Announcements

- Homework 3 due today
- Honors section meets at 4PM today in the Blue Wall
The second editorial focuses on the drawbacks of corn based ethanol as an alternative fuel in the context of the energy bill now before Congress.

Discussion questions.....
• What questions do we need to be asking about corn based ethanol as an alternative fuel?
• What are the alternatives to this alternative?
• What are the political forces pushing for corn based ethanol?
Discussion questions…
• What are cap & trade schemes
• Should we think of them as giving industries a “right to pollute”?
We’ve been discussing potential new regions for oil supplies to meet world needs in the coming decades….

Whether, or not, to drill for oil in the Arctic National Wildlife Refuge (ANWR) in Alaska is a frequent topic for debate in Congress. How much oil is likely to be recovered from ANWR if it is opened to drilling?

In 1998 USGS estimates of ANWR oil reserves were
- 5.7 billion bbl recoverable @ 95% confidence
- 16 billion bbl recoverable @ 5% confidence
- 10.3 billion bbl recoverable - “most likely value”

Recall
- 30 billion bbl - current world consumption
- 7.5 billion bbl - current U.S. consumption
- Total U.S. reserves (2005) - 22 billion bbl

ANWR would add substantially to U.S. reserves, but still only represents about 4 months of current world oil consumption.
Oil summary…. EIA projections (2007)

World oil consumption
2004 - 83 million bbl/day
2015 - 97 million bbl/day
2030 - 118 million bbl/day

EIA projects that world oil production will be able to rise in parallel with demand with OPEC nations playing a leading role.

According to EIA, OPEC production will increase by
8 million bbl/day by 2015
23 million bbl/day by 2030
Making up about 1/2 and 2/3 respectively of the projected increases in consumption.

Source: http://www.eia.doe.gov/oiaf/ieo/oil.html
Physics 190E: Energy & Society
Fall 2007
In 2005, OPEC countries accounted for 41.7% of world oil production. OPEC generally seeks to keep the price of oil stable by increasing or decreasing the production rates of member states.

OPEC first formed in 1960 essentially as a bargaining unit to help negotiate better deals with Western oil companies.

OPEC came into prominence in October 1973 during the Yom-Kippur war between Egypt & Syria and Israel. OAPEC (the Organization of Arab Petroleum Exporting Countries, consisting of the Arab members of OPEC plus Egypt and Syria) announced that they would stop selling oil to nations that were supporting Israel - the U.S., western Europe & Japan. (The embargo was ultimately ended in 1974.)

In the short term, this led to the 1973 Oil Crisis. Sharply rising oil prices...

Source: http://www.wtrg.com/prices.htm
And serious gasoline shortages.

In the longer term, the 1973 oil crisis spurred improvements in energy efficiency, as well as a surge in oil exploration in non-OPEC nations. Both of these served to diminish the influence of OPEC on the world oil market.

Although with the large expectations of increased OPEC oil production in the coming years, this influence may return.
One last OPEC item…
The east African nation of Angola joined OPEC in January 2007 (the last of the current members to join was Nigeria in 1971)

EIA report on projected increases in OPEC oil production says, “Angola became a 1.1 million barrel per day producer in 2004, and the results of deepwater exploration indicate that its production could increase to as much as 4.0 million barrels per day by 2030. The rapid increase in Angola’s production demonstrates the importance of political stability, international investment, and technology advances. Angola’s oil production languished for the most part during a 20-year civil war, which ended in 2003. It was not until the late 1990s, when prospects for a peaceful resolution were taking shape, that the foreign investment needed to support offshore production began to materialize.

On the other hand, a Human Rights Watch article on the occasion of Angola’s joining OPEC states…
We are not alone in looking outside our borders for oil. There is the whole list of oil importing nations, including in particular….

- China’s oil consumption is growing at 7.5% per year, 7 times faster than the U.S.
- The number of automobiles is growing at 19% per year
- China currently imports 32% of its oil and has relatively small domestic oil reserves
- 58% of China’s oil imports today come from the Middle East, projected to rise to 70% by 2015

Obviously, there will be geopolitical conflict over remaining oil reserves in the coming decades….

