Study Guide for
Atmospheric Sciences 5270: Wind Power Meterology

Example Questions

(The number after question is the relevant subsection in the *Wind Resource Assessment Handbook*.)

1. Calculate the *average wind speed* and the *average wind power density* for a site at which the wind speed is 4 m/s for 75% of the time and 8 m/s for 25% of the time. The air density is 1 kg m^{-3}. (10.1)

2. Based on the wind rose shown below, what is the most frequently occurring wind direction? For which two wind directions is the wind power density the largest? (10.1)

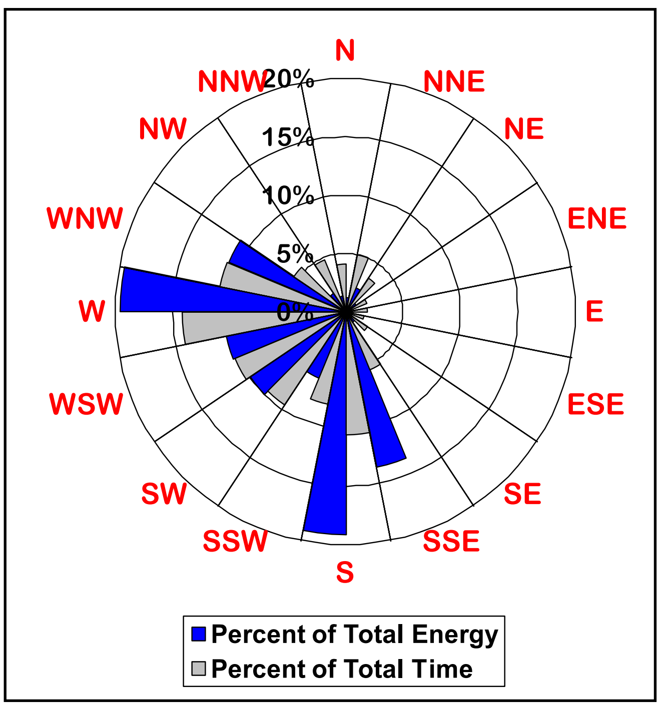

Figure 10-4 Wind rose plot example. (Source: AWS Truepower)

3. The power law equation relates the wind speeds at two heights:

$$\frac{v_2}{v_1} = \left(\frac{z_2}{z_1}\right)^{\alpha}.$$

What is the wind speed v_2 at height z_2 if $v_1 = 10$ m s^{-1}, $z_1 = 50$ m, $z_2 = 80$ m, and the wind shear exponent $\alpha = 0.14$? (10.1, 11.1)

4. The log wind speed profile is

$$v = \frac{u_*}{k} \log\left(\frac{z}{z_0}\right),$$

where u_* is the friction velocity and z_0 is the roughness length. Apply this formula to the wind speed at two different heights, z_1 and z_2 to obtain

$$\frac{v_2}{v_1} = \frac{\log(z_2/z_0)}{\log(z_1/z_0)}.$$

According to Table 11-1, what value of z_0 corresponds to $\alpha = 0.14$? Use this value for z_0 and the same values for v_1, z_1, and z_2 as in the previous problem, and calculate the wind speed v_2 at height z_2. (Lecture 6: Surface layer wind profiles; 11.1: Eq. 11-7)

5. Using the formula for the total uncertainty of two independent (uncorrelated) components,

$$\sigma = \sqrt{\sigma_1^2 + \sigma_2^2},$$

calculate the total uncertainty if $\sigma_1 = 4\%$ and $\sigma_2 = 2\%$. (14.3: Eq. 14-2)

6. Using the formula for the uncertainty of the average obtained from N measurements,

$$\sigma = \frac{\sigma_1}{\sqrt{N}},$$

where σ_1 is the uncertainty of the average from a single measurement, and N is the number of measurements, what is the uncertainty in the long-term mean wind speed based on 15 years of measurements if the uncertainty based on a single year of measurement is 4%? (14.3: Eq. 14-3)

7. The basis of the climate adjustment process is to use the longer period of record at a reference station to reduce the uncertainty of the average wind speed obtained from one year of measurements at the target station. The uncertainty of the long-term mean wind speed at the target station in this case is

$$\sigma = \sigma_A \sqrt{\frac{r^2}{N_R} + \frac{1 - r^2}{N_T}},$$

where σ_A is the uncertainty of the annual mean wind speed, (σ_A is assumed to be the same for the reference and target sites), r is the correlation coefficient between the target and reference station (usually for daily average wind speeds), N_R is the number of years of reference data, and N_T is the number of years of concurrent reference and target data. For $\sigma_A = 4\%$, $N_T = 1$ year, and $N_R = 16$ years, for what correlation, r, is σ, the uncertainty of the long-term mean wind speed at the target station, the least? The greatest? What are the corresponding values of σ? (12.2: Eq 12-1)

8. Using the plot shown below, determine the uncertainty of the long-term mean wind speed at a target site if the interannual variation is 5% and the correlation coefficient between the reference site and the target site is either 60% or 90%.

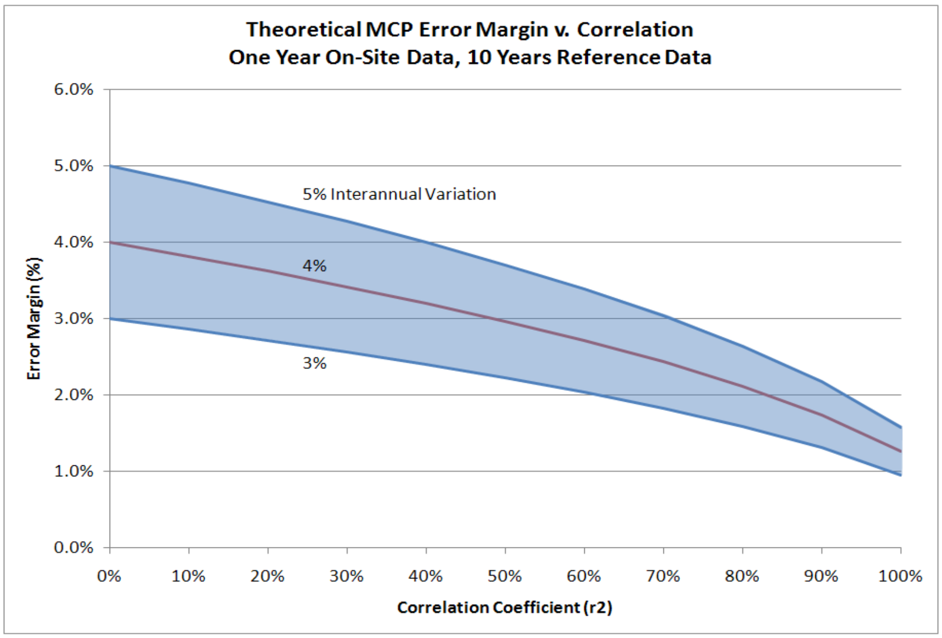

Figure 12-3 Uncertainty margin in the estimated long-term mean wind speed at a site, assuming one year of on-site data and 10 years of reference data, as a function of the r^2 coefficient between them and of the interannual variation in the wind at the site (the standard deviation of annual mean wind speeds divided by the long-term mean). (Source: AWS Truepower)