AN OVERVIEW OF PRINCIPLES OF WIND ENERGY CONVERSION& ITS APPLICATION

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ABSTRACT

There are two primary physical principles by which energy can be extracted from the wind; these are through the creation of either lift or drag force (or through a combination of the two). The difference between drag and lift is illustrated by the difference between using a spinnaker sail, which fills like a parachute and pulls a sailing boat with the wind, and a Bermuda rig, the familiar triangular sail which deflects with wind and allows a sailing boat to travel across the wind or slightly into the wind. Drag forces provide the most obvious means of propulsion, these being the forces felt by a person (or object) exposed to the wind. Lift forces are the most efficient means of propulsion but being more subtle than drag forces are not so well understood.

Keyword: Generator, Rotors, Wind Energy, Wind Force, Wind Machine, Wind Speed.

I.INTRODUCTION

Modern wind generators, the first wind powered electricity was produced by a machine built by Charles F. Brush in Cleveland, Ohio in 1888. It had a rated power of 12 kW (direct current - dc). Direct current electricity production continued in the form of small-scale, stand-alone (not connected to a grid) systems until the 1930's when the first large scale AC turbine was constructed in the USA. There was then a general lull in interest until the 1970's when the fuel crises sparked a revival in research and development work in North America (USA and Canada) and Europe (Denmark, Germany, The Netherlands, Spain, Sweden and the UK). Modern wind turbine generators are highly sophisticated machines, taking full advantage of state-of-the-art technology, led by improvements in aerodynamic and structural design, materials technology and mechanical, electrical and control engineering and capable of producing several megawatts of electricity. During the 1980's installed capacity costs dropped considerably and windpower has become an economically attractive option for commercial electricity generation. Large wind farms or wind power stations have become a common sight in many western countries. In 2001 Denmark alone had 2000 Megawatts of electricity generating capacity from more than 5,700 wind turbines, representing 14% of their national electricity consumption.

Wind is a clean, safe, renewable form of energy. To a lesser degree, there has been a parallel development in small-scale wind generators for supplying electricity for battery charging, for stand-alone applications and for connection to small grids.

1.1 The Classification System For Wind Turbines

Scale	Rotor Diameter	Power Rating
Micro	Less than 3 m	50 W to 2 kW
Small	3 m to 12 m	2 kW to 40 kW
Medium	12 m to 45 m	40 kW to 999 kW
Large	46 m and larger	More than 1.0 MW

Table 1: The classification system for wind turbines.

II. TECHNICAL THE POWER IN THE WIND

The wind systems that exist over the earth's surface are a result of variations in air pressure. These are in turn due to the variations in solar heating. Warm air rises and cooler air rushes in to take its place. Wind is merely the movement of air from one place to another. There are global wind patterns related to large scale solar heating of different regions of the earth's surface and seasonal variations in solar incidence. There are also localized wind patterns due the effects of temperature differences between land and seas, or mountains and valleys. Wind speed generally increases with height above ground. This is because the roughness of ground features such as vegetation and houses cause the wind to be slowed.

Windspeed data can be obtained from wind maps or from the meteorology office. Unfortunately the general availability and reliability of windspeed data is extremely poor in many regions of the world. However, significant areas of the world have mean annual windspeeds of above 4-5 m/s (meters per second) which makes small-scale wind powered electricity generation an attractive option. It is important to obtain accurate windspeed data for the site in mind before any decision can be made as to its suitability. The formula used for calculating the power in the wind is shown below,

$P = ½.\rho.A.V^3$ Where,

P is power in watts (W)

ρ is the air density in kilograms per cubic meter (kg/m^3)

A is the swept rotor area in square meters (m^2)

V is the wind speed in meter per second (m/s)

The fact that the power is proportional to the cube of the windspeed is very significant. This can be demonstrated by pointing out that if the wind speed doubles then the power in the wind increases by a factor of eight. It is therefore worthwhile finding a site which has a relatively high mean windspeed.

III. WIND INTO WATTS

Although the power equation above gives us the power in the wind, the actual power that we can extract from the wind is significantly less than this figure suggests. The actual power will depend on several factors, such as the type of machine and rotor used the sophistication of blade design, friction losses, and the losses in the pump or other equipment connected to the wind machine. There are also physical limits to the amount of power that can be extracted realistically from the wind. It can be shown theoretically that any windmill can only possibly extract a maximum of 59.3% of the power from the wind (this is known as the Betz limit). In reality, this figure is usually around 45% (maximum) for a large electricity producing turbine and around 30% to 40% for a windpump, (see the section on coefficient of performance below). So, modifying the formula for 'Power in the wind' we can say that the power which is produced by the wind machine can be given by:

$P_M = ½.Cp.ρ.A.V^3$

where,

P_M is power (in watts) available from the machine

C_p is the coefficient of performance of the wind machine

It is also worth bearing in mind that a wind machine will only operate at its maximum efficiency for a fraction of the time it is running, due to variations in wind speed. A rough estimate of the output from a wind machine can be obtained

Where,

P_A is the average power output in watts over the year

V is the mean annual windspeed in m/s

The basic features that characterize lift and drag are:

• Drag is in the direction of air flow
• lift is perpendicular to the direction of air flow
• generation of lift always causes a certain amount of drag to be developed
• with a good aerofoil, the lift produced can be more than thirty times greater than the drag
• lift devices are generally more efficient than drag devices

