Midterm Posted

- I posted the midterm from last fall on the ELMS site (documents)
- I will post the answers in a week or so
Companies strive to build a better (more expensive) light bulb

A pipeline predicament for Obama - With Keystone decision, president faces choice of which allies to anger

In May a NASA scientist was asked to calculate what it would mean for the Earth’s climate if Canada extracted all of the petroleum in its rich Alberta oil sands region.

The answer, “It is essentially game over.” wrote the head of NASA’s Goddard Institute for Space Studies and is one of the nation’s leading voices against fossil fuel energy.
Presentations this week

- Energy Audit Assignment 3
  - I was not particularly happy with Energy Audit number 3
  - I want to be able to understand your numbers
  - Fluorescent lights 250 @40W x 24 hours/day = 240kWh/day
  - Refrigerators ~100 (+- 40) @500W for ~3hrs/day (+-2)
    = 150kWh +- 100kWh
- What I want for the presentation:

Fossil Fuels

- Oil (petroleum)
- Natural Gas (methane)
- Coal
- Peat

Note: propane is derived from oil
Hubbert

Marion King Hubbert (October 5, 1903 – October 11, 1989) was a geoscientist who worked at the Shell research lab in Houston, Texas.

“Our ignorance is not so vast as our failure to use what we know.”

Fig. 8. Human affairs in time perspective.
Peak Oil

Peak Oil is inevitable (we don't know when)

The question is what will happen?

Two choices:

1) We smoothly transition to another energy source
e.g. From wood to fossil fuel

2) We run short before enough alternative capacity exists

Hirsch Report of DoE 2005

- World oil peaking is going to happen, and will likely be abrupt.
- Oil peaking will adversely affect global economies, particularly those most dependent on oil.
- Oil peaking presents a unique challenge ("it will be abrupt and revolutionary").
- The problem is liquid fuels (growth in demand mainly from transportation sector).
Mitigation of maximum world oil production: Shortage scenarios

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Points out we lose ~ 1% of GDP for every 1% of oil shortage
(from previous Oil Crises – 1973, 1979)

- Best case – a long plateau of constant production – gives time to adapt
- Medium case – short plateau and slow (few percent) decline
- Worst case – short plateau and steep decline

-Our experience of peak oil in individual countries may not translate to global situation

Why did the Japanese attack Pearl Harbor?

1. The US attacked them first
2. They wanted to start a war with the US
3. The US cutoff their oil supply
4. The Japanese had invaded China
5. They wanted to invade other Asian countries for their oil and they wanted to disable the US fleet
6. They wanted to take over Asia
7. All of the above
8. All of the above but #1
9. All of the above but #1 and #2
Japan and Oil

- In the 1930s Japan was very aggressive militarily
  - It invaded Manchuria in 1931
  - It invaded China in 1937
  - However it chose poorly from an oil point of view
- Japan imported 90% of it’s oil
  - ~80% came from California
  - There were signs of a trade embargo from the US
  - In 1940 the US cutoff machine tools and aviation fuel in response to the invasion of French Indochina
- In July of 1941, the US cutoff oil exports to Japan
  - Japan planned to invade Dutch East Indies because they had oil
  - They knew the US fleet (moved from CA to Hawaii) would be used to stop them, so
- December 7, 1941 – the Japanese bombed the US fleet in Pearl Harbor

By the end of the war

- Japan was so short of fuel that:
  - They didn’t have enough fuel for an ambulance to transport Premier Tojo to the hospital after a suicide attempt
  - They didn’t have enough fuel to mount a real air attack or bring their air force back from advanced bases
  - Some argue this was why they made a series last ditch Kamikaze attacks
Global energy crunch: How different parts of the world would react to a peak oil scenario

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c

Three Scenarios:

- Predatory Militarism
  example – Japan – WWII

- Totalitarian Retrenchment
  example – North Korea – 1990s

- Socioeconomic Adaption
  example – Cuba – 1990s
Natural Gas

- Since the late 1990s, natural gas has been the fuel of choice for the majority of new generating units, resulting in a 99.0 percent increase in natural gas-fired capacity since 1999.
- The construction of natural gas plants began increasing in 1999, peaked during 2002 and 2003, but has since declined considerably.
- On December 31, 2006, natural gas-fired generating capacity represented 388,294 MW or 39.4 percent of total net summer generating capacity. Although new natural gas-fired combined-cycle plants produce electricity more efficiently than older fossil-fueled plants, high natural gas prices can work against full utilization of these plants if such prices adversely affect economic dispatch.
Marcellus Shale

