Fossil Fuels

By

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What are Fossil Fuels?

Fossil fuel" is a term for buried combustible geologic deposits of organic materials, formed from decayed plants and animals that have been converted to crude oil, coal, natural gas, or heavy oils by exposure to heat and pressure in the earth's crust over hundreds of millions of years.

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What kind of fossil fuels are out there?

- Coal and relatives
- Petroleum
- Gas
- Oil Shales
- Tar Sands
- Methane Hydrates

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Roman Quarry

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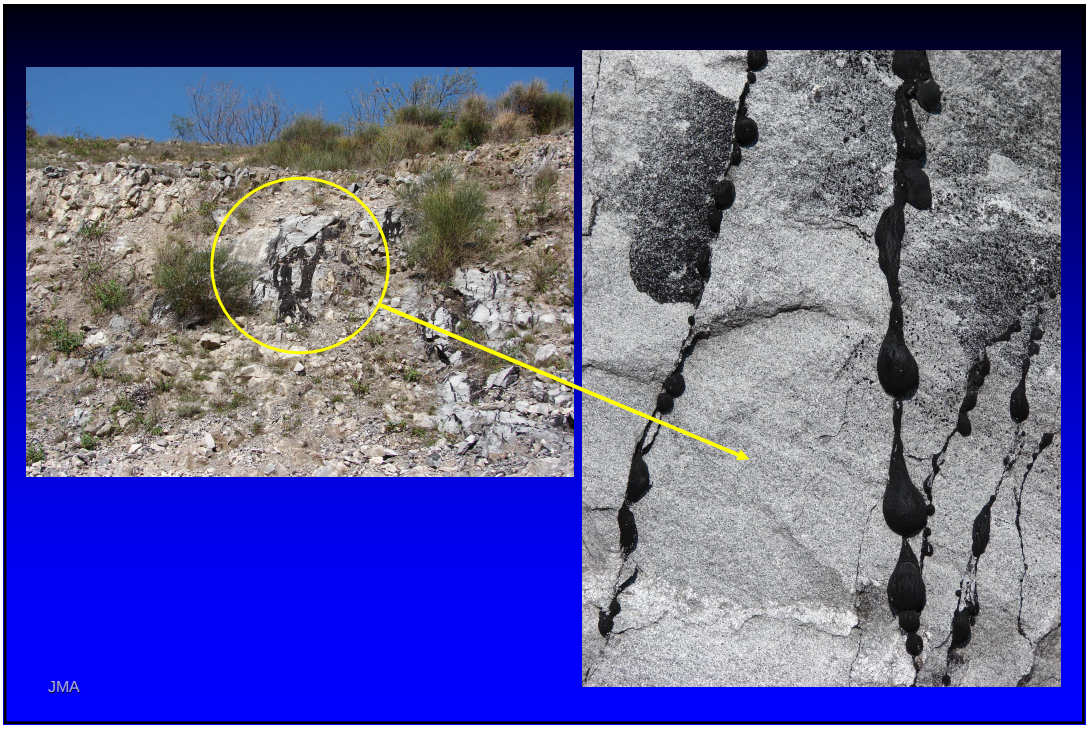

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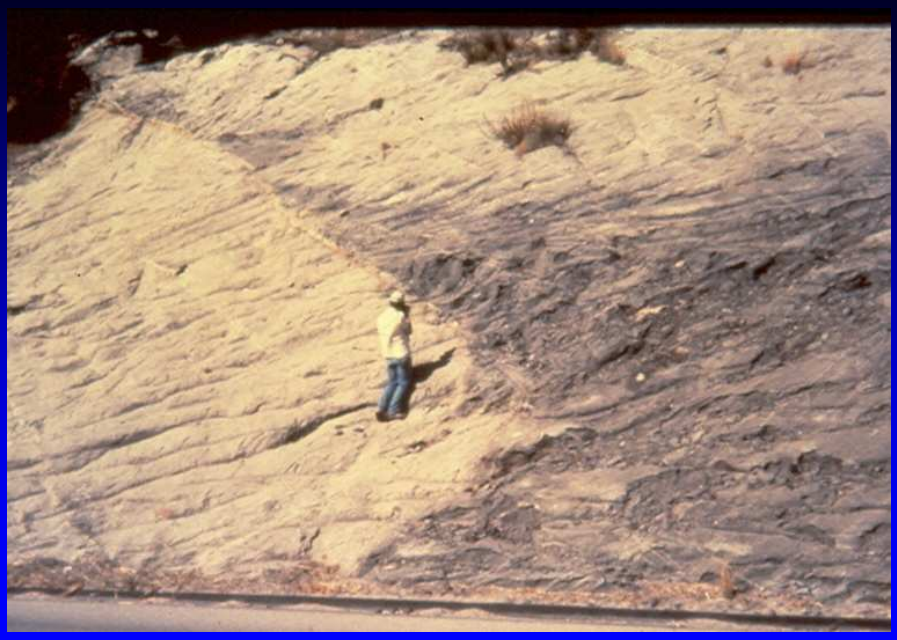

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Fossil Fuels Uses

- PRIMARY energy resource (all other resources depend on it)
- Fertilizers
- Chemical Industry and plastic

Excluding wood, 90% of the world energy is produced by fossil fuels (oil 40%, gas, coal)

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Change in Primary Energy Sources

- Up to pre-fire civilization – Carbohydrates
- From the discovery of fire to 1700 – Wood
- From 1700 to 1900 – Coal
- From 1900 to present – Oil/gas
- From today to the future – Hydrogen ???

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Dilithium?

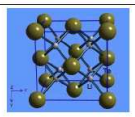

Figure 6. **Crystal structure of "dilithium" (dilithium telluride). Courtesy Dr. Mark J. Winter, University of Sheffield, UK)"**

DILITHIUM Li_2Te

Crystallography

Cubic, pseudo-orthorhombic, space group *m*3*m*.

