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Wind energy technology

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Abstract --- *The electricity requirements of the world including India are increasing at alarming rate and the power demand has been running ahead of supply. generation of electrical energy, may not be either sufficient or suitable to keep pace with ever increasing demand of the electrical energy of the world. Also generation of electrical power by cold based steam power plant or nuclear power plants causes pollution, which is likely to be more acute in future due to large generating capacity on one side and greater awareness of the people in this respect.*

The recent severe energy crisis has forced the world to develop new and alternative methods of power generation, which could not be adopted so far due to various reasons. The other non-conventional methods of power generation may be such as solar cells, fuel cells, thermo-electric generator, thermionic converter, solar power generation, wind power generation, geo-thermal energy generation, tidal power generation etc.

Keywords --- *Wind energy, Wind Turbine, Electricity, electrical energy, power generation.*

I. INTRODUCTION

Wind energy is derived fundamentally from solar energy via a thermodynamic process. Sunlight warms the ground causing air above it to rise. The ensuing pressure differential causes air from elsewhere to move in, resulting in air motion (wind). Different regions on earth are heated differently than others—primarily a function of latitude. Air motion is also affected by the earth's rotation. The net effect is that certain par t s of the world experience higher average winds than others. The regions of highest winds are the most attractive for extracting it s energy: Theoretically, the power which can be extracted from the wind is proportional to the cube of the velocity, so a good wind regime is particularly important. The power that can be extracted in practice, however, is somewhat less than proportionally related to the cube of velocity.

The total energy impinging on at the outer atmosphere, assuming a solar constant of 1,367 W/m2, is 1.53x1018 kWh per year. The conversion of solar energy to wind has been estimated to occur at an efficiency of 2%; approximately 35% of this is in the lower boundary layer where it could potentially be extracted by wind turbines (Gustavson, 1979). According to this estimate, the maximum global wind resource is approximately 1.22x1015 kWh/yr.

WIND ENERGY TECHNOLOGY

Wind energy experienced a resurgence beginning in the early 1970s. Over the last 35 years, turbine rotors have grown in size from approximately 10 m to more than 120 m. Power ratings of individual turbines have increased from tens of kW to more than 5 MW. As of 2006, an estimated capacity of 73.9 GW was installed worldwide (WWEA, 2007). Also according to the World Wind Energy Association, this capacity produces more than 1% of the world's electricity and in the case of one country (Denmark) produces an amount equal to 20% of its consumption. Figure illustrates a typical wind turbine.

Figure : Typical Wind Turbine.

WIND ENERGY SYSTEM DESIGN

Converting the energy in wind into a socially useful electrical or mechanical form involves many types of processes which all have their own particular characteristics. Some of these processes are well developed ,others less so. Modern turbines have evolved primarily from what is known as the 'Danish concept '. This design was based on a three bladed, upwind, stall-controlled rotor which drove an induction generator via a gearbox. Today's turbines have extended that concept; many of them now incorporate blade pitch control, power electronic converters and use different types of generators. Some of the key features of modern wind turbines are summarised below and are illustrated in Figure.

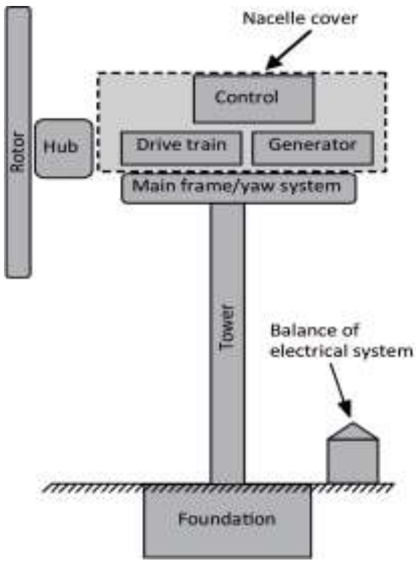

Figure: Schematic of typical wind turbine

The first step in the extraction of energy is converting the kinetic energy of wind to mechanical energy in a rotor via an aerodynamic lift. Rotors nowadays typically have three blades, but having more or fewer is possible. Blades are constructed primarily of composite material. Most rotors have a horizontal axis of rotation, although a vertical axis is also possible. The rotor i s general l y oriented such that the blades are upwind of t he tower, although downwind orientation has sometimes been used.

Positioning of the rotor is provided by a yaw system (which turns the entire nacelle, see below). The rotor, which turns relatively slowly (the more so for larger rotors), is connected to a main shaft which in turn connect s (typically) to a gearbox. The gearbox provides an increase in speed such that the speed of the gearbox's output shaft is matched to the speed requirement s of the generator. The generator, which is the next step in the process, performs the conversion of mechanical energy to electrical energy. The shaft s, gearbox, generator and associated equipment are contained in a nacelle which is located on top of a tower.

