

Thursday, October 18th....

Announcements....

- Homework 5 due today
- Homework 6 due Thursday, October 25th
(posted online tomorrow)

October 17, 2007

Oil Back Over \$88 After Refinery Blast

By THE ASSOCIATED PRESS

Filed at 10:28 a.m. ET

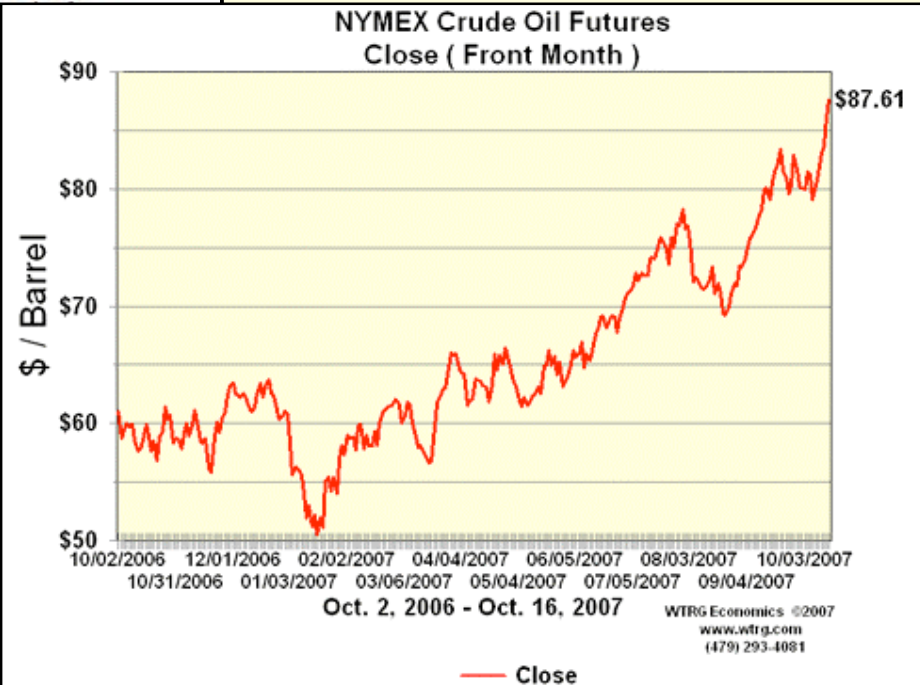
NEW YORK (AP) -- Oil prices moved back above \$88 a barrel Wednesday after an explosion at a small [Exxon Mobil Corp.](#) refinery in Montana exacerbated already growing concerns about the adequacy of crude supplies.

There were no immediate details about damage from the early morning explosion at Exxon Mobil's Billings, Mont., refinery, or its effect on production. The plant can process 60,000 barrels of oil per day. That's a small amount, but news of the explosion lifted oil prices that had fallen in expectations that the Energy Department report due later Wednesday will show oil and gasoline inventories grew last week.

That would counter a market perception in recent days that oil supplies are falling as demand is growing. Reports by the Energy Department, the International Energy Agency and the [Organization of Petroleum Exporting Countries](#) over the past week have all supported that belief, as have Turkey's plans to launch a cross-border attack into Iraq in search of Kurdish rebels. Traders are concerned any escalation of conflict between the Kurds and Turkey will cut oil supplies from northern Iraq.

Light, sweet crude for November delivery rose 40 cents to \$88.02 a barrel on the [New York Exchange](#), after earlier matching the trading record of \$88.20 a barrel set Tuesday.

Crude oil prices have risen almost 50% in the past year.



Some questions for discussion...

- Do you think the price of oil will stay high? Will it decline again? Will it keep rising higher? What factors will influence this?
- What would happen if the price of gasoline doubled again to near \$6/gallon? Would people curtail their driving habits? Buy more fuel efficient cars?
- Should the government place additional taxes on gasoline (like in Europe) to discourage gasoline consumption?



Non-conventional oil...

There exist further types of oil-like fossil fuels. These are generally considerably heavier and more viscous than standard crude oil, and are more difficult and expensive to extract and make use of.

Yet they exist in very large quantities and may become economically favorable to use if the price of crude oil rises (as it already has) and stays high (as remains to be seen).

Heavy oil, Tar sands, Oil shale.

First recall the basic crude oil numbers, as a basis for comparison...

