



1.818J/2.65J/3.564J/10.391J/11.371J/22.811J/ESD166J
SUSTAINABLE ENERGY

Spring 2005

PROBLEM SET #4

Due: Thursday 10 March 2005

Energy Conversion and Systems Analysis

1) **Chemical Kinetics** -- Problem 3.2 in textbook

2) **Transportation needs and options**

(a) As a first approximation, let's imagine that everyone in the world drove autos at the current US rate. What would be the effect on petroleum demand? (you can assume that current oil consumption in the world is about 80 million bbls per day).

(b) Let's suppose that we want to transition to a hydrogen economy where all our transportation fuels are converted to hydrogen. At today's US consumption rates would there be enough natural gas available to produce the hydrogen we need? If so, what might this do to the price of natural gas and hydrogen?

Show how you arrived at your answer with appropriate calculations. Keep in mind that current world production of methane is about 90 trillion or 10^{12} SCF per year.

3) A good geothermal well produces 75 kg/s of hot, pressurized water at 250 °C.

(a) For the same amount of delivered energy what would the production rate have to be from an oil well? How does this compare with a typical US oil well producing about 10,000 bbl of oil per day? You can assume that the average heat capacity of the geothermal water is 4200 J/kg K and that the minimum useful temperature is 50 °C and that crude oil has a heating value of about 5.5 million BTU per bbl.

(b) In New England, a high percentage of homes are heated with oil. How much 250°C geothermal fluid would be required to heat a high-efficiency 4 bedroom home that consumes about 500 gal/year in oil?

(c) As we will learn soon in class, the depth needed to reach such geothermal temperatures in New England is prohibitively high so alternatives are needed. One approach would be to use a geothermal heat pump that extracts thermal energy from just a few meters into the ground below the seasonal frost line where the temperatures average about 15 to 20°C and "pumps" it up using an electrically powered heat pump cycle to temperatures of about 50°C for use in home heating. Another reported advantage would be that the heat pump could also be used for summer air conditioning by just reversing the cycle. Discuss the sustainability gains for such a scheme.

4). US and UK Energy Policies:

Prof. Jacoby talked about some of the international challenges to reducing global GHG emissions out into the future – in the face of population and economic growth and all sorts of competing national and regional goals. He stated that this is not a problem we can “solve” – rather we must find ways to manage future risks of global changes in a responsible way.

In February 2003, Prime Minister Blair’s government in the UK presented an Energy White Paper to Parliament, which set goals and policies for achieving a significant reduction in carbon emissions by 2020 (reducing carbon emissions by 15-25 MtC over projected growth from today’s levels of around 80 MtC), and by 60% over projected growth out to 2050. See at least the executive summary of:

<http://www.dti.gov.uk/energy/whitepaper/ourenergyfuture.pdf>

In the US a bipartisan study group of 16 leading energy experts from diverse backgrounds was sponsored by the National Commission on Energy Policy – a group established by the William and Flora Hewlett Foundation in partnership with several other leading foundations. This group released a report in December 2004, entitled “Ending the Energy Stalemate: A Bipartisan Strategy to Meet America’s Energy Challenges.” See a summary of recommendations at:

<http://64.70.252.93/O82F4692.pdf>

On March 10 we will have a joint class with “Sustainable Energy” students at the University of Cambridge to discuss British and US national policies and issues. From your look at the two different reports, please address:

- a. What are the projected costs of following each of these two proposed plans for the UK and the US respectively? What future impacts on national GDP are estimated for each plan?
- b. List two major similarities and two major differences in approach between the two plans. Discuss your opinions briefly.
- c. Which program seems sounder from a “risk management” viewpoint? Why?