**Final Exam TIM 155: Energy and Water Management**

**Summer 2016**

**Open book, notes, internet**

**9:00 am-12:30 pm**

1. *Background*: An analysis of the hydrology of a lake shows average inflows of 10 cfs, and an average volume of 60 thousand acre-feet (taf). Two factories are point-source polluters into the lake of a total of 200 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 60 ppm. Your job is to estimate the relative impact of ***non-point sources*** of pollutant A on the lake.

1.a Calculate the steady-state quantity (in tonnes) of pollutant A entering the lake from the factories. Show all steps. (2 points)

1.b If factories were the only source of pollutant A, what would be the lake’s concentration of pollutant A in ppm? 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? (3 points)

1.c How many tonnes of pollutant A do you estimate are entering the lake each year from non-point sources? (1 point)

1.d You have been approached by farmers who believed they are being falsely accused of polluting. They own the fields next to the lake and they are now being sued based on your answers to questions 1.a through 1.c. The trial has begun and they have asked you to be their expert witness. Your job is to present a set of arguments they can use to convince a judge that the pollution dispersion model cannot be relied upon to accurately depict what is happening in the lake and on their fields. Present at least 3 challenges to the model and what might be different about the results in Q 1.a-1.c if the model were more accurate. *(Hint: you might focus on the simplifying assumptions and show how the equations might be different.)* (6 points)

2.a What does NEM stand for? (1 point)

2.b Download the file on our class website called “Residential electricity and gas bill for final exam.” It is near the bottom of the page. Look at page 6 of 8. On the left hand side, look at the section that starts “Tier 1 allowance” and provides Tier 1 net usage, Tier 2 net usage, etc. Suggest a reason why these amounts are negative and not positive. (1 point)

2.c Now look at the bar graph at the bottom of p. 6 called Net Energy Usage This Period. The bars have dark, grey, and clear (white) sections. Explain what information is imparted by the clear sections inside the bars. (1 point)

*The rest of question 2 doesn’t need data directly from the bill but you can use it as a reference…*

2.d What is the difference between “tiers” and “peak…part peak…not peak”? (1 point)

2.e How would someone manage their energy consumption if they wanted to minimize their cost of power related to “tiers” only? Explain. (1 point)

2.f How would some manage their energy consumption if they wanted to minimize their cost of power related to “peak…part peak…not peak” only? Explain. (1 point)

3.a One of the main reasons that photovoltaic energy systems are being adopted is to fight greenhouse gas loading into the atmosphere. We saw in an earlier homework that solar potential differs around the U.S., favoring the Southwest. But we also saw in class that Germany, with relatively weak solar power potential, leads in solar installations. Explain in general why Germany installs more solar PV than, say, Arizona? (1 point)

3.b Roughly what 4-hour time window each day is it most likely that a residential PV system will produce more power than the residence is consuming? (1 point)

3.c Now open up your SAM model and select a new project. Let it be a PV detailed-residential project. On the left hand side menu select Electricity Rates. Arizona Public Service Co should be pre-loaded. If it isn’t, then select it and the “Residential TOU ET2” rate. Using your answer to 3.b, explain how much income per kWh the homeowner will earn during the time period. Compare this to how much per kWh the individual will spend on power when the sun is down. Hint: information for this question can be found in the “Rate Structure for Energy Rates” section. Your answer should include costs per kWh at different times and an explanation of them. (1 point)

3.d The more PV panels residents put on their roofs, the more non-GHG-emitting power is generated. However, in Arizona, California, and elsewhere, we don’t see roofs jammed with PV panels. Rather, there are typically just enough panels to meet the individual needs of the house but not more. Again referring to the same page in the SAM model, explain why the incentives in the rate structure don’t encourage maximizing the number of panels one can put on one’s roof. (1 point)

3.e If you could change one thing on the SAM electricity rate page to encourage the installation of more panels on each roof, what would it be? (1 point)

4. Deborah the solar PV sales manager who doesn’t use the SAM system to model her potential clients’ rooftop systems, found out that you have taken TIM 155. She has asked you to summarize the three most important elements in a SAM Report. Using the report you turned in for Homework #3 Q. 16, explain what in your opinion are the three most important sections of the report, and why. (1 point)

5.a In the electricity world, what does “peak shaving” mean? (1 point)

5.b Why does peak shaving matter? Based on our discussion in class, who benefits from peak shaving and who potentially suffers? (1 point)

6. Answer ***only one*** of the following two questions (1 point total):

* Mention at least one point Prof. Haddad made on Tuesday evening August 23 (two days ago) when addressing the City Council on the proposed new water rate plan for Santa Cruz.
* In one of our lectures, the class discussed water readiness to serve charges. *Based on the overheads from that lecture*, what is the purpose of these charges?