World crude oil reserves	1,317 Billion bbl
U.S. crude oil reserves	22 Billion bbl
World oil consumption	31 Billion bbl/year
U.S. oil consumption	7.8 Billion bbl/year



U.S. oil consumption is roughly 1/4 world total, but U.S. oil reserves are much less.

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If we could simply use up this oil at the present rate, it would last

$$(1317 \text{ Billion bbl}) / (31 \text{ Billion bbl/year}) = 42 \text{ years}$$

However, world demand for oil is expected to rise by roughly 50% by 2030, while production rates may very well start to decline within the next decade or so (peak oil).

It seems likely that a gap will be opening between crude oil supply and demand. This is the situation that Hirsch discussed in his report, which we read at the beginning of the semester. Development of non-conventional oil supplies was the main direction he pointed.

Hirsch's list of ways to "mitigate" the shortage of liquid fuel supplies...

1. Fuel efficient transportation,
2. Heavy oil/oil sands,
3. Coal liquefaction,
4. Enhanced oil recovery,
5. Gas-to-liquids.

Non-conventional oil



Items 3 & 5 are also usually considered along with non-conventional oils.

We could think of items 2 - 5 as the most "business as usual" approaches to dealing with a liquid fuel shortage. They do nothing to address the problem of greenhouse gas emissions.

Nonetheless, these schemes will very likely be moving ahead and we should ask questions such as...

- What are heavy oil, tar sands and shale oil?
- Where are they found and in what quantities?
- What makes them hard to extract and use?

Heavy crude oil is any type of oil that does not flow easily (as opposed to light crude oil)... It is also heavier. Hydrocarbon molecules in heavy oil typically contain over 60 carbon atoms. Heavy oil typically has higher impurity levels (e.g. sulfur) than light oil.

Heavy oil, like the oil in tar sands, is more difficult, and hence more expensive, to extract, transport and refine than light oil. For example, steam must be injected into wells to heat up the heavy oil so that it flows. Wells must be spaced more closely together.

However, world reserves of heavy oil and tar sands are twice as large as light crude oil reserves!

Venezuela has conventional oil reserves of 77 billion barrels, but non-conventional reserves of 1200 billion barrels in its Orinoco tar sands, almost as big as the world's conventional oil reserves. Canada has a similarly large reserve of non-conventional oil, the Athabasca oil sands of Alberta.



