MAE 119: Homework 1

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1. World energy consumption in 2010 was about 500 quadrillion BTUs. Using internet resources, estimate the equivalent energy quantities in:
    a. Barrels of oil
    b. Metric tonnes of coal
    c. Standard cubic feet of natural gas
    d. Liters of reservoir water elevated 1000m above sea level.
    e. Kilograms of steam (saturated vapor) at 200 deg C
    f. Kilograms of hot water (saturated liquid) at 200 deg C
    g. Cubic meters of granite at 250 deg C
    h. Kilograms of fissile uranium.
2. For the different energy sources of problem 1, estimate the annual carbon emissions that would result from each of these energy sources.

3. Estimate your own personal energy consumption per year. If this energy was produced from oil consumption, how much oil would you be responsible for consuming? If it was from natural gas, what would your gas consumption be? Do the same for coal. What would your personal carbon emission per year be? How does this energy consumption compare to your annual caloric intake (which is a rough measure for how much energy your body consumes).

4. Let us estimate the expected evolution of C-emissions into the atmosphere by constructing a simple model as follows. The existing human population is about $7x10^9$ people this year, and data from the UN show that the population growth rate is about 1%/year. Assume that this growth rate gradually drops, and that by mid-century, in 2050 the population is in equilibrium – i.e. the growth rate is zero. To make the problem easy, assume that the growth rate declines linearly in time until reaching a value of zero in 2050. Economic data show that for the past several decades, the global economic activity has grown at a rate of about 3%/year; let us assume that this growth rate continues into the future. Finally we note that currently the total world economic activity has a dollar value of about $\$5x10^{13}$/year, and currently the total world-wide primary power demand is about 15 TW.

    a. If all of the world's primary energy were to be somehow derived from natural gas – the lowest carbon intensity fossil fuel – calculate the annual C-emission into the atmosphere from now until 2050, showing your result as a plot of annual C emissions vs. year. [Hint: 1 kG of CH4 contains about 50 MJ of energy release during combustion, and you should weight the average of the energy intensity of the three different economic regions

shown in the figure above by the amount of economic activity in each region].

b. Repeat the model assuming that the so-called Energy Intensity decreases at 1% per year. Remember Energy Intensity simply gives how much energy is required to produce a given amount of economic activity (i.e how many MJ of energy are needed for $1 of economic activity). Show your result as a plot vs. year.

c. Discuss and explain the results and differences from these two models, and compare them against more complex projections found on page 8 of the IPCC's Executive Summary (see Link)

5. Using the results found in the Pasternack paper (see link in Schedule of Lectures page), estimate what the present day world-wide electricity demand would be if today all human beings had access to enough electricity such that all human societies had a Human Development Index, HDI = 0.9. How much of a change relative to present-day world-wide electricity demand does this represent?

6. Compare your estimated change in electrical energy demand in problem 2 above with the estimated increase in electrical energy demand contained in the International Energy Outlook over the available projections contained in that document.

7. Use the GapMinder website to explore the links between education, agriculture, and access to energy. Once you have opened the website, click on the "GapMinder World" tab at the upper left of the homepage. This will open a plot of Life Expectancy vs. Income per person per year (purchasing power parity adjusted). Click the "Play" button to see how this plot evolves from the 19th century until now. Now click on the x axis pull down menu. From the pull-down menu, choose Economy=>Sectors=>Agriculture (% of GDP) and make a plot of total adult literacy rate vs. the percentage contribution of agriculture to the economy. Use per-capita CO2 emissions as the indicator size by clicking on the "Size" pull down menu found in the lower right hand corner, and choosing per capita annual CO2 emissions for the data point size. Click play to see how these data evolve in time, and examine the plot for the data from the most recent year that data is available. What if anything do you conclude from this plot about links between CO2 emissions, life expectancy (which is a marker for quality-of-life) and the role of agriculture in the economy vs other activities? What role if any does energy access play in this problem?