7. Two ranchers share a property line and an aquifer. Each has a right to draw water from wells on their own property, but not to drawn down the aquifer under their neighbor’s property. One rancher is trying to decide where to drill a new well. They want to place the well as close to the property line as possible without having the cone of depression impact the water level across the property line. They have asked you for an explanation of how the Theis equation can help them locate the well. Prepare an explanation that includes:

7.a. what the Theis equation is and what it tells us. (2 points)

7.b. the information the rancher would need to run a Theis-based model (2 points)

7.c. how the rancher would use the model in deciding how close to the property line to place the well. (2 points)

8.a What are sluice gates and why would someone open one (provide one reason given in class)? (1 point)

8.b Provide the equation that measures the energy potential of hydropower and explain how opening a sluice gate impacts the value of the any of its variables. (1 point)

9. Take a look at the large spreadsheet of 2015 hourly power consumption of metered UCSC buildings. The file is called **UCSC buildings power consumption 2015** and it is just below the residential energy bill on the course website. The goal is develop a hypothesis about which building has the greatest potential to reduce energy consumption improvements based on the data in the spreadsheet.

a. First suggest and verbally justify a hypothesis about what is the best target for energy efficiency improvements. *(Hint: Hypothesis examples could be “the goal of lower overnight energy consumption is the easiest approach to energy consumption reductions” or “reducing peak summertime consumption…”.)* (1 point)

b. Now examine the data based on your hypothesis. Find a building that you think has consumption qualities that would lend itself to reductions based on your hypothesis. Eexplain why you chose that building. (2 points)

c. Give some examples of the kinds of actions you might take to reduce energy consumption consistent with your target approach from 3.a and your selected building in 3.b. (2 points)

10.a We reviewed Figure 2.1 of our USDOE text, the “Sankey Diagram” in class. You can find it on p. 30 of the USDOE pdf. One of the “sources” of water missing from the diagram is urban reclaimed water. This question considers how to integrate urban water reclamation and reuse into the Sankey diagram. First make a list of all the energy and water inflows and outflows from an urban wastewater treatment plant. (1 point)

10.b Now either describe or show where you believe those flows should occur in the Sankey diagram. (1 point).

11.a Take a look at Figure 37 in our USEIA reading (the 2015 Annual Energy Outlook). It can be found on p. 43 of the pdf. First explain what the figure is telling us. (1 point)

11.b Figure 37 is, of course, a projection, not a future certainty. If you wanted to target policies to reduce GHG emissions even further than projected, which sector would you choose first and what policies would you propose? (1 point)

11.c Why did you choose that sector over the others? (1 point)

12. Chapter 13 on carbon capture and storage (CCS) in the GEA reading, starting on p. 1011 of the pdf, proposes that CCS could remove the carbon emissions from an individual fossil fuel facility by 65%-85%. The summary and conclusion section, starting on p. 1077 of the pdf, provides among other things an evaluation of the technological readiness of CCS. Review this section and provide your own brief overview of remaining **technical** challenges that need to be met before CCS can be scaled up significantly. (1 point)

13.a Some of the new tables of the USEIA Annual Energy Outlook 2016 have been released. You can find a copy of a presentation from our web site at the bottom, called **USEIA Annual Energy Outlook 2016 summary**. Take a look at p. 10 of the pdf. Let’s assume there will be no Clean Power Plan (CPP). Compare the 2040 mix of primary energy sources to the 2015 project, found in Figure 18 of the 2015 USEIA Annual Energy Outlook, on p. 31 of the pdf. What are the differences in the 2040 primary energy consumption patterns between the 2015 projection and the 2016 no CPP projection? (1 point)

13.b Now scan the 2016 document and identify three reasons why the two projections are different. (3 points)