PS#6, PSC-320, Due in class, **Tuesday May 19**. We will solve all of these on an Excel spreadsheet.

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). We can solve this by I starting with the CO_2 emissions of burning coal to release a MJ of thermal energy. Then calculate the associated % increase in total anthropogenic GHG emissions and corresponding increase in the radiative forcing. 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?

2. Calculate the busbar cost of electricity from a nuclear plant. Please do this for a 1 GW nuclear electricity generation facility. Assume a 7% discount rate. I provide information below. Do this using the formula we introduced in in the video for finding the cost of electricity. Parts a) b) and c) do not use the excel *model* but you'll use an Excel Spreadsheet.
a) Assume that the plant is miraculously dropped down the moment you pay the capitol cost and begins generating electricity for a 40-year lifetime. Solve this on an Excel Spreadsheet.
b) Repeat the above problem for a 20-year lifetime.
c) The reality is that nuclear power facilities can take up to 12 years to construct… or have traditionally taken that long in the US. Assume that the citing and capitol costs are spread uniformly over the 12-year construction period, with electricity generation beginning in year 13. Please solve this problem by calculating the debt that you have accumulated by the time the facility begins its 40 year operational stint. Hint: It may be best to put all costs into "present value" for t = 12 years, and start the problem at the beginning of the useful lifetime of the facility.

3. Using a financial model in Excel. Please download the accompanying Excel File. It is for a Natural Gas Peaker Plant. Please note the graph describes the financial balance if we were to have taken out a loan from the bank at the indicated interest rate. With the present values, we would pay off the loan in 17 years, but the lifetime might be 40 years and the price I am charging for electricity is very high and may not be competitive.
a) (10 pts) Please lower the price of electricity until I take an entire 40 years to pay off the loan. What is this price of electricity? What happens to the required price of electricity for a 40 year lifetime if:

i) I finance the project with a 6% interest rate rather than a 10% interest rate?
ii) The duty cycle is increased to 95%?
iii) The duty cycle drops to 0.05% for a true peaker plant that only runs for 4 hours a year.
iv) The cost of NG doubles?
v) If the facility was a NGCC: (Capital cost \$3/W, efficiency 60%, duty cycle 90%)

b) Solve question #2 by modifying this spreadsheet to correspond to a nuclear facility. Make sure you figure out how the model works before you start changing it. How do I calculate costs? Revenue. See if you can get the same cost for electricity as you did for question #2 – that would be the price of electricity so that you end up at the end of the lifetime with zero balance.
c) Now that you have a financial model (see Excel Document), please explore what the following changes do to the cost of electricity, stating what the new price of electricity is:

i) a 12 year building time as in #2 part c)

ii) doubling the cost of nuclear fuel (without increasing the rest of the O&M costs)

iii) changing the useable lifetime to 20 years.

iv) a $2 per watt decommission fee at the end of the 40 years. Don't believe me? See: http://en.wikipedia.org/wiki/Nuclear_decommissioning

v) if instead of decommissioning as in part iv) above, you pay off the debt after 40 years, and (*instead*) invest $700 million for two new steam generators, and extend the lifetime of the plant 20 *more* years thereby, and you keep the cost of electricity the same as in iii) above, how much money have you made at the end of the extra 20 years? Don't believe me? See: http://www.ksby.com/news/700-million-steam-generator-replacement-project-nears-an-end-at-diablo-canyon/

Useful Information:
We will calculate the cost of Nuclear electricity production for a **1 GW** Nuclear power facility. Nuclear Power Plants now have a duty cycle of 90% and a lifetime of 40 years. The capital costs… are between $1000 and $5000/kW (please see: http://nuclearinfo.net/Nuclearpower/WebHomeCostOfNuclearPower), so let's compromise at $3000/kW. Then there is the cost of fuel (at: http://www.uic.com.au/nip08.htm). Showing:

In January 2007, the approx. US $ cost to get 1 kg of uranium as UO_2 reactor fuel at likely contract prices (about one third of current spot price):

Uranium:	8.9 kg U_3O_8 x $53	472
Conversion:	7.5 kg U x $12	90
Enrichment:	7.3 SWU x $135	985
Fuel fabrication:	per kg	240
total, approx:		US$ 1787

At 45,000 MWd/t burn-up this gives 360,000 kWh electrical per kg, hence fuel cost: 0.50 c/kWh.

If assuming a higher uranium price, say two thirds of current spot price: 8.9 kg x 108 = 961, giving a total of $2286, or 0.635 c/kWh.

Keep in mind that this website is from the nuclear industry of Australia, so this is most likely a lower limit for price. Please take the higher price at the very bottom of 0.635 cents/kWh_e. This means that the cost is 0.635 cents for every kWh of *electricity produced*. They have already divided by the efficiency of the nuclear facility. At present, only ¼ the operating costs are for fuel because nuclear requires a considerable amount of highly paid operators, fire fighters, safety oversight, and people carrying machine guns to protect from possible attack. Or do what you have to in order to find a value for operations and maintenance for nuclear with documentation (see for instance: http://www.hks.harvard.edu/hepg/Papers/EIA_Nuclear_Outlook_94.pdf).

4. My house was built in 1928 with no insulation in the walls. In comparing my winter (6 months) and summer bills, I estimate a $40 difference per month, which I attribute to winter. I assume I could cut this difference in half if I hired a company to cut holes and fill the walls with insulation. Let's say the cost after considering the tax credit I receive from SoCalGas is $2050. Assume this is paid for with a 30 year loan at a 7% interest rate. You can do this all in Excel.

a) Calculate the CRF (Capitol Recovery Factor) for this loan, how close to 8% is it?
b) How much energy would I save each year (put in Therms, and BTUs).
c) How much less CO_2 will I emit each year (in tons)?
d) What is my cost of conserved energy in $/kWh?
e) What is my cost of abated carbon in $/Ton($CO_2$)?
f) Would a carbon tax be necessary to make this a financially advantageous decision? If so, how much of a carbon tax?
g) Would there be other "additional value" not seen in this calculation? Would you do it?

5. In class Wednesday, I showed the graph below, and indicated that the present cost of PV panels is about $0.50 per W. Presume the market continues to grow exponentially as it has been, What will be the total global solar capacity by 2030, and what will be the cost of a 1 kW PV panel?