Figure by MIT OCW.

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SUSTAINABLE ENERGY MODULES

Biomass Module Problem Set
Due February 22, 2007

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1. Problem 10.1 in the textbook

2. Problem 10.2 in the textbook

3. Let's see if it makes sense for a major US city to utilize its municipal solid waste (MSW) as a sustainable biomass feedstock. Using Chicago as a model Midwestern US city where the average citizen produces MSW, how much bioenergy can be recovered from the entire population of the city? Compare this figure with the amount of bioenergy that could be produced by growing high yield "energy crops" on a portion of Illinois' vacant farmland – amounting to 10% of total land area of the state.

   Population of Chicago = 2.873 million
   Land Area of Illinois = 57,918 square miles

4. Assuming that the stored chemical energy content of pure ethanol is about 30 MJ/kg based on its standard heat of combustion, you are asked to make an estimate of the net energy produced by two ethanol biofuel processes that utilize different feedstocks to used in same biorefinery. The following data are provided regarding the energy requirements associated with each element of the process.

Energy requirements [MJ per kg of ethanol]		
Energy Input	Sugar Cane	Corn Grain
Feedstock Conversion and Purification	7.3	15.2
Fertilizer and Chemicals	0.6	6.4
Water Pumping and Irrigation	0.1	0.4
Electricity	1.5	2.5
Fuel Oil/Diesel/Gasoline	1.0	2.4
Embedded Energy Contained in Machinery and Buildings	0.1	0.3

   In several paragraphs, discuss the reasons for and implications of the differences of the net energy results for these two feedstocks.

5. Assume for the moment that you have been just appointed as the Secretary of Energy for the State of Hawaii and you just received the following letter from the Governor of Hawaii, her Excellency Q. Lil.

Dear Madame Secretary,

In order to ensure our energy independence from the lower 49 states and other questionable imported oil sources, I would like you to evaluate the potential of using Hawaii's vast biomass resource to provide all our transportation fuels for autos, trucks, ships and airplanes. I need to know whether this is possible and what issues will have to be considered to implement such a transition. Your evaluation should consider environmental impacts and sustainability aspects of using both cultivated and idle cropland on our island chain, as well as major technology developments, policies, and economic requirements. You are also free to recommend other measures to achieve this goal including demand reduction and complete transformation of our transportation system.

I appreciate you giving my request your highest priority in the next week. Please submit your findings in a short memorandum – no longer than 2 pages by 11 am on Thursday, February 22 – just in time for my upcoming briefing on fossil energy from Professor Incropera.

Sincerely,

The Governor

P.S. The recent "Biomass and bioenergy resource assessment: State of Hawaii" is electronically attached
(see http://www.hawaii.gov/dbedt/info/energy/publications/biomass-assessment.pdf).

Note -- List all assumptions and approximations made in arriving your answers. You can use the textbook as a source for conversion factors and other needed data to solve these problems. Feel free to use other sources -but make sure that you list the sources in your solution.