Unit cell data: *a* 6.504 Å, *b* 14.55 Å, *V* 275.13 Å^3, *Z* 12.

Class 222, *a*:*b*:*c* = 0.5271:1:0.5271.

Morphology: Occurs as well-formed to coarse crystals up to fist size. Similar in appearance to quartz. Tabular form thin in one direction along [010].

Twinning: none observed.

Crystal structure: Four coordinate tetrahedral prototypical antifluorite structure.

X-ray powder diffraction data: 3.7400 (80) (111), 3.2517 (50) (200), 2.2993 (80) (220), 1.9609 (100) (311), 1.4920 (50) (331), 1.4542 (50) (420), 1.3275 (50) (422), 1.2516 (50) (333), 1.0993 (50) (531), 0.9107 (50) (711), 0.8696 (50) (642), 0.8472 (75) (553)

General Appearance

Oblong crystals from a few centimeters to approximately 30 centimeters usually free from other minerals. May be partially altered to ilsim 629.

Physical Properties

Luster adamantine to resinous; transparent to translucent; white, pale pink, amber brown or bottle brown with a white streak. Tribeluminescent. Hardness 5, very brittle, Cleavage [001] distinct; fracture conchoidal.

Density: 3.240 g/cm^3 (meas.), 3.42 g/cm^3 (calc.).

Optical Properties

Uniaxial (+); ω = 1.952-1.984, ε = 1.971-2.010.

Chemical Analytical Data

The ideal formula requires: Li 9.81 %, Te 90.19 %. Total 100.00 wt.%.

Localities

Rigel XII, Rigel system. Dvena IV. Coridan. Rura Penta, Klingon Empire.Troyius. Vaska. Interplanetary asteroids, Halkon system. Dozaria system. Remian mines on Remus, a planet in the Romulan system.

Occurrence

Silica-poor planetesimals which did not undergo significant parent-body metamorphism during formation.

Relationship to Other Species

Polymorph with neodilithium.

Name

Named after its composition.

Comments

Not IMA Approved. Also referred to as 2(5)6 Dilithium 2(-)1 Diallosilicate 1:9:1 Heptoferranide (of Krauss, 1995), Lithium (I) Telluride, Lithium crystal (part). Only known substance other than neodilithium that allows anti-hydrogen to pass through its structure without coming in contact with it.

REFERENCES:

BARTHELMY, D. (2004): *Mineralogy Database*. http://www.webmineral.com

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KRAUSS, L. M. (1995): *The physics of Star Trek*. Basic Books, New York, New York, 97.

WINTER, M. (2002): *WebElements, Professional edition*. University of Sheffield, England. http://www.webelements.com

ZINTL, E., HARDER, A., and DAUTH, B. (1934): Dilithium Telluride. *Zeitschrift für Elektrochemische Angew. Physik und Chemie* 40, 588.

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Until now the change in primary energy sources have been caused by changes in technology not by the total depletion of an energy source.

" The stone age did not finish, because cavemen run out of stones "

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Fossil Energy Problems

1.Possible short term depletion
2.Global warming

There are no predictive models based on history.
There is a strong political approach to these problems that are important for our way of living and for the greenhouse effects:

Problem n°1
•Right wing – Nuclear energy
•Left wing – Save energy
Problem n°2
•Right wing – The problem does not exist
•Left wing – The problem is catastrophic

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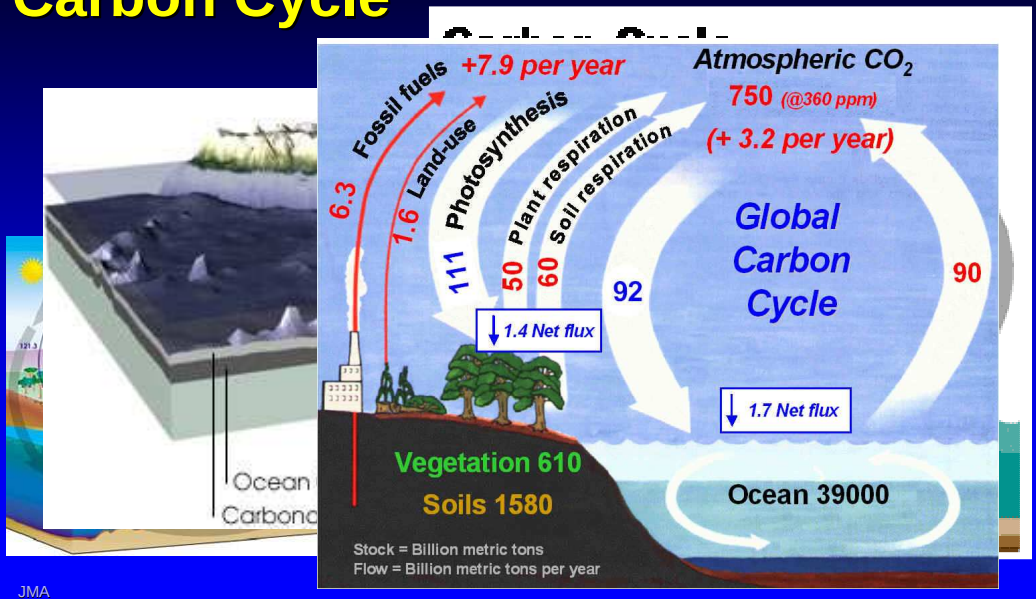
Carbon Cycle