<http://www.dollardaze.org/blog/images/heavyoil/Orinoco.gif>

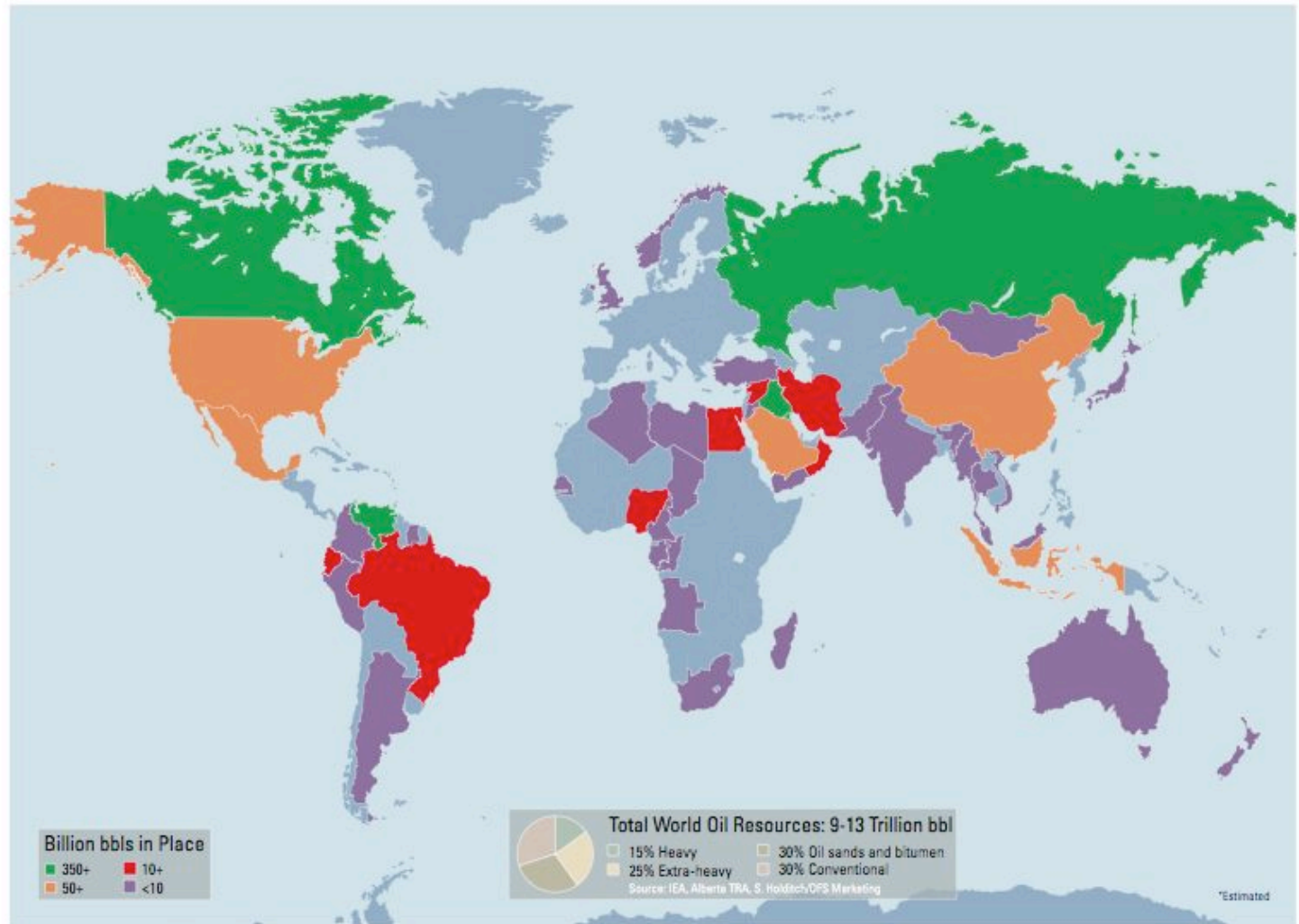
The deposits in both of these regions are considered economically viable at current oil prices.



http://en.wikipedia.org/wiki/Athabasca_Tar_Sands

Production in Canada's Athabasca Oil Sands is currently at 1 million bbl/day, and is projected to increase to 4 million bbl/day by 2015. (This would be comparable to Saudi Arabia's Ghawar field) The U.S., China and India are all looking for substantial shares in this increased production.

Including heavy oil alters the map of world oil reserves quite considerably.



Physics 190E: En
Fall 2007

www.heavyoilinfo.com

Worldwide Heavy Oil Reserves by Country

Schlumberger

Oil shales are sedimentary rocks containing substantial amounts of **kerogen**. Kerogen is a mixture of organic , such as that can be processed into hydrocarbons.

It is believed that kerogen represents a prior stage in the formation of oil and natural gas. If sufficient geological heat has not been applied, the transformation into hydrocarbons is incomplete, leaving oil shale.

World reserves of oil shale are said to be equivalent to 2600 billion bbls of oil, again twice world reserves of conventional light crude oil.



Oil shale deposits are concentrated in the United States, with about 2,000 Billion bbl of reserves concentrated in the Green River formation of Colorado, Utah and Wyoming! This is extremely attractive from an energy security point of view.

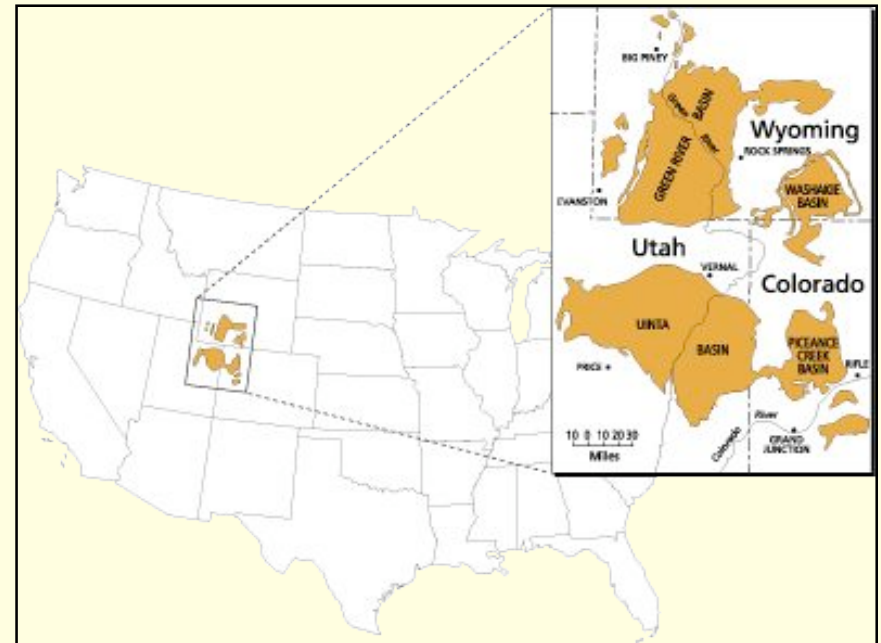
However, the technology to exploit oil shale is expensive and has not yet been developed on a commercial scale.

