EVST201a/G&G140a
The Atmosphere, Ocean and Environmental Change
Problem set #8 (due Friday Dec 2, 2011)

1. Explain why there are really two different ozone problems; one in the atmospheric boundary layer and one in the stratosphere.

2. If the partial pressure of ozone in the ozone layer is $20 milliPa = 0.02 Pa$ and the temperature is -30C:
    a. Find the mass density of ozone (kg/m3)
    b. Find the column density of ozone if the ozone layer is 10km thick (units: kg/m2) [Note: ozone column density is usually expressed in Dobson Units; see below.]
    c. Express your column density answer in Dobson Units. A Dobson Unit is the thickness (in 0.00001m) of a layer of pure ozone if the actual atmospheric ozone is compressed to standard pressure of 100000Pa at standard temperature T=0C (i.e. 1DU=milli-atm-cm) [Hint: One way to do this problem is to compute the column density (kg/m2) of a standard layer of ozone with depth 0.00001m. Then use proportions.]

3. Why is ozone in the lower troposphere considered a “secondary” pollutant? Why does it reach it maximum concentration in the afternoon?

4. Why does the ozone hole occur only over the South Pole and only for a short period each year?

5. Describe how the sun is ultimately responsible for the generation of hydroelectric, biomass, fossil fuel and wind energy. Is it responsible for tidal energy?

6. Explain why natural gas is a better fuel than coal. Mention both air pollution and global warming aspects.

7. Explain the major advantage and disadvantage of moving to a “hydrogen economy”, e.g. using a fuel cell to make energy from hydrogen gas.

8. Assume that a high mountain plateau with dimensions of 100 by 100 km has an altitude of two kilometer, an annual rainfall amount of 2 meters, an average wind speed of 10m/s and an average solar insolation of 200W/m2.

    a. Compute the maximum possible annual hydroelectric power for the region. (Joules)

   b. Compute the maximum possible annual solar electricity power for the region (Joules)
   c. Compute the maximum possible annual wind for the region. (Joules) Describe the turbine you assume. (Assume that the ratio of turbine spacing to turbine disk diameter is ten.)
   d. Which energy source is the greatest.

9. Summarize briefly how Connecticut, Ohio and Oregon differ in their generation of electrical energy.

10. Using a global population of six billion and an estimate of annual world energy consumption (0.4x10^21J: from the Energy Scorecard), compute the wattage of each person's "equivalent light bulb". That is, what light bulb wattage corresponds to the per capita energy use?

11. Using the same annual world energy consumption, and the assumption that burning one kilogram of carbon gives $33*10^6$ Joules of energy, compute the mass of carbon burned each year. What mass of carbon dioxide does this add to the atmosphere?

12. Compare the answer to question 14 with the accepted value for anthropogenic carbon flux to the atmosphere: 6 Gt-C/year. Discuss the difference in the two values.

13. (Use the Energy Scorecard) Compare the relative size of the coal and petroleum reserves. Which one is more abundant? What other energy sources might be important over the next hundred years?

14. Log into Carma.org. (using Geographic Regions)
    a. Which two countries emit the most carbon?
    b. What mass of carbon dioxide was emitted last year by these two countries?
    c. What is the mass of carbon in that emitted carbon dioxide?
15. Log into Carma.org (search for Connecticut)
    a. How much carbon dioxide did the Connecticut power plants emit last year?
    b. How much carbon dioxide did the New Haven Power Plant emit last year?

11/29/01

Energy Scorecard (Prof. Brian Skinner, Yale University)

(Units are joules)

Energy Source	Estimated Reservoir	Recoverable
Flowing oil	25×10^{21}	25×10^{21} (half already used)
Trapped oil	25×10^{21}	?
Heavy oils (nonflowing)	50×10^{21}	2.5×10^{21}
Tar sands	20×10^{21}	10×10^{21}
Shale		
Less than 40 l/ton	$100{,}000 \times 10^{21}$	0
More than 40 l/ton	$2{,}000 \times 10^{21}$	$10–20 \times 10^{21}$
Plant biomass	1.2×10^{21}/y	0.12×10^{21}/y
Coal	$42{,}000 \times 10^{21}$	$21{,}000 \times 10^{21}$
Water power	0.085×10^{21}	0.085×10^{21}
Ocean waves	$>5 \times 10^{21}$/y	?
Ocean currents	$>5 \times 10^{21}$/y	?
Wind	$\geq 5 \times 10^{21}$/y	?
Ocean heat	$>5 \times 10^{21}$/y	?
Solar direct	$3{,}650 \times 10^{21}$/y	?
Conducted heat flux	100×10^{21}/y	0
Convection in thermal pools	5×10^{21}	2.5×10^{21}
Hot rocks	$10{,}000{,}000 \times 10^{21}$	?
^{235}U in ore deposits	1.1×10^{21}	0.6×10^{21}
^{238}U in ore deposits	150×10^{21}	75×10^{21}
^{238}U (low grade, US alone)	$63{,}000 \times 10^{21}$	$30{,}000 \times 10^{21}$
^{232}Th (low grade, US alone)	$63{,}000 \times 10^{21}$	$30{,}000 \times 10^{21}$
World energy consumption (2000)	0.4×10^{21}/y	