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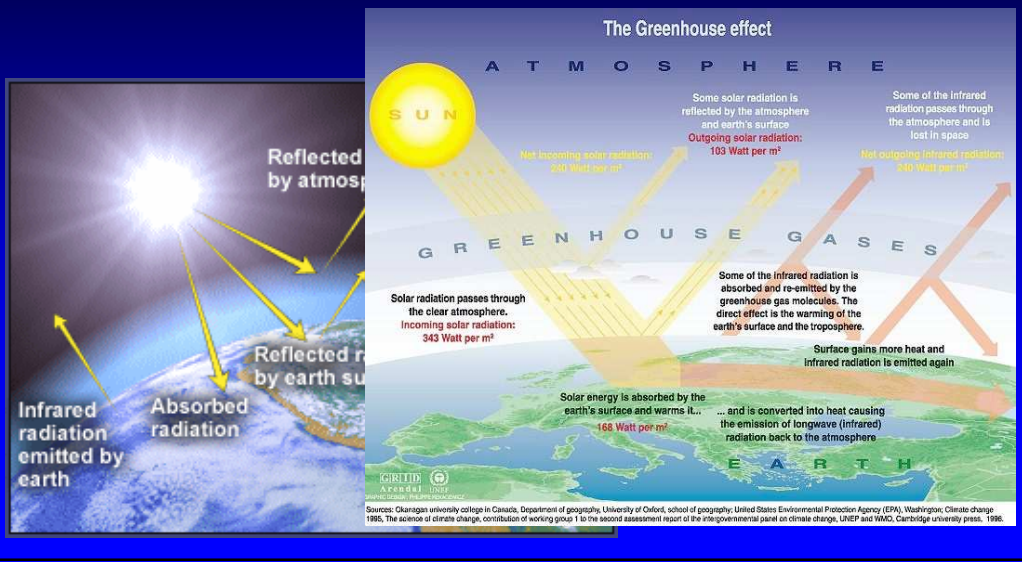
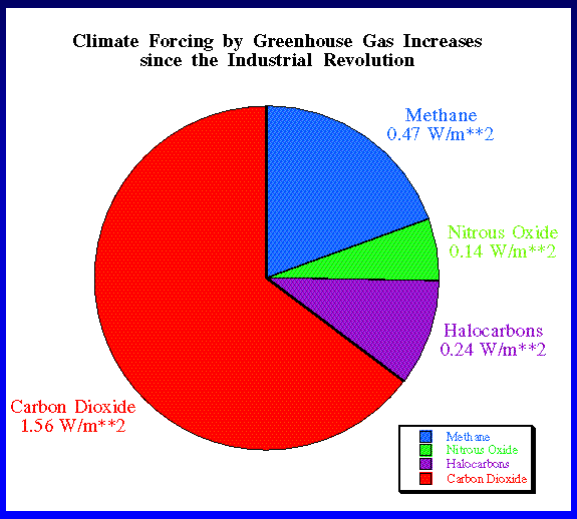
Greenhouse Effect



Greenhouse gases



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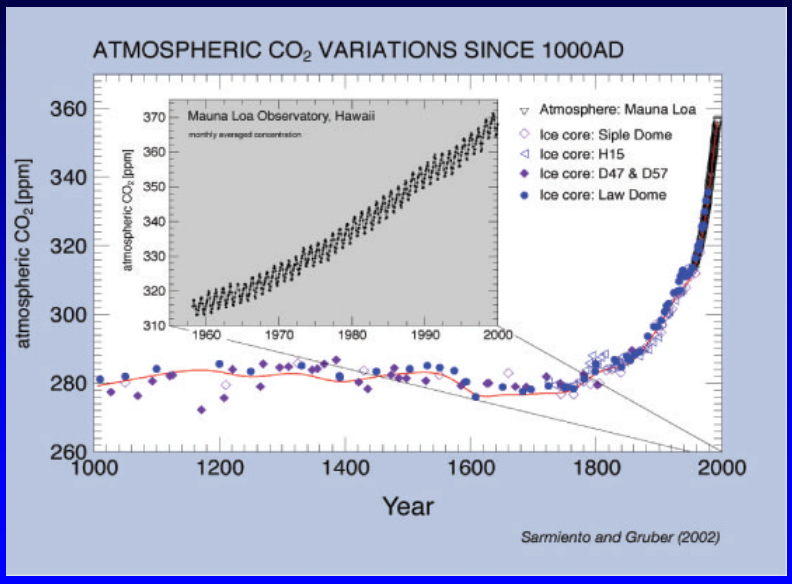
Increase in Atmospheric CO2



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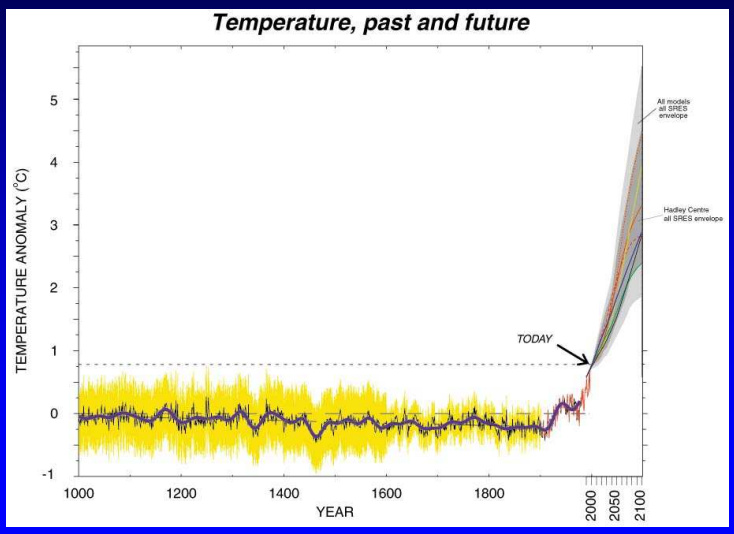
Temperature trends