Oil shale must be heated to render an oil like liquid from it, a process called retorting. Technology for large scale retorting has not yet been developed and will require substantial research and capital investment.

A Rand Corporation report (2005) estimates that production at the 1 million bbl per day level is at least 20 years off, and production at the 3 million bbl/day level is at least 30 years off.

The retorting process also has substantial environmental impacts. It requires vast quantities of water and releases large amounts of CO₂.

Source: <http://www.netl.doe.gov/energy-analyses/pubs/Oil%20Shale%20Development%20in%20the%20United%20States%20-%20RAND%20August%202000.pdf>

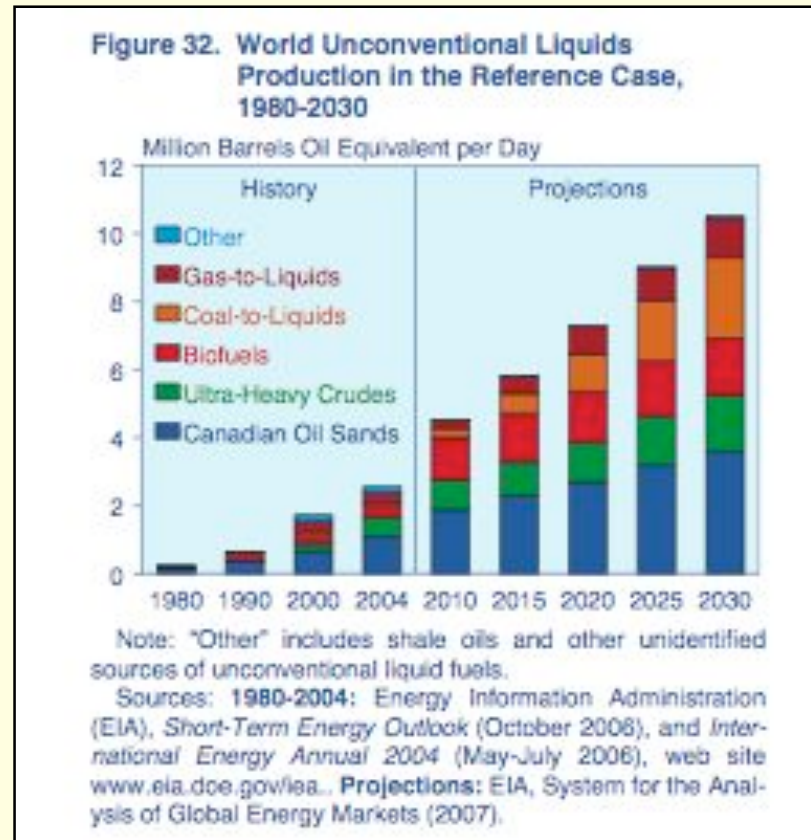


<http://www.rand.org/publications/randreview/issues/fall2005/energy2.html>

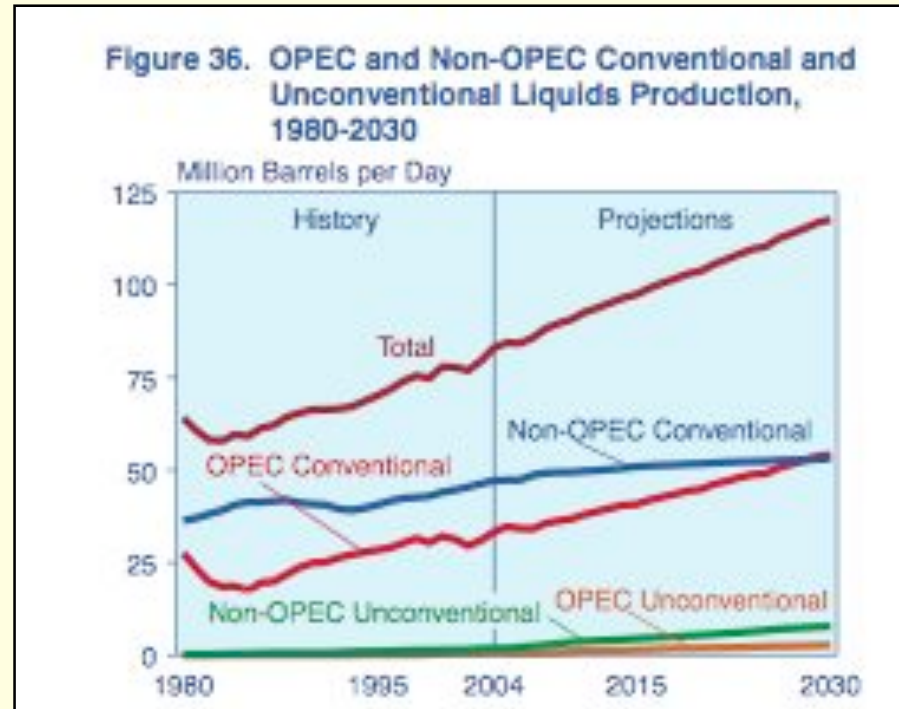
Oil shale development is encouraged under the Energy Policy Act of 2005. It would be a good paper topic to look into what has happened since...

Coal Liquefaction.....Liquid “synthetic gasoline” can be made from coal by a variety of catalytic processes. This was widely done in Germany during World War I and World War II, because they lacked crude oil supplies. In contrast to shale oil, coal liquefaction techniques are well established.

EIA projections assume that non-conventional liquid fuel production will more than triple by 2030.



Although non-conventionals still make up only a small component of total supplies...



