Thermodynamics of Energy Conversion and Storage

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EXERCISES 10

1) Calculate the power of the wind for disc of 1 m and 100 m diameter for a wind speed of 15 km/h and 30 km/h.

$P = 0.5 \cdot r \cdot d^2/4 \cdot p \cdot v^3 = 0.5 \cdot r \cdot d^2/4 \cdot p \cdot v^3 = 0.39\ kg/m^3 \cdot d^2 \cdot v^3$
$P = 0.39\ kg/m^3 \cdot d^2 \cdot v^3 = 0.39\ kg/m^3 \cdot 1\ m^2 \cdot 72.3\ m^3/s^3 = 28.2\ kg \cdot m^2/s^3 = 28.2\ W$
$P = 0.39\ kg/m^3 \cdot d^2 \cdot v^3 = 0.39\ kg/m^3 \cdot 10'000\ m^2 \cdot 72.3\ m^3/s^3 = 280\ kW$
$P = 0.39\ kg/m^3 \cdot d^2 \cdot v^3 = 0.39\ kg/m^3 \cdot 1\ m^2 \cdot 579\ m^3/s^3 = 225.8\ W$
$P = 0.39\ kg/m^3 \cdot d^2 \cdot v^3 = 0.39\ kg/m^3 \cdot 10'000\ m^2 \cdot 579\ m^3/s^3 = 2.3\ MW$

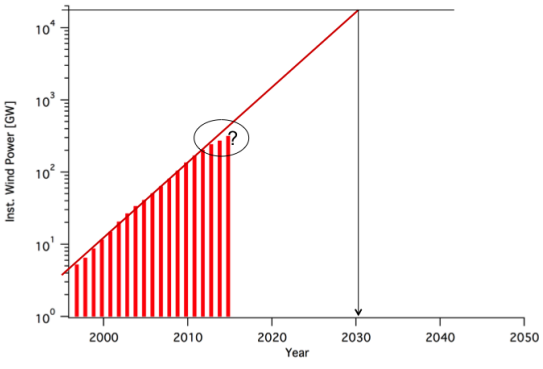
2) What is the minimum distance between wind rotors?

$v_2/v_1 = 1/3 = A_1/A_2$
Rotor: R, $A = R^2 \cdot p$
$A_2 = 2 \cdot A$, $A_1 = 2/3 \cdot A$
$A_2 = R_2^2 \cdot p = 2 \cdot R^2 \cdot p$
$R_2/R = \text{sqrt}(2) = 1.4$

3) What is the size of a wind rotor in order to cover the average electricity consumption per person in Switzerland?

Average electricity consumption 2 kW
$d^2 = 2000\ W/(0.39\ kg/m^3 \cdot 579\ m^3/s^3 \cdot 0.59) = 15$
d = 3.8 m at a wind speed of 30 km/h

4) Extrapolate the installed wind power to the future and estimate, when it would cover the world energy demand.



5) Estimate the cost of a 2MW wind turbine and the pay back time if the electricity is sold for 0.05 CHF/kWh at no operation cost.

Cost: 900 CHF/kW·2000kW = 1'800'000 CHF
pay back time t = (900 CHF/kW)/(0.05 CHF/kWh) = 18'000h = 2.05 years if always runs at full power