Energy, Power, and Climate Change Questions

1. Consider a scheme in which thermal energy is extracted from the ocean. Some of the extracted energy is used to perform mechanical work (run the ship) and the rest is discarded back into the ocean. Why will this not work?

2. Explain what is meant by degradation of energy. Give one example of energy degradation.

3. Water that falls from a height of 75 m is used to drive a turbine.
   (a) Explain what is meant by energy density of a fuel.
   (b) Estimate the energy density of the falling water.

4. A power plant produced 500 MW of power.
   (a) How much energy is produced in one second? Express your answer in joules, kWh, and MWh.
   (b) How much energy is produced in one year?

5. A power plant operates in four stages. The efficiency in each stage is 80%, 40%, 12%, and 65%.
   (a) What is the overall efficiency of this plant?
   (b) Make a Sankey diagram for the energy flow in this plant.

6. A coal power plant with 30% efficiency burns 10 million kg of coal a day. The energy density of coal is 30 $MJkg^{-1}$.
   (a) Calculate the power output of the plant.
   (b) At what rate is thermal energy being exhausted by the plant?
   (c) If the exhausted thermal energy is carried away by water whose temperature is not allowed to increase by more than 5 °C, calculate the rate at which water must flow away from the plant.

7. One litre of gasoline releases 35 MJ of energy when burn in a car engine. The efficiency of this car engine is 40%. The speed of the car is 9.0 ms^{-1} when the power output of the engine is 20 kW. Calculate the fuel efficiency (kmL^{-1}) of the car when driven at this speed.

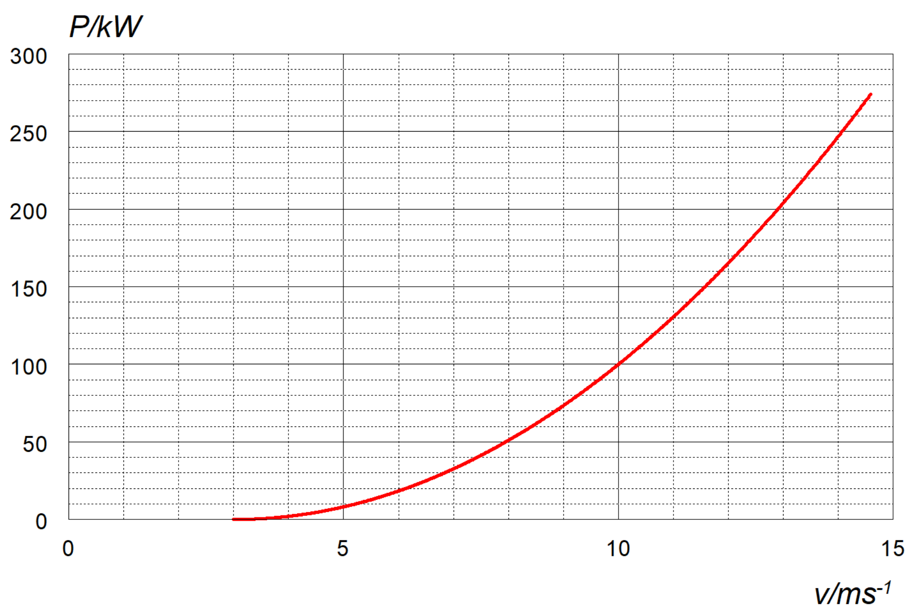
8. A coal fire power plant produces a constant 1 GW of electrical power. The overall efficiency of the power plant is 40%. The energy density of coal is 30 $MJkg^{-1}$. Calculate the amount of coal that must be burned in one day.

9. Sunlight of intensity 700 Wm^{-2} is captured with 70% efficiency by a solar panel. The solar panel then sends the captured energy into a house as heat with 50% efficiency.
   (a) Assuming a thermal loss in the house of 3.0 kW, calculate the area of solar panel needed to maintain a constant temperature in the house.
   (b) Draw a Sankey diagram for the energy flow.

10. A solar heater is to heat 300 L of water from a temperature of 15 °C to 50 °C in 12 hours. The amount of solar radiation on the solar panels is 240 Wm^{-2}. Calculate the area of 65% efficient panel needed.

11. A solar heater is to warm 150 kg of water by 30 K. The intensity of solar radiation if 6000 Wm^{-2} and the area of the panels is 4.0 m^2. The specific heat capacity of water is 4.2×10^3 J $kg^{-1}K^{-1}$. Estimate the time this will take, assuming a solar panel efficiency of 60%.

12. The following graph shows the power curve of a wind turbine as a function of the wind speed.



13.

14. Assuming a wind speed of 10 ms^{-1} for 1000 hours in a year, calculate the energy produced over the course of one year.

15. State the expected increase in the power extracted from a wind turbine when
    (a) the length of the blades is doubled;
    (b) the wind speed is doubled;
    (c) both the length of the blades and the wind speed is doubled.
    (d) Outline reasons why the actual increase in extracted power will be less than your answers.

16. Wind of speed v is incident on the blades of a wind turbine. The blades present the wind with an area A.
    (a) Deduce that the maximum theoretical power that can be extracted is given by

$$P = \frac{1}{2}\rho A v^3$$

    (b) State any assumptions made in deriving the relation in (a).

17. Air of density 1.2 kgm-3 and speed 8.0 ms^{-1} is incident on the blades of a wind turbine. The radius of the blades is 1.5 m. Immediately after passing through the blades, the wind speed is reduced to 3.0 ms^{-1} and the density of air is 1.8 kgm^{-3}. Calculate the power extracted from the wind.

18. Calculate the blade radius of a wind turbine that must extract 25 kW out of 9.0 ms^{-1} wind. The density of the air is 1.2 kgm^{-3}. State any assumptions made in this calculation.

19. Estimate the power developed when water in a waterfall with a flow rate of 500 Ls^{-1} falls from a height of 40 m.

20. Water falls from a vertical height h at a flow rate Q. Deduce that the maximum theoretical power that can be extracted is given by

$$P = \rho Q g h.$$

21. Sunlight of intensity 800 Wm^{-2} is captured by a tank containing 100 kg of water with an efficiency of 80%. The tank is rectangular in shape and has dimensions 1.0 x 1.0 x 0.10 m. It has walls of thickness 5.0 mm. The surrounding air has a temperature of 20 °C. Assume that the tank is well insulated from all sides expect the top surface (of area 1.0 m^2). The material of the tank has a thermal conductivity (k) of 0.30$Wm^{-1}K^{-1}$, its density is 1200 kgm^{-3}, and its specific heat capacity is 450 $Jkg^{-1}K^{-1}$.

    The rate of flow of thermal energy through a surface of area A and thickness x separated by temperatures T_1 and T_2 is given by

$$\frac{\Delta Q}{\Delta t} = kA\frac{T_1 - T_2}{x}$$

    (a) Calculate the mass of the tank.
    (b) By equating the energy received from the sunlight to the thermal energy lost by conduction to the surrounding air, estimate the final temperature of the water.