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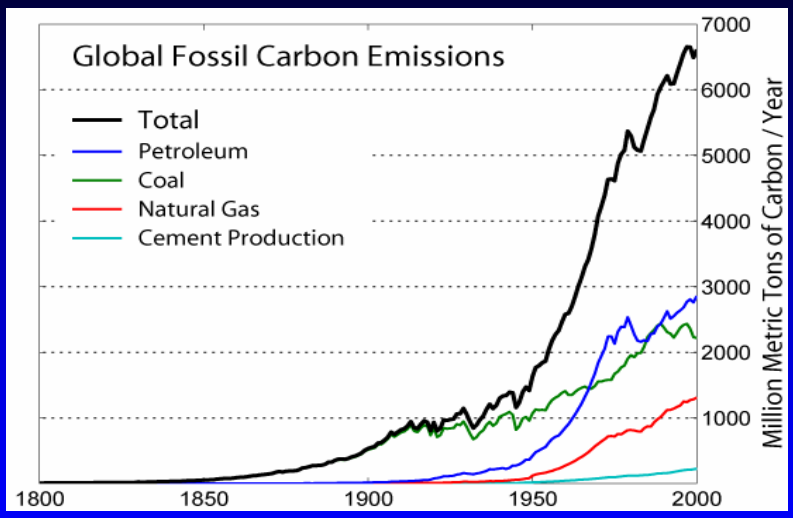

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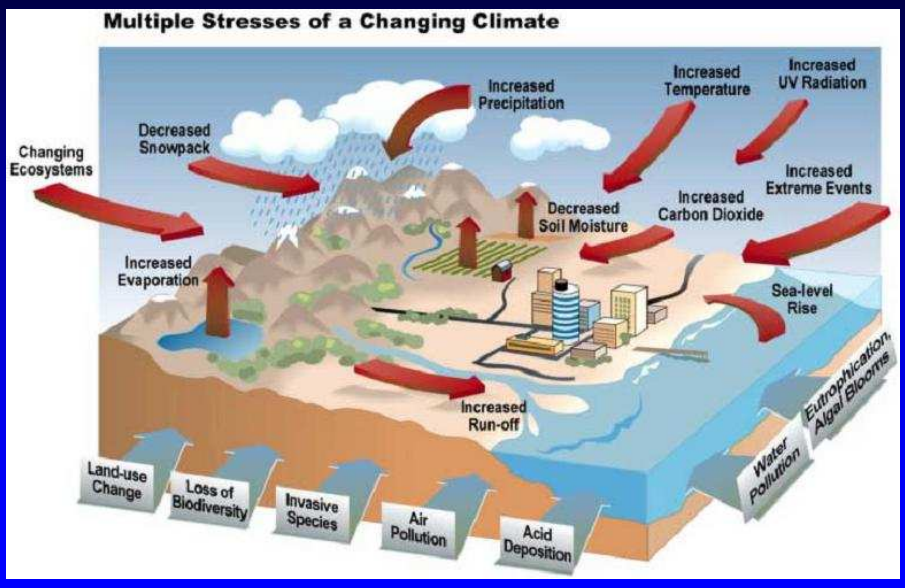
Does it matter?



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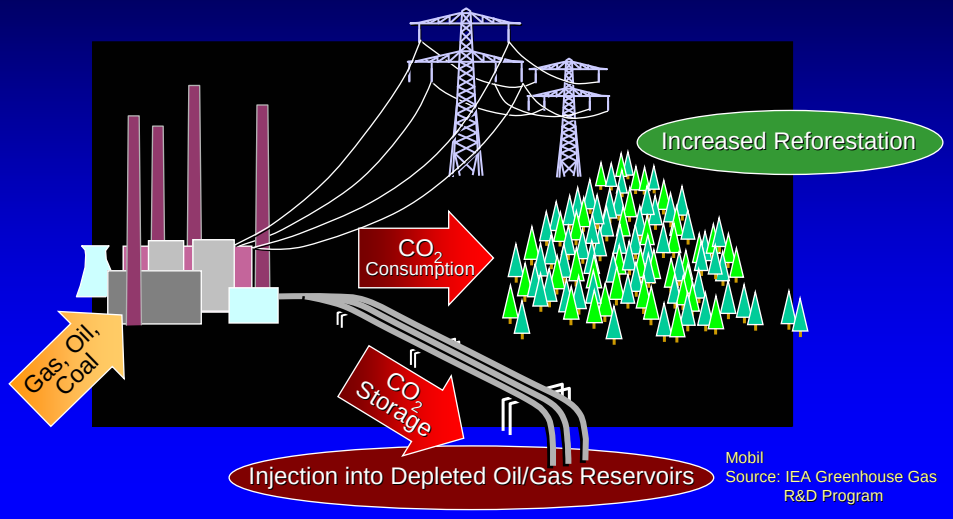
CO_2 Capture and Storage

Potential for Reducing CO_2 Emissions from Fossil Fuel Power Generation



Mobil
Source: IEA Greenhouse Gas R&D Program

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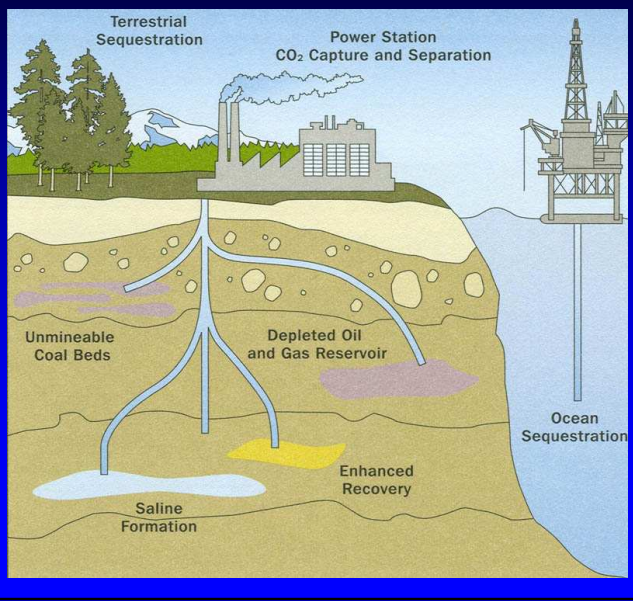
CO2 Sequestration



