MEC 3040 HW for Module 1: Intro to Bioenergy

Please note that homework asks you to go outside of lecture notes and do a bit of research on your own. You might begin by looking at resources and links provided in the Module (find those within each dropdown Module on richmond-hall.weebly.com) and then move to a search engine, book on reserve or librarian. When answering questions, please:

- Cite your source.
- Answer in complete and punctuated sentences or by using or creating tables or charts.
- Be thorough!

Section I: Answer all questions

1.2: Current and projected energy use

1. Are there countries that depend more on bioenergy than the US does? Which countries? Describe the types and amounts of bioenergy they use?
   In 2014, Austria, Brazil, Denmark, Finland, Germany, Italy, Africa, Sweden and more used a higher proportion of bioenergy than the US did.

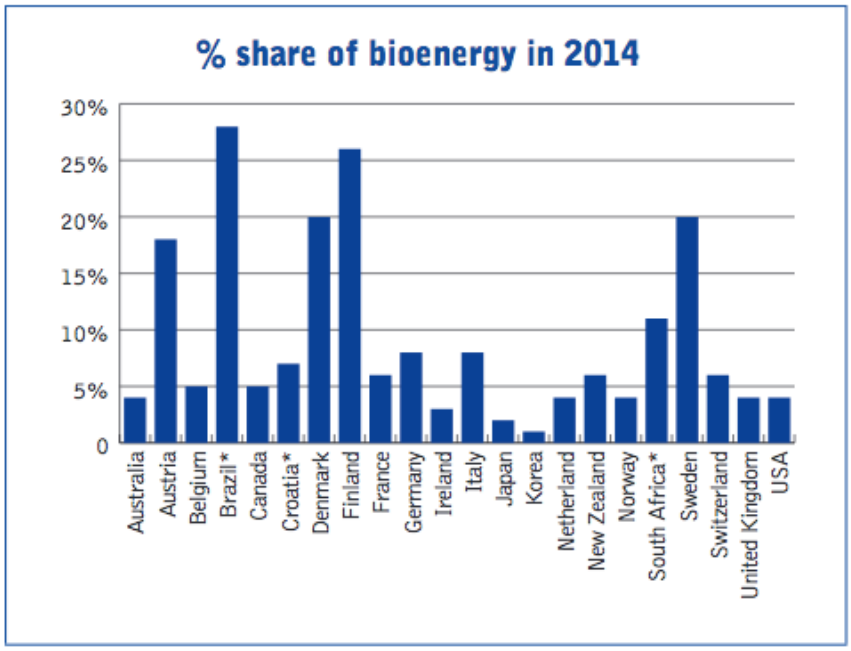

Figure 2: Percentage of bioenergy in year 2014
(Source: Renewables Information © OECD/IEA 2015)

2. Many countries are hoping to shift some transportation energy use from petroleum to some form of biofuel. What types of biofuel are other countries using for transportation? How do their choices contrast with ours?
   The US uses corn bioethanol. Brazil uses sugarcane bioethanol. Quebec and others scrubbed and compressed biomethane from anaerobic digestion. Europe uses biodiesel.

1.3: Forms of bioenergy

3. What do energy density values of biofuels suggest about the most appropriate use of biofuels?
   Generally, biofuel energy density is much lower than fossil fuel energy density (and EROEI). Therefore, it makes most sense to use biofuels locally, close to their sources of production.

1.4: Bioenergy feedstock materials

4. US biomass energy use has focused on primary (or virgin) feedstock materials, while European biomass is focused on waste feedstock materials.
   (a) What bioenergy technology demonstrates this clearly? Find some evidence and statistics.
   (b) Why do you think US and European approaches differ?
   (a) For me, anaerobic digestion is the best example as it is focused on waste biomass feedstocks. In 2015, the EU had 17,400 biogas plants accounting for 10 GW. The US has less than 250.
   https://www.sciencedirect.com/science/article/pii/S096014811830301X
   (b) The US, a young country, has maintained a mindset of abundance even as some resources begin to peak while European countries have used up many readily available resources and seek some measure of resource independence to prevent conflict.

1.5: Bioenergy co- and byproducts

5. Carbon dioxide is the ultimate byproduct of biomass energy. The holy grail of biomass energy is capture of carbon dioxide to prevent it from entering the atmosphere. Is this being done? Is anyone working on converting carbon dioxide from a byproduct to a co-product? Do some research and explain!
   While most of us have heard about 'carbon capture and storage' a number of researchers and energy companies are working on 'carbon capture and reuse'. These schemes seek to capture carbon from energy emissions and chemically change the carbon into a fuel. Such a process would allow use to replace carbon-rich fossil fuel with carbon-rich recycled fuel and would allow us to keep remaining fossil fuels in the ground.
   https://www.nationalgeographic.com/news/2018/06/carbon-engineering-liquid-fuel-carbon-capture-neutral-science/

1.6: Drivers of bioenergy development

6. Some fear that the appearance of sustainability and/or carbon neutrality is the biggest driver of policies that favor bioenergy. Do some research and summarize a few examples and arguments that suggest that some are promoting bioenergy in what amounts to greenwashing.
   There are many greenwashing examples: transporting wood pellets from the SE US to the EU; co-firing coal with a bit of wood; clearing forest to create palm plantations to make biodiesel for the EU; etc.,.

1.7: Bioenergy debate and 1.8: Is bioenergy sustainable?

