Sustainable Energy/Aronson

Biomass Quiz

Please work the following word problems:

1.

In the renewable energy community, municipal solid waste is considered biomass. Explain qualitatively why we can write $A_g \approx A_N$ for municipal solid waste (see Equations (10-3) and (10-4)). Why are these quantities not equal exactly? Estimate whether a family saving all their municipal solid waste and burning it could harvest enough energy to heat their home. Use the following assumptions: family of four in a well-insulated New England home that burns 800 gallons per year of No. 2 home heating oil (140,000 Btu/gal); MSW production is 3 dry lb/person-day at a heating value of 8,000 Btu/lb (dry); furnace efficiencies: oil 90%; MSW 80%.

2.

A stock of biomass (waste wood) is found to have a sulfur content of 0.1 wt% (dry basis) and a heating value on a dry basis of 8,000 Btu/lb. This fuel will be used to replace a Wyoming subbituminous coal which has a sulfur content of 1.0 wt% (dry basis) but a heating value (dry basis) of 10,000 Btu/lb. By how much will the emissions of sulfur dioxide, in lb per Btu, be lowered when the coal is replaced by the biomass?

3.

US residents consume roughly 10 million barrels per day of gasoline for transportation fuel. Using the ethanol yields projected to be attainable from advanced fermentation technology (Table 10.8), how many acres would be needed to be devoted to cellulosic biomass production to supply 10% of the miles traveled on gasoline using fermentation ethanol as the automotive fuel? Note that ethanol provides roughly 2/3 the miles per gallon attainable from gasoline. Compare your answer with the total area of France and of the state of California.

4.

The US has a lot of federally owned land. Unfortunately, uncontrolled natural forest fires destroy large areas in the western US every summer. In 2002, about 1,000,000 acres of standing timber in national forests were consumed. Some consideration is being given to improved management practices that could produce electrical power from residual forest thinnings. Estimate the lost energy content of burned US forests during 2002. Assuming the US average electricity demand load is about 300,000 MWe, how much forested land would be needed to produce all the country's power? Is this a sustainable alternative? A few facts to consider:

- The total forested area on US federal lands in the lower 48 states is about 600 million acres with a standing stock density of about 100 dry metric tonnes of wood per acre
- Woody plants and trees capture solar energy via photosynthesis at an average rate of about 0.8 W/m^2 which corresponds to producing about 5–10 dry tons of biomass per acre annually with an average heating value of 8,000 Btu/dry lb. Note that 1 acre = 43,560 ft^2 = 0.405 hectare = 4,047 m^2
- A representative heat-to-work conversion efficiency of a biomass fired electric power plant is about 35%

5.

Massachusetts is considering growing energy crops and burning them to produce electric power as part of a renewable energy deployment initiative that state lawmakers approved some time ago. Assuming the state's average electricity demand load is about 4,000 MW_e, how much forested land would be needed to produce all the state's power? Is this a feasible alternative? The total land area in Massachusetts is 8,284 square miles or 21,385 km^2 (see facts listed in Problem 10.8).