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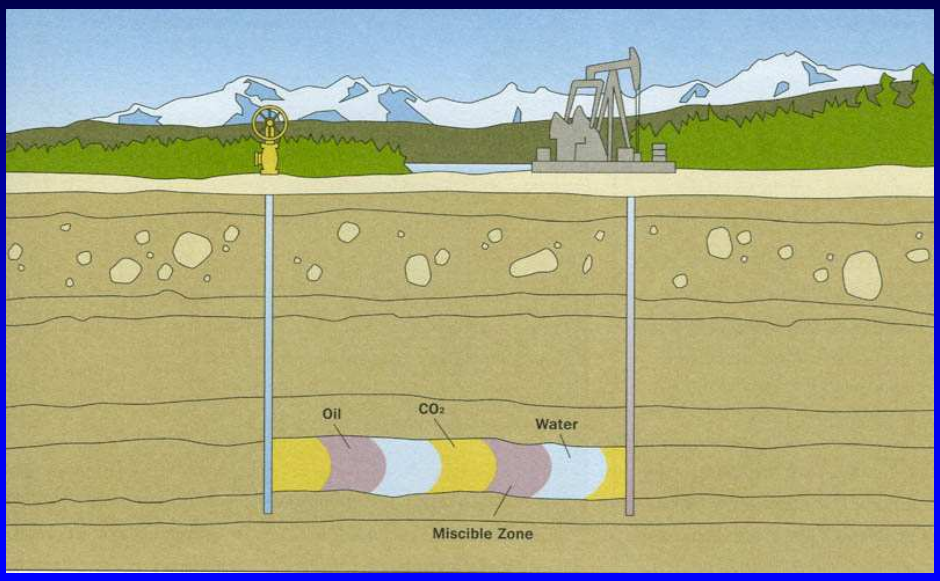
CO2 Sequestration



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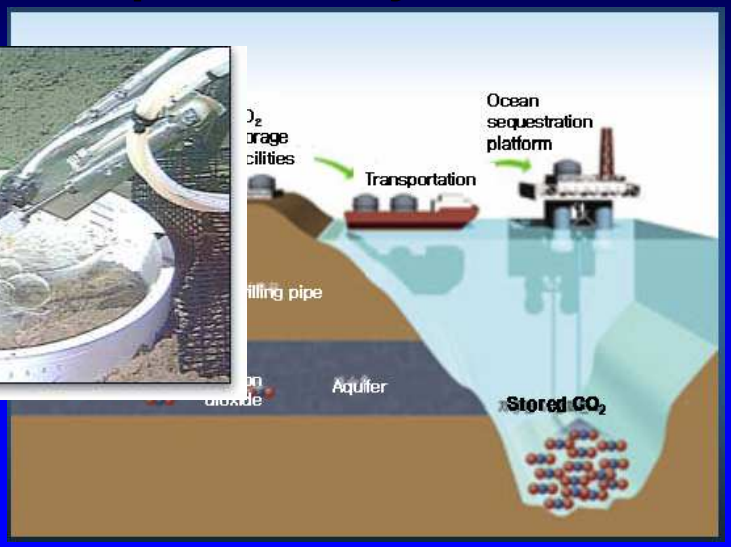
CO2 Sequestration in Oceans to make CO2 hydrate liquids or crystals



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Is it enough? …. Bottom line

- Winners
- Losers

- ADAPTATION …… only viable solution

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Myths about Fossil Fuels, the Energy Market and the Energy Industry

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1. The world is running out of oil and gas.
2. The fossil fuels industry determines the price of oil and natural gas.
3. The ff energy industry is low tech.
4. The ff industry is environmentally insensitive.
5. Oil and gas can be easily and economically replaced with renewables in the next few years.
6. There is no future working in the ff industry.
7. Quality of life and GDP are not significantly influenced by energy use.

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Myth: The world is running out of oil and gas.

Reality: Oil and Natural gas will continue to be the primary energy sources for years to come.

Unconventional oil and gas will become increasingly more important.

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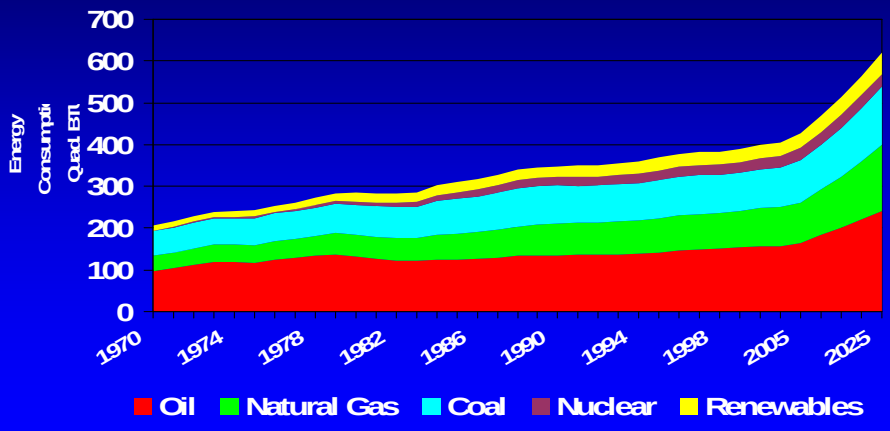
World Demand for Fossil Fuels Will Continue to Grow



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Source: EIA, International Energy Outlook 2004

1 Btu = 0.252 cal

Primary Energy Demand (10^{15} btu)

	2010	2015	2020	2025
• Petroleum	185	204	224	245
• Natural Gas	108	122	139	156
• Coal	108	117	127	140
• Nuclear	30	31	32	30
• Other	39	43	47	50

