

Onshore Windmills

They are those wind farms which are located on the land surfaces along with either residential areas or non residential areas like hillsides, valleys and so on where they can tap enough wind from which it can produce electricity. Figure of a typical wind farm is shown below :

http://3. mm. g-media. com/766636. jpg

Onshore wind farm at Isle of Man

The advantages of on shore windmills are:

It is a commercially available technology.

Modern turbines are quiet in its operation.

Wildlife impacts are low

2. Offshore wind farms

As the name suggests wind farms are constructed in bodies of water to generate electricity from wind. These farms may be either located at inshore areas like lakes , fjords and sheltered coastal areas.

By the end in 2009, 26 off shore wind farms have been constructed over Europe with an average rated capacity of 76 MW. This figure shows the trend in off shore wind farm over Europe.

http://www. finfacts. com/irelandbusinessnews/uploads/winddec102007. jpg Horns rev wind farm, North Sea, West

of Blavands Huk.

The advantages are :

Sea wind provides greater wind speeds.

Less turbulence provides long life.

Lower visual intrusion.

Environmental Impacts

We have both positive and negative impacts to the use of wind energy . But, with their future applications, positive sides will out way its negative sides.

1. Benefits of electricity generation by wind energy

While producing electricity, wind turbine does not release Carbon dioxide or Carbon monoxide, which can cause severe environmental impacts. UK is having a huge potential for wind energy and it can be exploited as well. A

wind turbine does not consume water as needed by certain other energy sources to produce electricity. So, wind turbines can save much water.

2. Impacts to Environment

Possible environmental impacts caused are noise, electromagnetic interference , visual impacts including ‘ flicker’ caused by sunlight interacting with rotating blades on sunny days. A number of concerns are arising due to the offshore wind farms related to marine fishes, mammals, migratory birds. Noises are usually caused by the gear box and generator in the wind turbine.

The graph below gives an idea about bird mortality rate caused by wind turbines

http://www. eurotrib. com/files/3/050711_what_kills_birds. jpg

Scope of wind energy in the UK by 2050

During 1991, UK constructed its first wind farm developing of over 400 KW power , sited in North Cornwall , connected to the national grid. Till year 2009, UK has over 280 projects producing about 5189. 595 MW power for its energy needs.

File: UK windfarm growth. PNG

The above graph depicts about the increased growth in wind farms. UK itself has formed an agency comprising of industrialists and academics which came to be known as British Wind Energy Association (BWEA) with the aims

of providing information about wind energy to public and to gear up policies for future.

http://www. goodenergy. co. uk/wp-content/uploads/2008/11/good-energy-generator-map-2nd-edition-gif. gif

The above graph gives a clear picture of the number of wind farms located all over UK. This reveals that UK is mostly turning to wind energy rather than moving for any other renewable sources like solar, biogas, wave and hydro.

The graph below gives an idea about the winds available over UK in its speed levels measured in m/s. particularly in the Scottish areas wind is in its peak speed. The Scottish government is targeting to meet its 50% of electricity demand from renewable energy by 2020. After all UK government has itself aims to generate a total of 33GW of offshore wind energy .

http://www. kingspanpanels. com/Resource_Centre/Technical-Information/Structural-Performance/images/desg_intro_44_img01-jpg. aspx

Power generation technologies

Cost in Euro / MWh

Coal lignite

18-150

Oil

26-109

Gas

5-35

Nuclear

2-7

Onshore wind

1-3

External costs for various power generation technologies within Europe

Public reaction to wind energy projects in UK

Wind energy is a popular source of energy. During the month of September in 1991 , on a poll conducted by Friends of Earth for over 1010 people found that 87% demanded the government to increase the proportion of electricity from renewable sources while , 77% wanted more renewable energy power even it is more expensive.

A poll conducted by Greenpeace found that 67% of 1085 people agreed to pay an extra £7 extra per year on their electricity bills to support renewable energy.