7. What are the biggest factors used by those concerned about the use of each of these forms of bioenergy? Do some reading and cite your sources.
   (a) solid biomass combustion
   (b) bioethanol
   (c) biodiesel
   (a) Wood energy harvesting can cause deforestation and no decrease in carbon emissions.
   (b) In the US, bioethanol is made from corn and that's a food crop that could be used to feed the hungry.
   (c) Deforestation to create palm plantations to provide biodiesel feedstock.

1.9: The food vs. fuel debate

8. There are valid concerns that growth of virgin biomass could negatively impact food production. Are there forms of bioenergy (feedstock materials and technologies) that would not impinge upon agriculture and food production? Explain.
   Use of wood energy won't affect food supplies unless forest plantations are grown on good agricultural land. Ditto cellulosic ethanol from wood if that proves technically feasible. Biogas won't negatively impact food production if it uses only waste feedstock or input materials. And the nutrients recycled by biogas production might increase agricultural production.

Section II: Answer at least 3 of the following 6 questions

Note that all of the sources are linked here:
https://richmond-hall.weebly.com/1-introduction-to-bioenergy.html

A. How does the International Renewable Energy Agency (IRENA) define "traditional biomass" and "modern biomass"?

"Solid biomass combusted in inefficient & often polluting open fires, stoves or furnaces to produce heat for cooking, housing and small scale agricultural or industrial processing, typically in rural areas."

"Modern biomass is energy derived efficiently from solid, liquid & gaseous biomass fuels."

B. Use Energy Information Administration (EIA) or other resources to break out the types of bioenergy technologies that contribute to US use of biomass energy.

In 2017 5% of Unites State's energy came from Biomass. 47% of that biomass came from biofuel, 44% from wood and wood derived biomass, and 10% was from biomass municipal waste.
https://www.eia.gov/energyexplained/biomass/

"In 2012, biofuels accounted for roughly 7.1 percent of total transport fuel consumption, or 13.8 billion gallons, unchanged from the previous year. **Bioethanol**, made mostly from corn starch from kernels, is by far the most significant biofuel in the United States, accounting for 94 percent of all biofuel production in 2012. Most of the remainder is biodiesel, which is made from vegetable oils (chiefly soy oil) as well as animal fats, waste oils, and greases. Bioethanol used 38% of the US corn crop in 2017. **Biodiesel** production was only 1/10th of the volume of bioethanol production."

In 2016, biomass and waste fuels produced **1% of US electricity.**
(https://www.eia.gov/todayinenergy/detail.php?id=33872)

C. Biomass heating has recently been getting more recognition and support from state and federal governments. Use the "Outlook for Bioenergy 2015" article in Renewable Energy World to answer these questions:

(a) How high does the price of oil have to be before biomass thermal energy (rather than co-generation) is cost competitive?

Oil would have to be $80 – 100/barrel in order for thermal biomass to be cost-competitive.

(b) What is the most promising biomass technology now widely used in Europe that could be implemented across the US? Why?

Community scale biomass CHP that can use the heat for high energy efficiencies,

(c) Find a definition for "organic rankine cycle" power plants, a super-efficient and expensive CHP technology

The **Organic Rankine cycle** (ORC) is named for its use of an organic, high molecular mass fluid with a liquid-vapor phase change, or boiling point, occurring at a lower temperature than the water-steam phase change. The fluid allows Rankine cycle heat recovery from lower temperature sources such as biomass combustion, industrial waste heat, geothermal heat, solar ponds etc. The low-temperature heat is converted into useful work, that can

itself be converted into electricity. A prototype was first developed and exhibited in 1961 by solar engineers Harry Zvi Tabor and Lucien Bronicki. [Wikipedia]

D. The World Bioenergy Association believes that biofuels could produce more energy (~1,500 EJ) than is now used globally (~500 EJ). How? In your opinion, have they adequately addressed sustainability in making their estimates?
Nope! They have created an ambitious set of standards intended to preserve resources, biodiversity, and human quality of life, via sustainability. They plan to verify that their standards are being met. However, effective implementation of these (or other standards) will require widespread acceptance. Entrenched business and institutional interests may resist. Tremendous grass-roots efforts or dire consequences may be needed to drive acceptance and implementation of this type of system.

E. Vermont has a Comprehensive Energy Plan, first created in 2011 and updated in 2016.
(a) What is the overall renewable energy goal for 2050? 90%
(b) What is the state's current use of biomass for power and heat? 6%, 14% (2011)
(c) What recommendations are made for biomass?
Heating and CHP are recommended over electric generation because they are more efficient. The report stresses overall savings, not just the price of heat and electricity. Local use contributes to a positive fiscal balance.
(d) What are the challenges for meeting those biomass goals?
Changing minds, markets and infrastructure will be tough. Some funding sources, particularly federal, won't cover the costs of 'alternative' fuel systems. Incentives and funding will be needed.

F. Vermont is now roughly 80% forested and has fairly abundant forest biomass resources, yet has only two large wood-fired CHP power plants. Have a look at the 2012 report from the Biomass Energy Development Working Group and / or 'Biomass Busted…' a 2012 Seven Days article on the same topic. What do they suggest about the state's capacity to develop wood biomass and to construct large biomass plants?
Critics worry about the effect of wood harvesting on the environment, and the effects of combustion on air quality and human health. Developers don't have confidence-boosting histories in other states. Finally, proposed siting of the wood plants doesn't allow complete and efficient use of waste heat. Communities are wary of siting near residences, and developers aren't required to use all waste heat.