Source: Energy Information Administration, U.S. Department of Energy

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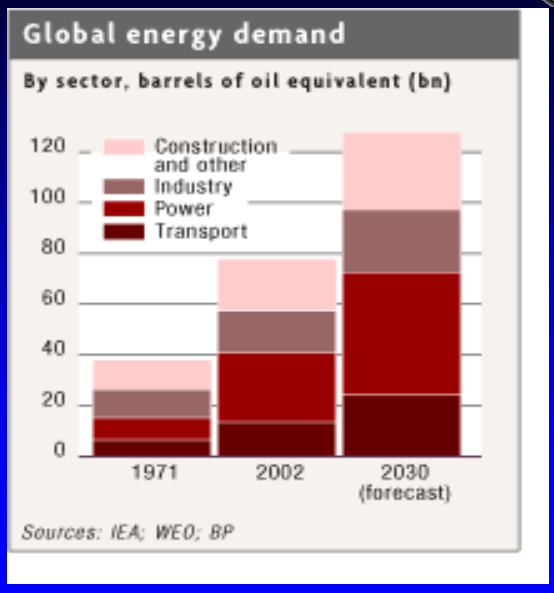
Global Energy Demand

by sector, billions barrels of oil equivalent



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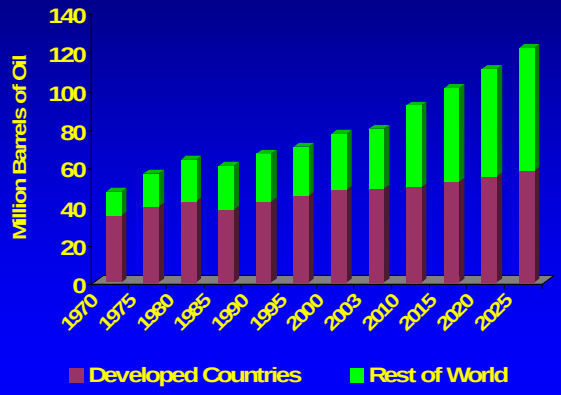
Source: Martin Wolf. "Why the energy revolution will continue to power ahead," *The Financial Times*, 28 June 2006, p. 17.

Petroleum Consumption in Developing Nations Will Exceed Developed Countries by 2025



Source: EIA, International Petroleum Monthly, June 2004; Projections, EIA Annual Energy Outlook, 2004

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- Where will all this oil and gas come from?
- Well, most of the places would not be on your list of top vacation destinations.

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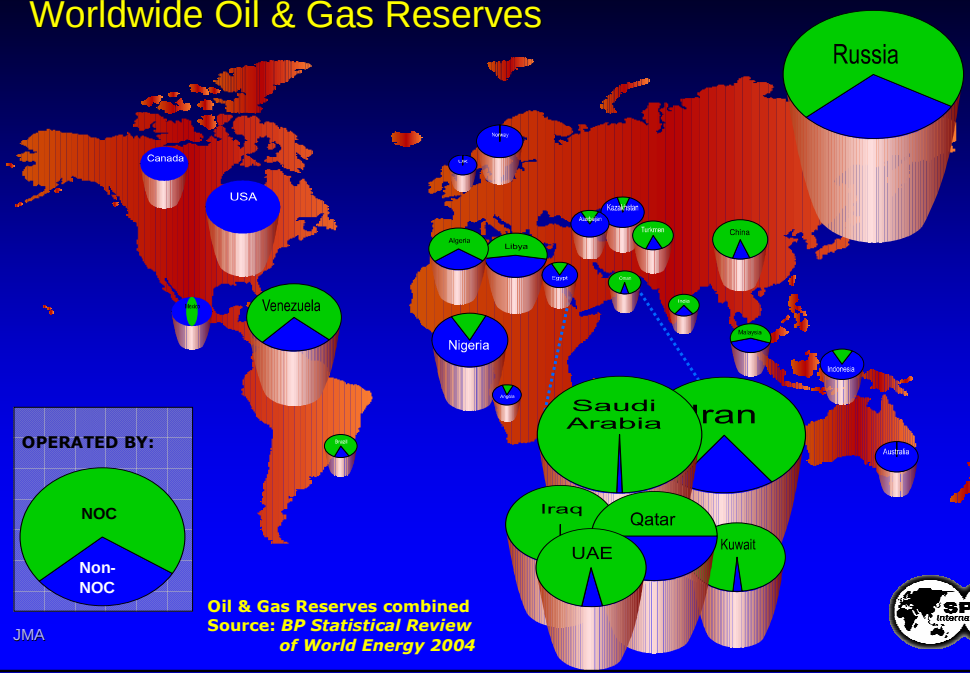
Worldwide Oil & Gas Reserves



Oil & Gas Reserves combined
Source: *BP Statistical Review of World Energy 2004*

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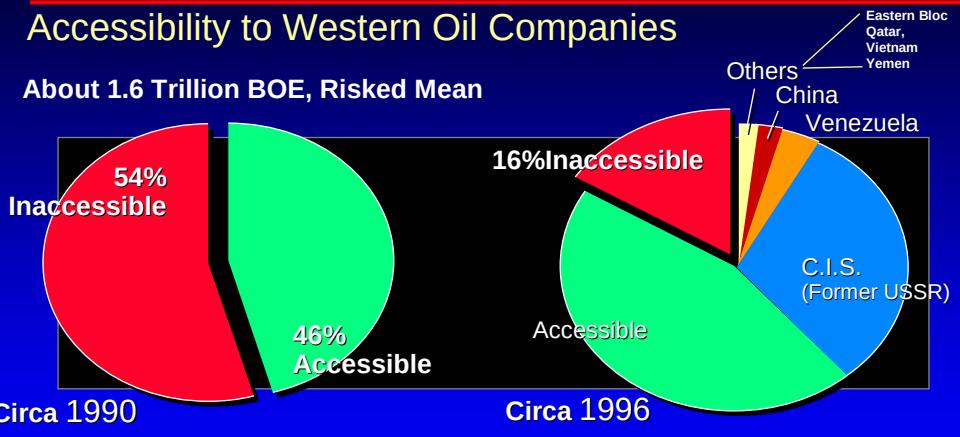
Global Undiscovered Potential

Accessibility to Western Oil Companies

About 1.6 Trillion BOE, Risked Mean



The recent opening to exploration of previously inaccessible areas has created a window of opportunity which has never been equaled before and likely will never be seen again.

