**TIM 155: Problem Set 1**

**Summer, 2016**

Due Tuesday, August 2, before class is over.

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

1. Take a look at “Indicator 4” table on p. 177 of the *World Water Development Report (Water and Energy), 2014* (vol. 2). *Per capita* means “per person.”

1.a To understand this figure better, first provide a definition of “total actual renewable water resources.” A list of definitions is available in the homework reading section of the web site. After your definition explain what “abstraction” means as it refers to water. (1 point)

1.b Notice that the units of Indicator 4 have been left off. It’s a safe bet they are SI units because this is a UN-sponsored agency. Determine what you think the correct units are. Do so by examining other tables (e.g., Indicator 6) and doing some math to compare data between the tables. Note that you get points for showing HOW you got your answer, not just for the answer itself. (1 point)

1.c Now notice that for every region except Europe, total actual renewable water resources per capita are currently going down and projected to drop further. What is the reason for these projected trends? Provide some data that demonstrate this trend for one of the regions. (1 point)

 2. Take a look at Table S.4 on p. 25 of *World Population Prospects: Key findings & advance tables, 2015 revision*. The middle column shows the annual population increase between 2010 and 2015 for rapidly-growing nations. Let us assume that the period 2015-2020 will have a similar pattern of population growth. For India and the United States, we are going to make predictions about how much energy will be needed to serve the additional population, and what kind of investments are needed.

2.a For India and the U.S., what are the total expected increases in population from 2016 through 2020 (assume equivalent annual population growth to 2010-15). (1 point)

2.b How much power **per year** is needed to support a new population of this size in each country? That is, how much additional power will be needed in each nation in 2021 to meet the needs of the population added from 2016-2020?

Let’s assume that everyone uses the same amount of power on average. Calculate kilowatt-hours per year per person in each country, and multiply by your answer in 2.a. (*Suggestion:* 2013 data on India’s and the US’s electricity consumption and population can be found in the long table called Selected Indicators for 2013 starting on p. 48 of *Key World Energy Statistics 2015*, published by the International Energy Agency. You might divide electricity consumption by population, arriving at a per-person average consumption. It’s OK to assume that 2013’s average consumption per person will remain the same between 2016 and 2020.) Show your work! Provide your answer in Gigawatt-hours per year (GWh/year). (1 point)

2.c Convert your answer from GWh/year to Gigawatts (GW). (1 point)

2.d Assume a nuclear power plant has a generation capacity of 1 GW, a hydroelectric dam ½ GW, a fossil fuel plant ½ GW, a wind turbine 2.5 MW, and a solar rooftop 5 kW. Propose a mix of new energy supplies for each nation to satisfy the demand generated by the anticipated population growth. Aside from total production capacity, are your proposals for India and the U.S. different or the same? Explain. (1 point)

3. Read the article “As appetite for electricity soars the world keeps turning to coal,” by Todd Lindeman, Ted Mellnik and Will Englund, found at <https://www.washingtonpost.com/apps/g/page/world/as-appetite-for-electricity-soars-the-world-keeps-turning-to-coal/1842/> . What are the one or two most interesting points made in the article in your opinion? (1 point).

4. Forty years ago, Amory Lovins wrote his seminal article describing “hard” and “soft” energy paths. It is in this week’s homework folder. Please review this article in preparation for the following questions.

a) In the article, what is the distinction between the “hard” energy path and the “soft” energy path? (1 point)

b) Pick a recent article from any major newspaper that addresses a contemporary energy issue and in a short paragraph comment on whether you think the issue is a result of a “hard-path” or “soft-path” approach. Please include a citation for your article. (1 point)

c) The Lovins piece is focused on energy in the context of the United States. How applicable do you believe the concepts and arguments are to energy-impoverished developing countries? In other words, is the “hard energy approach” vs. “soft energy approach” an issue exclusively for rich countries, or is this a valuable distinction for energy strategy in poor countries as well? Explain. (1 point)

d) Lovins makes numerous predictions and projections about the future energy path of the US. Some of them were on target and others were way off. Give an example of a prediction or scenario that turned out to be quite accurate, and an example of a prediction or scenario that did not come close to being realized. (1 point)

5. How many nuclear power plants would be needed to supply all of the US’s electricity demands? How many rooftop solar systems? Assume that the average nuclear facility generates one Gigawatt (GW) of power, and a rooftop generates 4 kilowatts (kW). *Hint: You can find US electricity consumption toward the bottom of p. 25 in the USEIA Annual Energy Outlook for 2015.* (1 point)

6. We find that the US has a mix of electricity-generation technologies and fuels, from small scale to large scale – a *portfolio* of power generation technologies. What were the largest primary energy sources for electricity production in the US in 2013? List the top five sources as a percentage of the total. *Hint: you will find the answer in the USEIA publication nearby the information needed in question 5.* (1 point)

7. Why do we have a portfolio of power sources? Why hasn’t the nation identified what the best primary energy source is for electricity generation and generated all its power from that one source? Give two or three reasons why the US has an energy *portfolio* rather than a single energy source. (1 point)