Now, we'll get back into some science **the greenhouse effect.** Let's try to understand what it is, how it works and the role played by CO₂ and other greenhouse gasses?

Why does a real greenhouse stay warm inside? The glass lets in the sun's rays, warming up the plants, soil and air inside, but then blocks the warm air from escaping.

The greenhouse effect for our planet makes the near Earth atmosphere warmer than it would otherwise be without the presence of heat trapping gasses.

The greenhouse effect is very well established scientifically. Without it, as we'll see, Earth's surface would be much colder, below the freezing point of water & life as we know it would not have evolved.

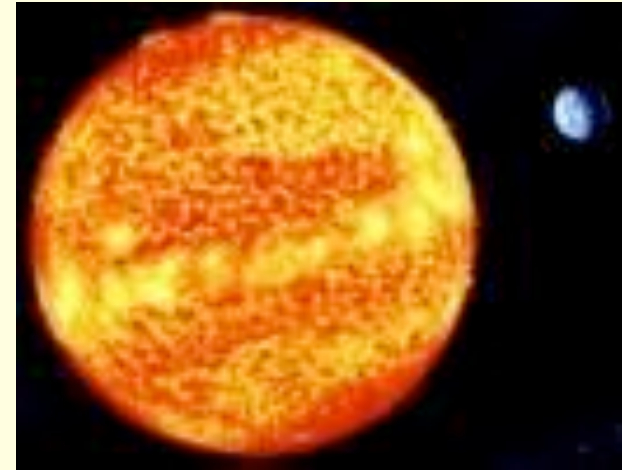


The Royal Greenhouses of Laeken in Brussels.

Before we try to understand how the greenhouse effect works, we'll calculate what Earth's temperature would be without it.... This requires some physics!

Roughly speaking, Earth's temperature is set by an energy balance with the Sun. Every day the Earth absorbs energy in the form of light from the sun.

Every day the Earth must radiate away this same amount of energy. If it doesn't, it will either heat up, or cool down. How much the Earth radiates depends on its temperature. If its temperature increases, it radiates more and vice-versa.



Let's look at all the pieces of this process, starting with the Sun. Where does the Sun's energy come from?