The tower keeps the rotor nacelle assembly well up into the air where the wind speed is higher and less turbulent than it would be closer to t he ground. The tower, which is normally made of steel, is attached to a foundation (reinforced concrete for onshore turbines) or to a more extensive support structure (as int he case of off shore turbines). Electricity is carried down t he tower via a droop cable. A control system port ions of which may be in then a cell e or on t he ground, per forms a variety of functions. These include star ting and stopping t he rotor and protecting t he machine during extreme winds or fault s. Most turbines today incorporate blade pitch control where t he blade may be turned about it s long axis to change it s aerodynamic properties. Other devices may also play a significant role in the process. These include in particular power electronic converters, which may facilitate variable speed operation of t he rotor, while allowing the output electricity to be of essentially constant voltage and frequency.

The electrical output of most turbines nowadays is directed into a conventional electrical net work. The volt age may be at the distribution level or higher, depending on the situation. In any case, a transformer is normally used to convert the generator's output (low volt age) to the electrical line volt age (medium or high volt age). Various other electrical devices and switchgear are also used to allow safe connection to the network and protection in the case of faults.

In some applications, such as where the grid is isolated or weak, or where there is large amount of wind energy generation installed, the interconnection process may be more involved. Such applications can benefit from the use of shot-term storage and super visor y control systems. As an increasing amount of wind generation is added to grids of whatever type, more attention must be given to the issues associated with interconnection. These could include demand side management, longer-term storage or even fuel production (e.g. hydrogen via the electrolysis of water).

CHARACTERISTICS OF WIND ENERGY TECHNOLOGY

There are a number of characteristics of wind energy technology which are distinctive and which affect the design of wind turbines and their use:

1. Low energy density of the resource
2. Fluctuating nature of the resource
3. Social acceptance
4 Non-dispatchability of wind generation
5. Material requirements
6. Costs

Low energy density

In most sites considered for wind energy development, the average wind power density is in the range of 200–800 W/m^2 (ver tical area). The implication is that rotors must be physically quite large (in comparison for example, to steam turbines or hydroelectric turbines) to produce a given amount of power. A seconday effect is that turbines are imposing in the landscape and so public reaction to their appearance is a factor that must be taken into account.

Fluctuating wind resource

The wind it self is highly variable both spatially and temporally and on many lengths and time scales. These fluctuations affect all aspect s of t he design, siting and operation of t he wind turbines. Wind speed measurement s are typically averaged over ten minute intervals for use in performance and economic assessment s. These long-term averages vary sufficient l y over t he day and from one season to another t hat the average power from wind turbines is typically between 20% and 40% of their rated maximum. Wind naturally exhibit s occasional extremes. These extremes result in very high forces on the turbines, even when they are not running. These extremes must be considered in the design process.

The magnitude ofthe extremes is typically closely related to the long-term average wind speed at a site, but not always so (as in the case of regions prone to hurricanes). In any case, it is desirable to utilise a turbine whose design is suited to its location ensuring that the turbine does not have either too much or too little material. Short-term fluctuations (known as turbulence) have major influence on the design of the turbines. In particular, fluctuations in wind speed and direction contribute to material fatigue in many of the wind turbine's component s. These fluctuations must be taken into account in the sizing of the component s, choice of materials, control strategies and maintenance schedules.

Social acceptance

Due to the relatively large size of wind turbines and the need to site them in exposed locations, public acceptance of wind energy development has sometimes been problematic. The need has arisen to address public concerns through education or by mitigating the impact.

Non-Dispatchability

Due to the nature of the wind it self and the technology used for it s extraction, energy derived from wind is inherently non-dispatchable. That means that generation cannot be turned on at will. When the wind turbines provide a relatively small portion of a net work's requirement s this is not an issue. When turbines are intended to supply a large fraction of the energy, then the overall system must be configured differently. In this case, the wind turbines need to operate in concert with a suitable control system and possibly storage.

Material requirements

Material requirement s of wind turbines relate directly to the low power densit y of wind and it s fluctuating nature. The low power densit y requires large heavy rotors. As the rotor rotates there are large reversing forces which contribute to fatigue along with the fluctuations in the wind.

Costs

To a significant extent, wind turbines can be designed that will work adequately and survive a sufficiently long period of time. There is still an issue of cost, however, both in terms of resources and required financial outlay. High cost s are associated with the material requirement s of the wind turbine. Long-termoperation and maintenance cost s are also important. There is a need for continuing work to drive down the cost s of the turbines while maintaining and improving their reliability. Cost reductions will benefit from improved understanding of the fundament al physics of the conversion process, as well as of the failure mechanisms. Continuous monitoring of the wind turbines and design and implementation of structural health management systems should help to decrease these costs.

It may be noted that cost s for wind generated electricity have decreased significantly over the last 30 years.

For example, the cost of energy from wind in 1980 has been estimated to be approximately US$0.50/kWh (EIA, 1995). Presently, it is less than a fifth of that in many locations. This is largely due to experience, research and development. The resulting enhanced understanding of the interaction of the wind turbine with its environment has led to improvements and cost reductions in all aspects of the technology. Costs are
moving towards parity with conventional energy generation.

CONCLUSION

This paper elucidates about Different Energy sources, why we are going for non-conventional energy sources, Different non-conventional energy sources & comparison between them, about wind energy.

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