Large Natural Gas Reserve now accessible with technology

Hydrofracturing

- Pump high pressure water, sand, chemicals to create small (< mm) cracks to allow gas to escape
http://www.gaslandthemovie.com/trailer/
http://www.gaslandthemovie.com/whats-fracking
http://www.pbs.org/now/shows/613/index.html

Marcellus Shale
Fracking

- **How does hydraulic fracturing work?**
  - Hydraulic fracturing or fracking is a means of natural gas extraction employed in deep natural gas well drilling. Once a well is drilled, millions of gallons of water, sand and proprietary chemicals are injected, under high pressure, into a well. The pressure fractures the shale and props open fissures that enable natural gas to flow more freely out of the well.

- **What is the Halliburton Loophole?**
  - In 2005, the Bush/Cheney Energy Bill exempted natural gas drilling from the Safe Drinking Water Act. It exempts companies from disclosing the chemicals used during hydraulic fracturing. Essentially, the provision took the Environmental Protection Agency (EPA) off the job. It is now commonly referred to as the Halliburton Loophole.
**From “Debunking GasLand”**

Once again, hydraulic fracturing has never been regulated under SDWA – not in the 60-year history of the technology, the 36-year history of the law, or the 40-year history of EPA. Given that, it’s not entirely clear which “restrictions” in the law Mr. Fox believes were “cleared away” by the 2005 energy bill. All the bill sought to do was clarify the existing and established intent of Congress as it related to the scope of SDWA.

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**From the EPA:**

Several statutes may be leveraged to protect water quality, but EPA’s central authority to protect drinking water is drawn from the Safe Drinking Water Act (SDWA). The protection of USDWs is focused in the Underground Injection Control (UIC) program, which regulates the subsurface emplacement of fluid. Congress provided for exclusions to UIC authority (SDWA § 1421(d)), however, with the most recent language added via the Energy Policy Act of 2005: “The term ‘underground injection’ – (A) means the subsurface emplacement of fluids by well injection; and (B) excludes – (i) the underground injection of natural gas for purposes of storage; and (ii) the underground injection of fluids or propping agents (other than diesel fuels) pursuant to hydraulic fracturing operations related to oil, gas, or geothermal production activities.”
Rebuttal of the rebuttal...

http://www.damascuscitizens.org/Affirming-GASLAND.pdf

All predictions are we will continue to increase global fossil fuel usage...
The Era of Fossil Fuels

- Fossil fuels: petroleum, natural gas and coal (organic)
- Relatively short-lived, ~ 500 years
- Currently 85% of current US energy from fossil fuels
- Expected oil production peak: 2010-2030
- Consumption currently increasing
- Projected world oil production will be exhausted by 2100
- Produces significant and diverse pollution problems
  - Greenhouse gases
  - Gaseous Sulfur and nitrogen oxides
  - Land-based disturbances

Figure 11. Impacts of four Kaya factors on world carbon dioxide emissions

The identity is expressed in the form:

\[ F = P \times (G / P) + (E / G) \times (F / E) = P \times g \times e \times f \]

where:
- \( P \) is global CO₂ emissions from human sources
- \( G \) is global population
- \( E \) is global primary energy consumption and \( g \) (GDP) is per-capita GDP
- \( F \) and \( e \) are the carbon intensity of energy and the energy intensity of world GDP,

Extensive variables are uppercase while intensive variables are lowercase.
Pollution

Heat (Thermal) Pollution
**Solar Insolation**

- How much power does the sun deposit on the Earth during the day?
  - Watts/m²

- How many 100 W bulbs in 1 sq. meter gives the same feel (heat and light) as a bright sunny day?

