Reading:

Text: From Masters’ 2nd edition
chapter 7 (sections 7.1, 7.2, 7.4, 7.5.1)

Solve the following problems:

Text: 7.1, 7.2

Problem a. Compare the total wind energy at 0°C, 1 atm of pressure, contained in 1-m² surface area under the following wind patterns:

(i) 100 hours of 10 m/s winds;
(ii) 50 hours of 8 m/s winds plus 50 hours of 12 m/s winds

What are the implications of your findings? Can you draw a generalization concluded on the average wind speed?
Problem b. 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 \( \eta_r \) 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 ( \( \rho \) is the air density) and state your explanation:

\[
\begin{align*}
(i) & \quad \frac{1}{2} \rho a_r v_r^3 \eta_r \\
(ii) & \quad \frac{1}{2} \rho a_u v_u^3 \eta_r \\
(iii) & \quad \frac{1}{2} \rho a_d v_d^3 \eta_r \\
(iv) & \quad \frac{1}{2} \rho a_r v_u^3 \eta_r
\end{align*}
\]
Problem c. In the following page you are given a diagram that represents the total energy flows for US in 2014. **Study** the diagram and **answer** the following questions.

(i) how much energy (in quads) from natural gas was consumed in 2014 from the residential, commercial, industrial and transportation sector and how much for electricity generation?

(ii) how much energy (in quads) from coal and petroleum was consumed in 2014 for the residential, commercial, industrial and transportation sectors and how much for electricity generation?

(iii) determine the inputs (in quads) and the outputs (in quads) of the electricity generation and comment on the efficiency of electricity production.

(iv) how much energy (in quads) is used to provide energy services and how much is rejected? Comment on the overall efficiency of the energy usage in the US in 2014.
Estimated U.S. Energy Use in 2014: ~98.3 Quads

Source: LLNL, 2015. Data is based on DOE/EIA-0025(2015-03), March, 2014. If this information or a reproduction of it is used, credit must be given to the Lawrence Livermore National Laboratory and the Department of Energy, under whose auspices the work was performed. Distributed electricity represents only retail electricity sales and does not include self-generation. EIA reports consumption of renewable resources (i.e., hydro, wind, geothermal and solar) for electricity in BTU-equivalent values by assuming a typical fossil fuel plant "heat rate." The efficiency of electricity production is calculated as the total retail electricity delivered divided by the primary energy input into electricity generation. End-use efficiency is estimated as 63% for the residential and commercial sectors 80% for the industrial sector, and 21% for the transportation sector. Totals may not equal sum of components due to independent rounding. LLNL-MA-110527