8.1 ENERGY DEGRADATION AND POWER GENERATION
8.2 WORLD ENERGY SOURCES *HW/Study Packet*

SL/HL	
Required: READ Tsokos, pp 415-418	Supplemental: None
DO Questions p 430, #3,4,5,6,7,8	

REMEMBER TO….

- ✓ *Work through all of the 'example problems' in the texts as you are reading them*
- ✓ *Refer to the **IB Physics Guide** for details on what you need to know about this topic*
- ✓ *Refer to the **Study Guides** for suggested exercises to do each night*
- ✓ *First try to do these problems using only what is provided to you from the **IB Data Booklet***
- ✓ *Refer to the solutions/key ONLY after you have attempted the problems to the best of your ability*

UNIT OUTLINE

I. ENERGY AND PROCESSES
- A. WORK AND THERMAL ENERGY REVISITED
- B. CYCLICAL PROCESSES AND ENERGY TRANSFER
- C. DEGRADED ENERGY AND ENERGY DENSITY
- D. ELECTRICITY PRODUCTION

II. SANKEY DIAGRAMS
- A. ENERGY FLOW
- B. CONSTRUCTING FOR FUEL PRODUCTION PROCESSES

III. ENERGY SOURCES
- A. RENEWABLE AND NON-RENEWABLE
- B. ENERGY SOURCES AND CO_2 EMISSION

IV. WORLDWIDE USE OF ENERGY
- A. RELATIVE PROPORTIONS IF DIFFERENT ENERGY SOURCES
- B. ADVANTAGES AND DISADVANTAGES OF DIFFERENT ENERGY SOURCES

FROM THE IB DATA BOOKLET

Nothing explicitly useful for this topic

WHAT YOU SHOULD BE ABLE TO DO AT THE END OF THIS TOPIC

- □ Explain the meaning of the term 'energy degradation' and construct Sankey diagrams.
- □ Understand that, in the cyclic operation of an engine, not all the available thermal energy can be transformed to useful mechanical work.
- □ Describe how electricity is produced.
- □ Define 'energy density' and discuss how choice of a fuel is influenced by it.
- □ Identify world energy sources and know the relative proportions of world use.
- □ Understand the difference between renewable and non-renewable sources of energy.
- □ Discuss the advantages and disadvantages of various energy sources.

HOMEWORK PROBLEMS:

1. Draw a Sankey diagram for:

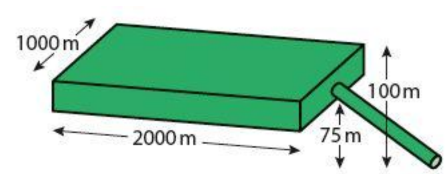
a) an electric light bulb.

b) a bicycle dynamo producing the electricity to illuminate a light from mechanical energy.

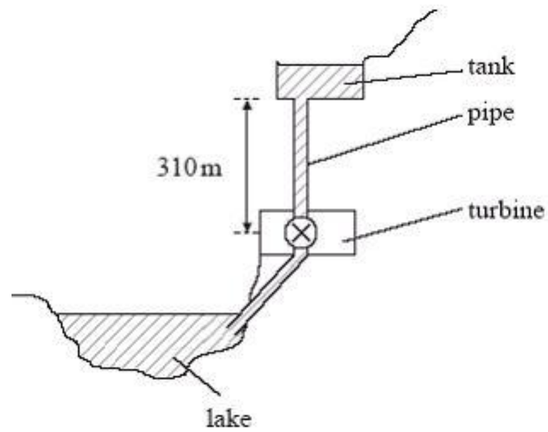
2. A thermal power station is 20 % efficient and generates useful electrical power at 1000 MW. The fossil fuel used has an energy density of 50 MJ kg^{-1}. Determine the mass of fuel consumed each second. **[100 kg]**

3. The maximum power output of the Drax coal-fired power station in the UK is 4.0 GW. Determine the minimum mass of pure U-235 (energy density = 82 TJ kg^{-1}) that would be required by a nuclear power station to provide the same maximum annual energy output as the Drax power station. **[1.6 x 10^3 kg]**

4. The following diagram depicts a volume of water stored in a lake at high altitude which is used to generate hydroelectric power. Calculate the total energy stored and power generated if water flows from the lake at a rate of 1.0 m^3 per second. **[4.29 x 10^{13} J, 875 kW]**



5. The following diagram, not to scale, shows a pumped-storage power station used for the generation of electrical energy.