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**Solar Insolation**

- Solar Constant = 1366 W/m²
  - (at top of atmosphere)

- In the US, averaging over the seasons and the day/night, solar load is about 250 W/m²
**Total Solar Energy on US**

- Estimate area of the US: \(10^7 \text{ sq. km} = 10^{13} \text{ m}^2\)

- Approximating as 0.25 kW/m\(^2\) what is total amount of solar energy hitting US in 1 year?

\[2 \times 10^{16} \text{ kWh}\]

- Estimate total US energy usage: \(3 \times 10^{13} \text{ kWh}\)

- US energy/US solar energy \(~ 0.001\) → global warming is NOT caused by our production of heat

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**Heat Pollution**

- *Locally heat pollution can be a problem*
**Heat Pollution**

- Lake Anna Virginia
  - Created to cool Nuclear power plants
  - 2 million gpm 14 deg. above lake temperature

**Heat Islands**

Solutions - white roofs, green roofs, plants…
What makes something a “pollutant”?

- It does bad things...

Linear No Threshold model (LNT)

Almost all substances have no reliable low-dose data

Maybe there is a threshold...

Threshold

Threshold: no effects below this dose.
Different Models

Example: Radiation

- almost all data comes from high dose exposures (e.g. Hiroshima)
Low dose radiation exposure

1995 study:
Correlate lung cancer deaths with radon exposure by county
- Found *negative* correlation!
- Possible biological model: DNA repair
CONCLUSION
The committee concludes that current scientific evidence is consistent with the hypothesis that there is a linear, no-threshold dose-response relationship between exposure to ionizing radiation and the development of cancer in humans.
Hormesis

- Some things that are bad for you at high dose are good for you at low dose
Hormesis

- Some things that are bad for you at high dose are good for you at low dose

![Graph showing Hormesis concept]

Estimating effects of pollution

- Must be careful in extrapolation
- Be mindful of uncertainties
- There should be a plausible physical model
- e.g. magnetic fields from power lines cause cancer?
- homeopathic “remedies”
- brain cancer from cell phones
Homeopathic “remedies”

- As originally conceived by the eighteenth-century German physician Samuel Hahnemann, substances that cause particular symptoms in a healthy patient can cure those symptoms in an ill patient. Many of these substances were quite toxic, so he decided to dilute them.
- Unsurprisingly, he discovered that the greater the dilution, the lesser the side-effects.
- Hahnemann was deluded into his second law, ‘less is more’. Less, in this case, amounted to a dilution of 10 parts water, or even a hundred parts water, to every one part of the particular substance - repeated anywhere from 30 to 200 times.
- Hahnemann was presumably unaware that his recommended 200 dilutions (using 100 parts water per one part of the substance) ‘were beyond the dilution limit of the entire visible universe’.

\[
(1/100)^{200} = 10^{-400}
\]

\~10^{80} \text{ atoms in the Universe}

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Hazards to life from Bernard Cohen, L.A. Times June 4, 1978

<table>
<thead>
<tr>
<th>Risk</th>
<th>days of life expectancy lost by taking the risk</th>
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<tbody>
<tr>
<td>Riding in cars (10,000 miles/yr)</td>
<td>200</td>
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<tr>
<td>Not using seat belts</td>
<td>50</td>
</tr>
<tr>
<td>Driving small cars</td>
<td>50</td>
</tr>
<tr>
<td>Smoking one pack/day</td>
<td>2200</td>
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<tr>
<td>Overeating by 200 calories/day</td>
<td>400</td>
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<tr>
<td>Being one pound overweight</td>
<td>30</td>
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<tr>
<td>One diet drink/day</td>
<td>2.5</td>
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<tr>
<td>Fire</td>
<td>30</td>
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<tr>
<td>Drowning</td>
<td>40</td>
</tr>
<tr>
<td>Being poisoned</td>
<td>20</td>
</tr>
<tr>
<td>Choking on food</td>
<td>12</td>
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<tr>
<td>Being asphyxiated</td>
<td>7</td>
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<tr>
<td>Struck by falling object</td>
<td>6</td>
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<tr>
<td>Electrocution</td>
<td>6</td>
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<tr>
<td>Lightning</td>
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<tr>
<td>Being bitten by an animal or insect</td>
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<tr>
<td>Being murdered</td>
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<tr>
<td>Consuming nuclear electricity (if it were all nuclear)</td>
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<tr>
<td>Consuming electricity from coal</td>
<td>15</td>
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<tr>
<td>Air pollution (all sources)</td>
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<tr>
<td>Being male rather than female</td>
<td>2700</td>
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<tr>
<td>Remaining unmarried</td>
<td>1800</td>
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<tr>
<td>Working as a coal miner</td>
<td>1500</td>
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