PS#5 PHYS 310 Due Friday May 3, in class

#1. Dinner Estimate: In 2011 DH organized the second of three Physics of Sustainable Energy conferences at Berkeley – I helped a little. The banquet speech not surprisingly was Art Rosenfeld, who gave half of his presentation time to Richard Muller. Funded by big oil interests such as the Koch Brothers, Richard promised to *correct* the "biased" global warming data with his BEST model results. Richard had managed to offend many climate scientists with his arrogant dismissal of their work, so it was a little tense as we waited. The guy sitting next to me said, "so would someone figure out if we get more heat from burning something than from the associated GHG emissions." I responded that the heating from the GHG emissions would continue forever, so the real question is "how long will it take for the GHG-radiative forcing heat to be equal to the combustion heat?" and added that we should find a physicist to do that calculation (this was an American Physical Society Conference). I asked myself, "what would DH do?" I started with the CO_2 emissions of burning coal to release a MJ of thermal energy. Then I calculated the associated % increase in total anthropogenic GHG emissions and corresponding increase in the radiative forcing.

a) Estimate the total anthropogenic GHG emissions from all time, using Pete's "1930 triangle method" (Carbon emissions began in 1930 and grew roughly linearly to today… what are present global emissions?. By what portion did your little combustion experiment increase our total emissions?
b) What would be the increase in radiative forcing due to this increase in GHG?
c) Can you calculate the rate of GHG thermal heating due to burning this coal, and thereby find the time required to provide the heat equal to that directly given off in the burning?
d) Can you make an argument that this increase may not be linear and so my estimate is (a little) too big?

This calculation was done in the video assigned for Monday's Class.

#2 You drive to San Francisco and back in a car of your choice – name the car. *Subaru Outback, ~30 mpg*

a) How much gas did you use? *~ 300 miles each way: 20 gallons*
b) How many kg of CO_2 did your trip contribute to the environment? ~ 10 kg/gallon => 200 kg
c) What is the rate of heat dissipation into the environment if your trip was just an immediate "there and back". Please put your answer in Watts. *Most important way to start is realize that all the energy eventually turns to heat. Most of the heat is initially given off by the engine because of the ridiculously poor efficiency of the Otto cycle, but the rest that drives the car results in turbulence in the air that turns into heat eventually. Any number of ways you could calculate this. ~46 MJ/kg energy density of gasoline, ~ 3kg/gallon… How about 20g(C)/MJ. It's a little under 3 GJ. The round trip is about 8 hrs, about 30,000s, yielding a power of about 100 kW, ~ 130 HP. While many cars can put out 130 HP, cruzing at constant speed on the freeway is closer to 20 – 30 HP. What we have calculated is the rate of power* ***intake*** *in gasoline, which is equal to the total power output (assuming complete combustion… a reasonable assumption) in heat and work (which later turns to heat).*
d) What portion of the earth's remaining accessible petroleum did your trip use? *We accept that the remaining accessible petroleum is about a Trillion Barrels (55 gallons)… and strangely has remained pretty constant over the past 20 years as we continue to take more. We've used 20 gallons, or about one part in 3 trillion of the earth's petroleum… how can we get an understanding of this? How about if everyone took a road trip like this every weekend. How long would the petroleum last? 7.5 people in the car means there are 1 billion road trips every weekend. Or 50 billion road trips per year. Hmm, it would still take about 60 years to use up all the petroleum. Damn, there's lots of petroleum in the earth.*
e) By what portion did your trip increase the total anthropogenic GHG? *Using the triangle method beginning in 1930 to 2020 is 90 years, and our present output rate is about 35 Gtons/year, meaning total GHG in atmosphere is ~ 1600 GT. We put out how many GT? 0.2 T = 2×10^{-10} GT. Out contribution is about 1.2×10^{-13} of total global anthropogenic GHG… or about 1 part in 8 trilion.*

#3 Calculating your carbon footprint: Please estimate your carbon footprint in Tons of CO_2 per year. Do this by doing rough calculations on your use of:

a) Car transport – calculate gallons used by you. So, if you and your room mate need 200 gallons for the year to commute to Cal Poly from Los Osos, you are responsible for 100 Gallons.

b) Air transport. What is the mileage of the planes you travel in? How far do you fly? How many people share this fuel? You can say that the planes use kerosene… but it is like gasoline.

c) Use of Natural Gas and Electricity

d) Food see below for a paper that will help you.