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Global Exploration

Opportunities for Future Growth

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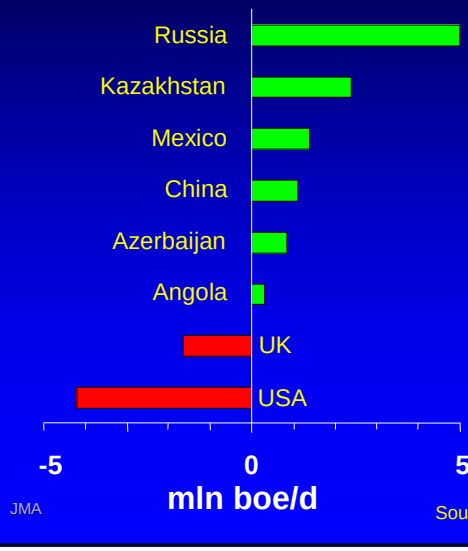
Where to go… Countries with Growth Potential

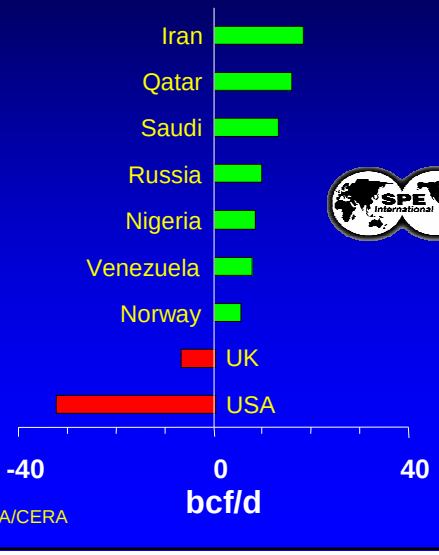
Oil

Capacity 2030 vs. 2000



Gas

Capacity 2030 vs. 2000



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Source: IEA/EIA/CERA

Most of the oil and gas going forward will not come from new fields

Primary Sources of Oil and Gas

- **To 1960** — **50-60% from new fields**
- **To 1990** — **20-25% from new fields**
- **Today** — **12-15% from new fields**
- **Tomorrow** — **7-10% from new fields**

Thus, new discoveries, while important, will not significantly impact future oil supply. At a modest 5% decline rate and 2.5% demand growth, we will have to add 6,250,000 bpd of new oil production next year, with larger increases in following years

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The Importance of Mature Fields

- **To date, we have produced approximately 1 trillion barrels of oil from existing fields**
- **Recovery rates of oil in place have averaged 15% to 18% worldwide**
- **If we increase our recovery rate in these existing fields to 35%, we will add another trillion barrels of recoverable oil reserves to the global inventory**
- **The same is true for natural gas**

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Unconventional Resources
CRUDE OIL

- **Oil Shale** - Shell has a large investment in this and will soon begin a pilot project in Southern Wyoming (in-situ recovery method)
- **Tar Sands** - If Canada counts these as reserves, they are right behind Saudi Arabia in amount of oil
- **Heavy Oil** - If Venezuela counts these as reserves, they are right behind Saudi Arabia in amount of oil

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Unconventional Resources
NATURAL GAS

- **Coal Bed Methane** - currently 13% of the US gas produced
- Shale gas - at recent ATW it was estimated that there are 40-120 BCF reserves/sq mile
- **Tight Gas and Ultra-tight Gas** 0.01 μD (0.00001md)
  - the largest gas discovery in the US in the last 15 years is the Jonah Field in Wyoming with an estimated 8-15 TCF in reserves which is ultra-tight
  - Wells drilled on 10 acre spacing with $1-2 MillionUS/frac job
- **Gas Hydrates** - worldwide estimated to be 70 to 130 times the proven reserves of conventional natural gas

What for the future?

Hedberg Resource Conference Conclusions 2007

- Peak oil production is not imminent.
- Nevertheless, peak oil is foreseeable (2020-40).
- A continuous decline in world oil production is inescapable in the latter half of the 21st century.
- The "peak" most likely will be a high plateau for a few decades.
- Production will grow slowly to the peak plateau.
- Peak plateau production is likely to be between 90-100 million bod, which is 0.75-1 percent of ultimate world oil resources.
- Peak plateau spans mid-point in cumulative world oil production.
- Achieving this production will require a massive, sustained industry effort for the next 40-50 years.
- Achieving this production will require an accommodating political environment.

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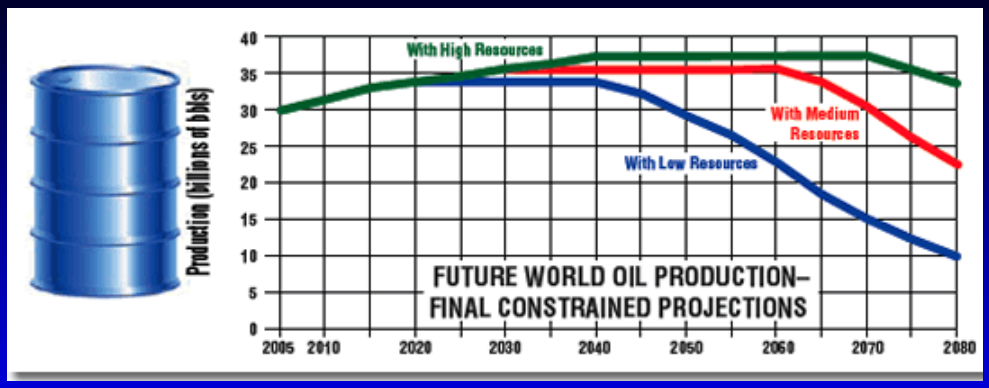

World oil production will reach a peak plateau by 2020-40. This was one of several key implications of a Hedberg Research Conference released at the AAPG Annual Convention in Long Beach.

