**TIM 155: Problem Set 2**

Due Tuesday, August 9, before class is over.

It can be turned in by hand or via email to bhaddad@ucsc.edu

1. In lecture we looked at a definition of the term “system.” Please repeat it here. (1 point)
2. The definition is actually 2 definitions. Do both definitions mean the same thing, just stated differently, or is there an essential difference? Explain. If you think that the two parts are different, which do you think is the more essential or central meaning of the terms “system” or are they both essential? Explain. (1 point)
3. One of our lecture slides reads:

**Storage** –

decouples energy supply and energy demand, thereby giving greater system flexibility, essential for both technical and economic reasons.

3.a Provide an example of a natural and/or engineered energy storage system for **natural gas** and explain how it gives **energy** **suppliers** flexibility by decoupling energy supply and demand. (1 point)

3.b Provide an example of a engineered energy storage system for **electricity** and explain how it gives **energy** **consumers** flexibility by decoupling energy supply and demand. (1 point)

4. Review Figure 1.13 (pdf p. 135) in GEA. There are seven red arrows leaving the blue flow of energy. The quantitative “unit” in the figure is the percentage of the initial amount of primary energy required to produce the outcome of someone utilizing illumination for a beneficial purpose. If you wish to reduce the total amount of primary energy consumed and could only intervene to reduce or eliminate one of the red arrows, which one would you focus on? What would you do and why would you intervene in that aspect of the power supply chain? Why is that way better than the next best way (say which way you think is second best). (1 point)

5.a The top of p. 880 (pdf) of GEA offers a definition of a microgrid. What is that definition? (1 point)

5.b Section 15.8.3 goes into more detail on the benefits of microgrids and the challenges facing their implementation. Summarize the benefits and challenges presented in Section 15.8.3. (1 point).

6. Review Figure 16.3 in GEA (p. 1,204 of the PDF). It presents a 3-dimensional graph. First explain what the graph is presenting. Then explain when the system experiences peak load. Why does a utility try to avoid periods of peak load? Give one strategy a utility might use to shave peaks. (1 point).

7. An analysis of the hydrology of a lake shows average inflows of 5 cfs, and an average volume of 38 thousand acre-feet (taf). Four factories are point-source polluters into the lake of a total of 50 tonnes per year of pollutant A. There also are farms with non-point-source runoff of the same pollutant (pollutant A) into the lake. The lake concentration of pollutant A is 20 ppm. Your job is to estimate the relative impact of ***non-point sources*** of pollutant A on the lake.

7.a Convert lake inflow (5 cfs) and volume (38 taf) into metric mass equivalents (tonnes/yr and tonnes, respectively). (0.5 points)

7.b Provide two assumptions that will simplify your mathematical task (0.5 points)

7.c Calculate the residence time of point-source discharges of pollutant A in the lake. (0.5 points)

7.d (*This is a side note to the rest of the question.)* 50 te per year may seem like a lot, but try converting it into cfs. Assume mass equivalent to water. (But we can’t really decide whether this is a lot or a little unless we know the potential this pollutant has to cause damage, which isn’t stated.) (0.5 points)

7.e Calculate the quantity (in tonnes) of pollutant A from point sources in the lake. (0.5 points)

7.f If factories were the only source of pollutant A, what would be the lake’s concentration of pollutant A? What is the remaining unaccounted-for concentration (i.e., how many ppm are left over)? What percentage of the total concentration of pollutant A in the lake comes from non-point sources? (0.5 points)

7.g How many tonnes of pollutant A do you estimate are entering the lake each year from non-point sources? (0.5 points)

8. Many people believe that California provides a wonderful quality of life to its residents. Water availability and consumption play an important role in Californians’ quality of life. Is there enough water in the world for everyone to consume water the way California does? Answer this question both for the world as a whole as well as for the major regions of the world. Your answer will require text, calculations, and tables. *(You can find a list of regions in Table 2 of our FAO Review of World Water Resources, p. 35 of the pdf. A different set of regions can be found in Table 1 of World Population Prospects, p. 7 of pdf. Either can be used.)*

8.a Explain how you will account for the different water-use sectors in California. (environmental, agricultural, domestic, industrial, etc.). *Hint: it is OK to make simplifying assumptions – just say what they are and why you are making them.* (0.5 points)

8.b For every data source give a citation. (0.5 points)

8.c Explain your calculations. (0.5 points)

8.d Provide a spreadsheet that includes your calculations. (0.5 points)

8.e Your answer should include a table that lists (a) regions; (b) how much water is needed for the region’s population to consume water at the same rate California does; (c) available water supply to the region; and (d) either how much extra water the region has beyond what is needed or how much additional water is needed to consume the way California does. The table could have (a) through (d) as its columns. It should be clearly labeled, use consistent units, and be neatly presented, and be accompanied by a paragraph that explains your findings. (0.5 points)

8.f Be sure that you always list the units of the numbers in your text and tables. (e.g., gallons per day; cubic kilometers per year). Also show your conversions. (0.5 points)

9. In the *FAO Review of World Water Resources* review Table 6 with the United States row in Table 11. The numbers are different. First explain what the differences are with respect to internal renewable water resources and external renewable water resources. Then offer at least two reasons from the nearby text about why the numbers for this one country may be so different. (0.5 points)

10. Section 17.1 of the World Water Development Report (assigned reading this week) lists examples of global water monitoring efforts, including JMP, GLAAS, and others. First provide the full name of each of the five programs mentioned. Then do some outside research and explain what one of the programs is doing, including who is doing it, what kind of data it is gathering, and why. (1 point)