IV. TYPES AND CHARACTERISTICS OF ROTORS

There are two main families of windmachines: vertical axis machines and horizontal axis machines. These can in turn use either lift or drag forces to harness the wind. The horizontal axis lift device is the type most commonly used. In fact other than a few experimental machines virtually all windmills come under this category. There are several technical parameters that are used to characterize windmill rotors. Thetip-speed ratio is defined as the ratio of the speed of the extremities of a windmill rotor to the speed of the free wind. Drag devices always have tip-speed ratios less than one and hence turn slowly, whereas lift devices can have high tip-speed ratios (up to 13:1) and hence turn quickly relative to the wind. The proportion of the power in the wind that the rotor can extract is termed the coefficient of performance (or power coefficient or efficiency; symbol C_p) and its variation as a function of tip-speed ratio is commonly used to characterize different types of rotor. As mentioned earlier there is an upper limit of C_p = 59.3%, although in practice real wind rotors have maximum C_p values in the range of 25%-45%.

Solidity is usually defined as the percentage of the area of the rotor, which contains material rather than air. Low-solidity machines run at higher speed and tend to be used for electricity generation. High-solidity machines carry a lot of material and have coarse blade angles. They generate much higher starting torque (torque is the twisting or rotary force produced by the rotor) than low-solidity machines but are inherently less efficient than low-solidity machines. The windpump is generally of this type. High solidity machines will have a low tip-speed ratio and vice versa. There are various important wind speeds to consider: Start-up wind speed - the wind speed that will turn an unloaded rotor • Cut-in wind speed - the wind speed at which the rotor can be loaded • Rated wind speed - the windspeed at which the machine is designed to run • Furling wind speed - the windspeed at which the machine will be turned out of the wind to prevent damage • Maximum design wind speed ,the windspeed above which damage could occur to the machine

4.1 Comparision Of Roter Types And Their Characteristics

Type	Speed	Torque	C_p	Solidity (%)	Use
Horizontal Axis					
Multi Blade	Low	High	0.25 - 0.4	50 - 80	Mechanical Power
Three-Bladed Aerofoil	High	Low	up to 0.45	Less than 5	Electricity Production
Vertical Axis					
Panemone	Low	Medium	less than 0.1	50	Mechanical Power
Darrieus	Moderate	Very low	0.25 - 0.35	10 - 20	Electricity Production

Table 2: Comparison of Rotor Types

V. ANATOMY AND CHARACTERISTICS OF THE WIND GENERATOR

A typical small wind generator has rotor that is directly coupled to the generator which produces electricity either at 120/240 volt alternating current for direct domestic use or at 12/24 volt direct current for battery charging. Larger machines generate 3 phase electricity. There is often a tail vane which keeps the rotor orientated into the wind. Some wind-machines have a tail vane which is designed for automatic furling (turning the machine out of the wind) at high wind speeds to prevent damage. Larger machines have pitch controlled blades (the angle at which the blades meet the wind is controlled) which achieve the same function. The towers are of low solidity to prevent wind interference and are often guyed to give support to the tower

5.1 The Specifications For The Practical Action Small Wind Turbine Are Shown In Below.

Type	3 Blade Upwind
Rotor Diameter	1.7 Meters
Drive	Direct
Rated Power	100 Watts
Start-Up Wind Speed	3.5 M/S
Cut-In Wind Speed	3.5 M/S
Rated Wind Speed	8.0 M/S
Furling Wind Speed	14.0 M/S
Generator	Permanent Magnet Alternator
Max. Power Output	200 Watts

Table 3: Practical Action Small Wind Energy System for Battery Charging Turbine Specifications

VI. GRID CONNECTED OR BATTERY CHARGING

Depending on the circumstances, the distribution of electricity from a wind machine can be carried out in one of various ways. Commonly, larger machines are connected to a grid distribution network. This can be the main national network, in which case electricity can be sold to the electricity utility (providing an agreement can be made between the producer and the grid) when an excess is produced and purchased when the wind is low. Using the national grid helps provide flexibility to the system and does away with the need for a back-up system when wind speeds are low.

Micro-grids distribute electricity to smaller areas, typically a village or town. When wind is used for supplying electricity to such a grid, a diesel generator set is often used as a backup for the periods when wind speeds are low. Alternatively, electricity storage can be used but this is an expensive option. Hybrid systems use a combination of two or more energy sources to provide electricity in all weather conditions. The capital cost for such a system is high but subsequent running costs will be low compared with a pure diesel system. In areas where households are widely dispersed or where grid costs are prohibitively expensive, battery charging is an option. For people in rural areas a few tens of watts of power are sufficient for providing lighting and a source of power for a radio or television. Batteries can be returned to the charging station occasionally for recharging. This reduces the inconvenience of an intermittent supply due to fluctuating windspeeds. 12 and 24 volt direct current wind generators are commercially available which are suitable for battery charging applications. Smaller turbines (50 -150 watt) are available for individual household connection.

VII. CONCLUSION

In this overview, the research is now being done to increase the knowledge of wind resources. This involves the testing of more and more areas for the possibility of placing wind farms where the wind is reliable and strong. Plans are in effect to increase the life span of the machine from five years to 20 to 30 years, improve the efficiency of the blades, provide better controls, develop drive trains that last longer, and allow for better surge protection and grounding.

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