CMR INSTITUTE OF TECHNOLOGY	USN											

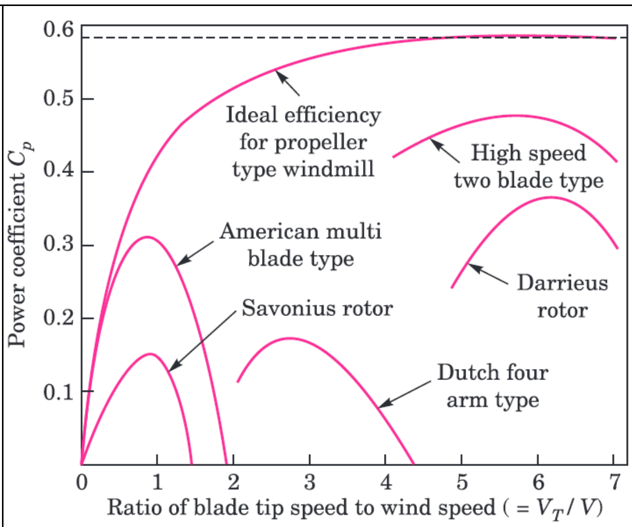
Internal Assesment Test – III

Sub:	Solar & Wind Energy							Code:	18EE731
Date:	02/01/2024	Duration:	90 mins	Max Marks:	50	Sem:	7	Branch :	EEE

Answer Any FIVE FULL Questions

		Marks	OBE CO	OBE RBT
1	What are the environmental benefits and problem of wind energy? The wind energy has significant advantage when compared to thermal based generation. However, the major environmental concerns of wind energy include indirect energy use and emissions, Burds life, noise, visual impact, telecommunication interference, safety and so on. The detailed explanation on disadvantage of wind energy is mentioned below: In case of indirect energy use and emissions, energy is required to produce material used to construct the wind turbine and its installation. The energy is paid back in a period of few months to about a year, what is known as energy payback period. Some pollution is caused due to use of energy during construction. Overall pollution generated through the wind mill will be low. Also, large wind turbines pose a threat to bird life as a result of collision with tower or blades. Their resting and breeding patterns are also affected. The disturbance caused by the noise produced by a wind turbine is another important factor that prevent its siting close to inhabited areas. The sound level of a 500kW machine rotating at 18 revolutions per minute at the hub typically 102dBA, which reduces down to 60dBA at a distance of 50m and declines very afterwards. Wind turbines are massive structures quite visible over a wide area in most locations. The visual impact of wind turbines is qualitative in nature. Telecommunication interference due to wind turbine present an obstacle for incident electromagnetic waves. These waves can be reflected, scattered and dithered. Thus, they interfere with telecommunication links and badly affect the quality of radio signals.	10	CO4	L2
2	List out the factors that influence the cost of energy generation and machine parameters. 1. Economic depreciation of the capital equipment 2. Interest paid on the borrowed capital 3. The operation and maintenance costs 4. Taxes paid to local and federal authorities 5. Government incentives and tax credits 6. Royalties paid to land owners 7. Payment for electricity used on a standby mode 8. Energy storage components, if used 9. The cost of wind as fuel is zero	10	CO4	L2
3	Explain in detail the different wind energy conversion system.	10	CO5	L2

	1. Rotational Axis: According to the type of rotational axis these are further classified as: Horizontal axis wind turbine: It is commonly used. The rotor blades are mounted Perpendicularly on a horizontal shaft to the ground. Vertical axis wind turbine: It is not very commonly used and on the vertical shaft the rotor blades are mounted to the ground. 2. Turbine: Based on the electrical output turbines can be further classified as: Low Power turbines: The maximum output is 30 kW. Medium Power turbines: The output ranges from 30 to 300 kW High Power turbines: Considerable amount of power is produced, 3. Power Control: It is important to control the level of wind energy for constant power output. It is achieved in the following ways: Active power control: Using pitch control mechanism the angle of the blades of the rotor is manipulated and the amount of wind is regulated. Reactive power control: Management and regulation of electricity is done by the generator. 4. Rotational Speed Control Criteria: The speed of the turbine blades is based on the speed of the wind. Below mentioned ways are used to control the wind speed: Fixed speed WECS: Governor is a device that is used to control the speed of the turbine. Variable speed WECS: Inverter device is used for controlling the turbine's speed.			
4	Elaborate the applications of wind energy. APPLICATIONS REQUIRING MECHANICAL POWER WIND PUMPS: Simple and reliable reciprocating or centrifugal pumps (Wind Pumps i.e., low power turbines) are used to pump water to supply for feeding livestock, small scale irrigation, low head pumping for aquatic breeding, domestic water supply and to operate farm appliances. HEATING: producing heat with 100% efficiency using paddlewheel or other turbulent fluid systems by direct dissipation of mechanical power. Available hot water is used directly or for space heating SEA TRANSPORT: The wind energy is used to propel the sailboats in river and seas to transport men and materials from one place to another	10	CO5	L1
5	Explain how you will evaluate the performance of wind machines?	10	CO5	L1



WECS efficiency is of interest to both aerogenerator designers and system engineers. As WECS is a capital intensive technology, it is desirable for the overall wind electric plant to have the highest efficiency possible, thus optimally utilizing capital resources and minimizing the busbar electric energy cost.