Info from…
Fueling the dragon: China’s race into the oil market
Institute for the Analysis of Global Security
http://www.iags.org/china.htm
Implications for U.S.-China relations  

U.S.-China relations are influenced by a wide array of issues from Taiwan to trade relations and human rights. But undoubtedly access to Middle East oil will become a key issue in the relations between the two powers. Clearly, in the short term, China recognizes that its energy security is increasingly dependent on cooperation with the U.S., rather than competition with it. China would like to maintain good relations with the U.S. and enjoy the economic benefits derived from such cooperation. **But this inclination is balanced by the feeling among many Chinese leaders that the U.S. seeks to dominate the Persian Gulf in order to exercise control over its energy resources and that it tries to contain China's aspirations in the region. The U.S. is therefore considered a major threat to China's long-term energy security.**
The geopolitics of oil and the possible military consequences could be the subject of an entire course (taught by someone else!). Someone like Michael Klare, Five College Professor of Peace and World Security Studies, whose most recent books is “Blood and Oil, the Dangers and Consequences of America’s Growing Dependency on Imported Oil.”

Klare summarizes the implications of the issues we’ve been discussing, “Demand is rising around the world; supplies are not growing fast enough to satisfy global requirements; and the global struggle to gain control over whatever supplies are available has become more intense and fractious. Because the first and second of these factors are not likely to abate in the years ahead, the third can only grow more pronounced.”

The Intensifying Global Struggle for Energy
http://www.tomdispatch.com/post/print/2400/Tomgram%253A%2520%2520Mike%2520Klare%2520on%2520Our%2520Energy-Stretched%2520Planet

Klare points to the fact that access to energy supplies is now regarded as a critical issue of national security by nations around the globe.

He also points to many friction points around the globe that are beneath the radar screen for most of us…. 
On the other hand…

China has its own organizations working toward a sustainable energy solution.

The **China Sustainable Energy Program** states the problem facing their society as…..

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http://www.efchina.org/FHome.do

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China faces a cascading energy challenge. The nation's economic goals—of quadrupling GDP by 2020 while only doubling energy growth—are at risk. Since 2001, energy has been growing 1.4 times faster than GDP due to (1) improved living standards catalyzing consumption of energy-intensive products, and (2) rapid growth in heavy industries as the world’s “factory floor” shifts to China. In 2005, China’s coal consumption surpassed 2.2 billion tons, more than the next three—the U.S., Russia, and India—combined. China added over 60,000 megawatts (MW) of power plants last year—mostly coal—and will do so again in 2006. Much of this growth in energy supply has been largely unnecessary: If the investment had gone into demand-side energy saving technologies (upgrading the equipment of enterprises and buildings) rather than new supply, China would today be more competitive, profitable, and environmentally sound.
Let’s get back more into the realm of science and talk about…What is the stuff that comes out of the ground that we call oil and ship around the world.

The oil that comes out of the ground in different places is in fact slightly different - we hear about light, sweet crude, etc. The price consumers are willing to pay for a barrel of oil depends on these properties… There are about 160 different types of internationally traded crude oil.

**Heavy or light** refers to the weight of the oil. **Sweet or Sour** refers to the concentration of sulfur impurities.

Some common varieties of oil are…

**West Texas Intermediate (WTI) or Texas light sweet -** has a sulfur content of 0.24%. When we (in the U.S.) hear about the price of a barrel of oil, it is usually for WTI oil, which is regarded as a benchmark.

**Brent crude from the North Sea region** is another sweet, light crude - but not as sweet as WTI - Brent crude has a sulfur content of 0.37%. “Brent Blend” is another benchmark for oil pricing.
OPEC seeks to maintain stability in oil prices. Hence, the price of an OPEC reference basket of oils is often quoted. The OPEC basket price is a weighted average of the prices for

- Saharan Blend (from Algeria)
- Minas (from Indonesia)
- Iran Heavy (from Islamic Republic of Iran)
- Basra Light (from Iraq)
- Kuwait Export (from Kuwait)
- Es Sider (from Libya)
- Bonny Light (from Nigeria)
- Qatar Marine (from Qatar)
- Arab Light (from Saudi Arabia)
- Murban (from UAE)
- BCF 17 (from Venezuela)

All these different crude oils are very complicated combinations of different hydrocarbon molecules, plus impurities. We do not pour crude oil directly into our cars. **How do we get from crude oil to gasoline?**
Oil refining separates out various useful petroleum products from crude oil… including petroleum gas (methane, ethane, propane & butane), gasoline, kerosene, Diesel oil, fuel oil, asphalt and various lubricating oils.

The world’s first oil refinery was constructed in Poland in 1856 by Jan Józef Ignacy Łukasiewicz (1822 - 1882), a pharmacist by training who invented a method for distilling kerosene from oil.

Oil refining is a form of distillation. Early forms of distillation had been known to Arab scientists since the 2nd millennium B.C.

