

ECE 333 Green Electric Energy

Homework 4

due Tuesday, September 30, 2014

Reading:

Text: From Masters' 2nd edition

chapter 7 (sections 7.5, 7.6, 7.7.1, 7.7.2 and 7.8)

Solve the following problems:

Text: 7.6, 7.7

Problem a. (i) **Sketch** the ideal power curve of the turbine with the following characteristics:

- rated speed is 14 m/s
- cut-in speed is 5 m/s
- rated power is 1.25 MW
- furling or cut-out speed is 20 m/s

(ii) **Given** part (i), calculate the energy produced in one day if the wind blows continuously between 15 and 20 m/s all day

(iii) Can the energy produced in one year be determined if you are told that the average wind speed is 14 m/s ? Explain why.

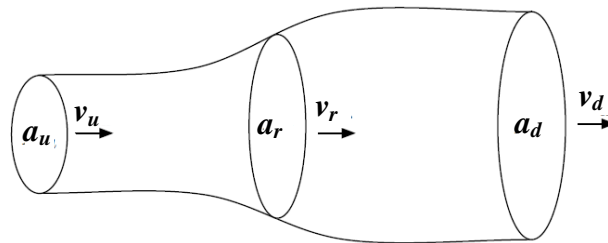
Problem b. Suppose an anemometer mounted at a height of 10 m with a 20- m/s average wind speed

(i) **Estimate** the average wind power at a height of 10 m , assuming Rayleigh statistics and under the following weather conditions

- 15°C
- -5°C

(ii) Suppose a 1300-kW wind turbine with 60-m rotor diameter is located in those winds with speed computed in the first condition of part (i). **Determine** the annual energy production with a 30% wind turbine efficiency

Problem c. As illustrated in the figure below, the air flowing in and out of a wind turbine is contained in a tube, where a_u is the tube cross-section upwind the turbine through which air enters, a_r is the tube cross-section where the turbine is located, and a_d is the tube cross-section downwind the turbine through which air exits. Similarly, v_u is the wind speed at the tube cross-section upwind the turbine, v_r is the wind speed at the tube cross-section where the turbine is located, and v_d is the wind speed at the tube cross-section downwind the turbine. Let η_r denote the so-called Betz's efficiency



Among the choices below, which one describes the maximum amount of power that can be extracted from the wind (ρ is the air density) and state your explanation:

- (A) $\frac{1}{2} \rho a_r v_r^3 \eta_r$
- (B) $\frac{1}{2} \rho a_u v_u^3 \eta_r$
- (C) $\frac{1}{2} \rho a_d v_d^3 \eta_r$
- (D) $\frac{1}{2} \rho a_r v_u^3 \eta_r$

Problem d. We consider the Rayleigh probability density function as the wind speed distribution function. **Evaluate** the numerical relationship between the average wind power and the wind power using average wind speed