The overall conversion efficiency, η_0 of an aerogenerator of the general type is

$$\eta_0 = \frac{\text{Useful output power}}{\text{Wind power input}}$$

$$= \eta_A \cdot \eta_G \cdot \eta_C \cdot \eta_{Gen} \qquad \text{...(6.40)}$$

where, η_A = Efficiency of the aeroturbine

η_G = Efficiency of the gearing

η_C = Efficiency of the mechanical coupling

η_{Gen} = Efficiency of the generator

We immediately recognise equation (6.40) as an application of cascaded energy conversion, from which overall efficiency will be strongly determined by the lowest efficiency converter in the cascade. For the aerogenerator this is the aeroturbine; the efficiency of the remaining three elements can be made quite high but less than 100 per cent. It is now evident why so much emphasis is placed on the efficiency of the aeroturbine in wind literature.

Consider an arbitrary aeroturbine (Note that aeroturbine ≠ aerogenerator) of cross-sectional area A driven by the wind. Its efficiency would be:

$$\eta_A = \frac{\text{Useful shaft power output}}{\text{Wind power input}} = C_P$$

$$= \text{Coefficienct of performance.}$$

6	Discuss in detail the different types of wind machines. Horizontal axis type (wind axis rotors) Oriented normal to direction of wind Single bladed, multibladed and by-cycle multibladed	10	CO5	L2

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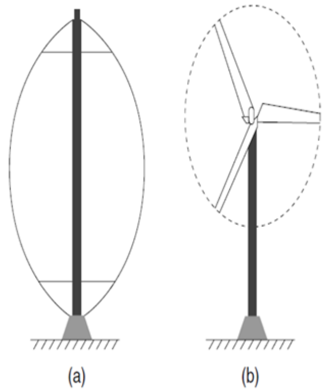
<tr><td></td><td>

Figure 6.8 Wind rotor configurations (a) Vertical axis (b) Horizontal axis

Vertical axis type (cross wind axis rotors)
Effective surface of rotor moves in the same direction as the wind
Savonious or S type rotor (low velocity wind) – Drag Force and Darrieus type rotor (high velocity wind) – Lift Force</td><td></td><td></td><td></td></tr>
<tr><td>7.</td><td>Explain how you will analyze the aerodynamic forces acting on the blade.

Aerodynamic forces acting on a blade element tending to make it rotate are important parameters for a system engineer. This illustrates the basic principle of aeroturbine rotation.

Consider the aerodynamic blade shown in Fig. 6.27. The blade can be thought of as a typical cross-sectional element of a two-bladed aeroturbine. The element shown is at some radius *r* from the axis of rotation. It is moving to the left. Because the blade is moving in the plane of rotation it sees a tangential wind velocity, V_T, in the plane of rotation. This velocity component added vectorially to the impinging

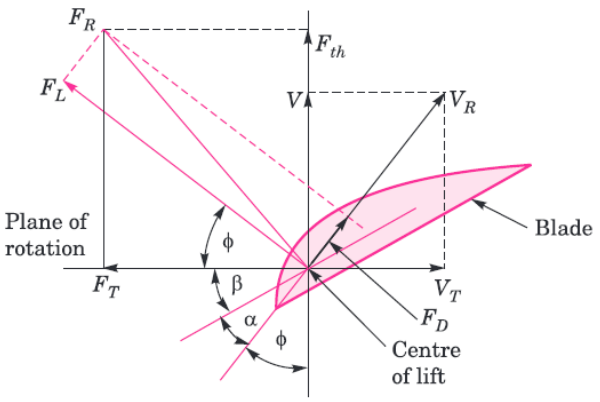


Fig. 6.27. Vector diagram of forces on a elemental blade section of an aeroturbine. (The blade is rotating to the left).

V = Impinging wind velocity.
V_T = Wind velocity in plane of rotation due to blade turning.
V_R = Resultant wind velocity seen by Aeroturbine blade.
F_L = Lift force (Normal to V_R).
F_D = Drag force (Parallel to V_R).
F_R = Resultant force on blade.
F_T = Torque producing component of F_R making aeroturbine rotate.
F_{th} = Thrust force component of F_R.
α = Angle of attack of blade.
β = Blade pitch angle.</td><td>10</td><td>CO5</td><td>L1</td></tr>
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	wind velocity gives the resulting wind velocity, V_R, seen by the rotating blade element. At right angles to V_R, is the lift force F_L caused by the aerodynamic shape of the blade. The drag force, F_D is parallel to V_R. The vector sum of F_L and F_D is F_R which has a torque producing component, F_T and a thrust producing component. The former is what drives the aeroturbine rotationally and the latter tends to flex the blade and also overturn the aerogenerator. The vector diagram is centred on the centre of lift of the aerodynamic blade. As is well-known from aircraft wing theory, one of the critical parameters is α, the angle of attack of the aerodynamic element. It determines lift and drag forces and hence speed and torque output of the aeroturbine. These quantities can be varied by changing the blade pitch angle β, and this is the basic torque control method used on large variable pitch wind-electric generators. The torque would determine the AC output power if a synchronous generator was used.			