Water stored in the tank is allowed to fall through a pipe to a lake via a turbine. The turbine is connected to an electrical generator. The pumped-storage ac generator system is reversible so that water can be pumped from the lake to the tank. The tank is 50 m deep and has a uniform area of 5.0×10^4 m^2. The height from the bottom of the tank to the turbine is 310 m. The density of water is 1.0×10^3 kg m^{-3}.

a) Determine the maximum energy that can be delivered to the turbine by the falling water.

[7.6×10^{12} J]

b) The flow rate of water in the pipe is 400 m^3 s^{-1}. Calculate the power delivered by the falling water.

[1.3×10^9 W]

c) The energy losses in the power station are shown in the following table.

Source of energy loss	Percentage loss of energy
friction and turbulence of water in pipe	27
friction in turbine and ac generator	15
electrical heating losses	5

Calculate the overall efficiency of the conversion of the gravitational potential energy of water in the tank into electrical energy. **[53%]**

d) Draw a Sankey diagram to represent the energy conversion in the power station.

6. When a car is driving at 80 km h^{-1} it is doing work against air resistance at a rate of 40 kW.

a) How far will the car travel in 1 hour? **[80 km]**

b) How much work does the car do against air resistance in 1 hour? **[1.44×10^8 J]**

c) If the engine of a modern diesel car is 75% efficient, how much energy must the car get from the fuel? **[1.92×10^8 J]**

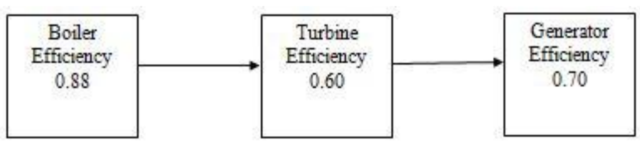
d) If the energy density of diesel is 45.8 MJ kg^{-1}, how many kg of diesel will the car use? **[4.2 kg]**

e) If the density of diesel is 0.9 kg l^{-1}, how many litres will the car use? **[4.7 liters]**

f) Calculate the litres of fuel used per kilometre. **[0.06 l km^{-1}]**

7. A wind farm produces 35 000 MWh of energy a year. If there are ten wind turbines on the farm, what is the average power output of one of the turbines? **[400 kW]**

8. A power station is represented by the following flow diagram.



a) What is the overall efficiency of the power station? **[0.37]**

b) If the power input from the fuel is 5.00 GW, how much power is wasted in the generator? **[7.92×10^8 W]**

9. A coal-fired power station gives out 1.00 x 10^3 MW of power.

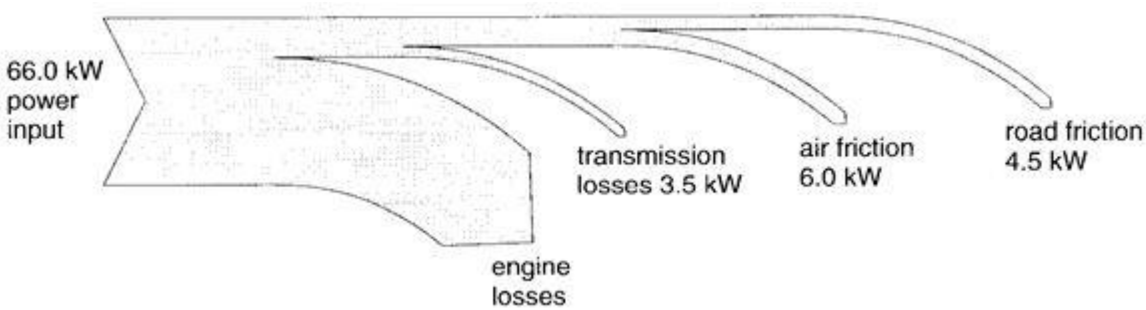
a) How many joules will be produced in one day? **[8.64 x 10^{13} J]**

b) If the efficiency is 40%, how much energy goes in? **[2.16 x 10^{14} J]**

c) The energy density of coal is 32.5 MJ kg^{-1}. How many kg are used? **[6.65 x 10^6 kg]**

d) How many rail trucks containing 100.0 tonnes each are delivered per day? **[67 truck loads]**

10. The following Sankey diagram shows the power transfers in a car moving at a steady speed of 18.0 m s^{-1} along a level road.



a) What percentage of the energy available from the petrol is transferred to internal energy in the engine? **[79%]**

b) Calculate the effective frictional force opposing the motion of the car produced by (remember $P = Fv$):

(i) the air **[333 N]**

(ii) the wheels. **[250N]**