Distilled water, for example, is made by boiling water, collecting the re-condensing the water vapor in another container, leaving most of the solid contaminants behind.

Distilled spirits, such as whisky, brandy and vodka, have higher alcohol concentrations than result from natural fermentation processes (which yield beer, wine, etc.)
Oil is refined via fractional distillation.
- The crude oil is heated and vaporized in the furnace.
- The vapor is fed into the fractionating column and cools as it rises.
- Different hydrocarbon “fractions” of the vaporized crude oil condense at different temperatures. These correspond to different heights in the column.
- Generally the heavier fractions condense at higher temperatures.

- Petroleum gas (small alkanes with 1-4 carbon atoms, i.e. methane, ethane, propane & butane) have a boiling point above 40°C and condense at the top of the column.
- Gasoline is a mixture of alkanes and cycloalkanes with 5-12 carbon atoms that condenses in the range 40°C to 205°C.

Source: http://science.howstuffworks.com/oil-refining2.htm
• **Kerosene** - fuel for jet engines and tractors; mix of alkanes (10 to 18 carbons) and aromatics, condenses between 175°C and 325°C.

• **Diesel oil** - used for diesel fuel and heating oil; alkanes containing 12 or more carbon atoms which condense between 250°C and 350°C.

• **Lubricating oil** - used for motor oil, grease, other lubricants; long chain (20 to 50 carbon atoms) alkanes, cycloalkanes, aromatics that condense in the range 300°C to 370°C.

• **Fuel oil** - used for industrial fuel; long chain (20 to 70 carbon atoms) alkanes, cycloalkanes, aromatics that condense between 370°C and 600°C.

• **Residuals** - coke, asphalt, tar, waxes; multiple-ringed compounds with 70 or more carbon atoms that condense at more than 600°C.
• **Cycloalkanes** are hydrocarbons that form one or more rings, such as….

• **Aromatics** are yet another class of hydrocarbons, the simplest of which is the benzene ring $C_6H_6$. 
Usually it’s the case that the refiner would like to have more of one of the fractions, usually gasoline, than naturally results from the refining process. Fractions can be transformed into each other using three chemical processes.

- **Cracking** - breaks large hydrocarbon chains into smaller pieces.
- **Unification** - assemble shorter pieces into longer ones.
- **Alteration** - rearranging pieces to produce a different hydrocarbon.
Homework 4 - Due Thursday, October 4th

This assignment requires you to begin focusing on the paper due the following week. Hand in the results of the following.

1. Choose a paper topic, either from the Paper Topic list or one of your own. If you want to pick one of your own, please send me an email with your idea first to check that it’s OK.

2. Find 5 sources related to your topic, either books, articles or websites. Tell me what these are. For websites, say what it is (not just the URL)

3. List 3 questions that you plan to address in your paper. These should be more detailed than the ones in the Paper Topic list. For example, if you are looking into China’s energy strategy, you could say you want to investigate China’s interest in African oil supplying nations.
1) What assumptions underlie EIA’s energy consumption projections?
2) Peak oil – what are the ingredients for determining when global peak oil will happen? What are the natures of the uncertainties in these ingredients?
3) Pumped storage hydroelectricity – What are the basic principles involved? Why is it useful? Where are facilities located? How much total capacity exists worldwide? What are the possibilities/limitations for future expansion?
4) Ocean Thermal Energy Conversion (OTEC) – What are the basic principles? What are the practical difficulties involved? Where have plants/research facilities been built? What are prospects for the future?
5) Arctic fossil fuel deposits – What are estimates for the extent of artic fossil fuel deposits? How will nations begin to figure out who will profit from them? What other issues affect the prospects for exploration and drilling?
6) Geothermal energy – What areas of the world have significant potential for geothermal power generation? What are the prospects/limitations of geothermal power?
7) Tidal Power – What different schemes for tidal power have been proposed/built? What are the prospects/limitations?
8) Saudi Oil fields – What is known about oil fields besides the giant Ghawar field? Can other fields take up the slack in Saudi oil production if Ghawar starts to decline?
9) EIA production projections – What are EIA’s projections for increased/decreased oil production for countries/regions we haven’t looked at? What are the technical, social and environmental issues surrounding oil production in this country/region?
10) China’s search for energy - Find out where China is focusing in its search for energy resources. What areas of the world is China focusing on? How does it go about constructing ties? What are the implications for the U.S.? What are the environmental implications?
11) India’s search for energy – What is India energy strategy?