e) Clothing and other goods

For the last two categories: The embedded carbon in the things you buy, there is a nice publication with some good graphs for you to look at (in particular Fig #2): http://escholarship.org/uc/item/55b3r1qj

#4 Climate Change and You: Chris Jones, at Berkeley has created a spreadsheet-based tool for individuals to estimate all direct and indirect emissions of GHGs in CO_2 equivalent units resulting from their primary energy related choices: transportation, food, housing (including energy use), goods and services, and waste. Go to Chris' website: http://consumerfootprint.org/ and spend some time exploring to understand the basic logic of what the site. Go to the calculators and fill out the widget that pertains to you, most likely the household widget at the bottom of the calculator page. Fill out the carbon calculator with your individual information for each sector. Please be as honest as possible (I won't publish your names). Go to the Summary tab and save your answers.

a) What is the ratio of the highest category (e.g. housing, food, etc.) of your emissions to the lowest? What is the ratio of your total emissions to the national average of 20 tons CO_2 per person per year? What is the ratio of your total emissions to the global average of 4.5 tons CO_2 per person per year?

b) What do you find most surprising about your results? Please explain in a short paragraph.

c) What lifestyle changes would you have to make in order to emit no more than the global per capita average of 4.5 tons of CO_2? To do this, change the values you entered in the spreadsheet until your total emissions are below 4.5 tons CO_2. Try to make realistic choices. What do the results say about how your lifestyle compares to the lifestyles of the majority of people on the planet? Could you live at or below the global average? Please explain in one short paragraph.

d) (10 points) What if, starting June 1, 2012, everyone suddenly started living like the average American (American per capita CO_2 emissions: http://en.wikipedia.org/wiki/List_of_countries_by_carbon_dioxide_emissions_per_capita)? How quickly would we reach what many climate scientists consider to be the dangerous level of 500 ppm (parts per million) of carbon dioxide in the atmosphere? State any assumptions you make.

e) (5 pts) How did your estimate from #3 differ from the output of the calculator above? Can you comment on reasons for the difference?

#5 (less likely to be directly pertinent toward an assessment) Dan Kammen at Berkeley says, "we're not running out of petroleum, we're running on of atmosphere. Please investigate this statement.

a) In the global stocks and flow energy diagram (this is provided for April 3 class on the class website), please estimate how many years our oil will last if we continue using it at the present rate. Assume that we can use every last drop (impossible – most of it is presently considered not accessible). But our rate of use is increasing.
b) Estimate the mass of CO_2 emitted into the atmosphere for every gallon of gas you burn, then
c) estimate the mass of CO_2 in the atmosphere if (when) we did use every last drop of petroleum.
d) Calculate the total mass of the atmosphere knowing that atmospheric pressure times the surface area of the earth is the force of gravity acting on the entire atmosphere (right?)
e) Knowing that the molecular mass of the atmosphere is about 29 g/mole, estimate the PPM increase in CO_2 in the atmosphere from burning all the petroleum.
f) Estimate the increase in the Radiative Forcing from this increase in CO_2.
g) Estimate the increase in global temperature from this increase in CO_2. You may find it helpful to consider the layer model that DH and I published a few years back: http://www.aps.org/units/fps/newsletters/200807/hafemeister.cfm ... But you may not find it helpful too.

#6 (**VERY** pertinent toward and Assessment). From the class slide:
Climate Change. I can describe

- The causes of climate change. *Make sure you know GHG and IR absorption/reradiation*
- Distinguish CC from Ozone Hole *CC is not about UV, CFC, sunburn*
- Define Radiative Forcing
  - What are units of Radiative Forcing? W/m^2, it's the *change* in GH effect since industrialization.
  - Relative increase in incoming heat?, *compare 250 W/m^2 (1000 W/m^2 divided by 4… why by divide by 4?)… it's an increase of about 0.5%... except we really don't get 250W on average from sun because of cloud cover/reflection. However, it's a reasonable amount.*
  - Total Thermal Power return to Earth? *Multiply by earth's surface area: ~ 7×10^{14} W.*
- Positive and Negative Feedback? *Make sure you can distinguish them and provide examples.*
- Tipping point? *If it gets bad enough, will the positive feedback throw us into a different (way way way hotter) equilibrium) that we can no longer stop through dropping our own emissions.*
- Physical Effects? *Make sure you can distinguish them and provide examples.*
- Biological Effects? *Make sure you can distinguish them and provide examples.*