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Global energy mix

Today

- 85.5 percent = fossil fuels (oil, gas, coal)
- 14.5 percent = nuclear and all other sources

By 2025

- 87 percent = fossil fuels (oil, gas, coal)
- 13 percent = nuclear and all other sources

-- Source:Energy Information Administration

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Oil and Gas Supply Summary

- Over the next 25 years, oil and gas demand will rise dramatically, primarily in developing countries
- There is sufficient oil and gas to meet increases in demand
- But:
- Most conventional oil and gas is located in remote, potentially unstable areas
- The bulk of new supply will have to come from more expensive mature assets and unconventional resources

Myth: The oil industry is low tech.

Reality: The oil and natural gas industry is very high tech.

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The petroleum industry uses more computing power on a daily basis than any other industry except the entertainment industry.

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NASA uses petroleum engineering technology to drill on Mars

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Petroleum Industry Scientists

Geologists
Geophysicists
Hydrologists
Petroleum Engineers
Chemical Engineers
Civil Engineers
Electrical Engineers
Mathematicians
Chemists
Physicists

Both Research and Applications

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Petroleum Industry Breakthroughs

1883	Anticlinal Theory	Concept of 'Where-to-Drill'
1900's	Rotary Drilling	Drill deeper
1914	Seismograph	1D Subsurface imaging
1924	Well Logging	Subsurface rock and fluid properties
1930's	Offshore Drilling	Access to new areas and basins
1960's	Digital Computer	2D Subsurface imaging & data management
1970's	Directional Drilling	Access to areas with surface obstacles
1980's	3D Seismic	More precise subsurface imaging
1990's	3D Simulation Basin and Reservoir	Predicting fluid movement

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Myth: The oil and gas industry determines the price of oil and natural gas.

Reality: Supply & demand, global instability and fear of supply disruptions determine oil prices. Gas is priced regionally and responds to regional demand.

Issues of oil and gas pricing

- Supply and demand
- Political and economic instability in major producing regions coupled with unreliable reserves estimates for those regions
- Price point panic on the markets and with traders
- The oil and gas industry does not want $65 oil or $10 natural gas any more than you do


Unleaded Plus
327 9/10
Performance Plus
339 9/10
High Performance
349 9/10

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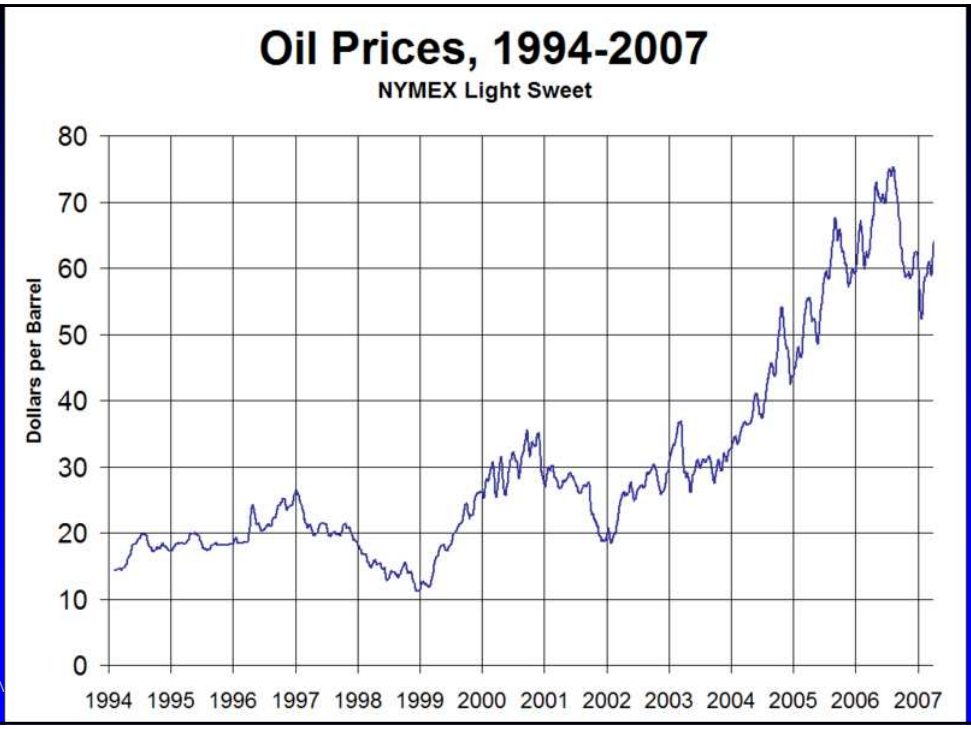
Oil Prices, 1994-2007
NYMEX Light Sweet
Dollars per Barrel
80
70
60
50
40
30
20
10
0
1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007

Costs/Barrel of Oil - At Well Head

1999 USA

	$24/BOE	$12/BOE
Exploration	$2.60 (11%)	$1.70 (14%)
Development	$6.00 (25%)	$5.10 (43%)
Operations	$3.00 (12%)	$2.00 (17%)
Tax	$2.40 (10%)	$1.20 (10%)
Basic Costs	$14.00/B (58%)	$10.00/B (84%)
Margin	$10.00/B (42%)	$2.00/B (16%)

50% Market decline → 500% Margin decline

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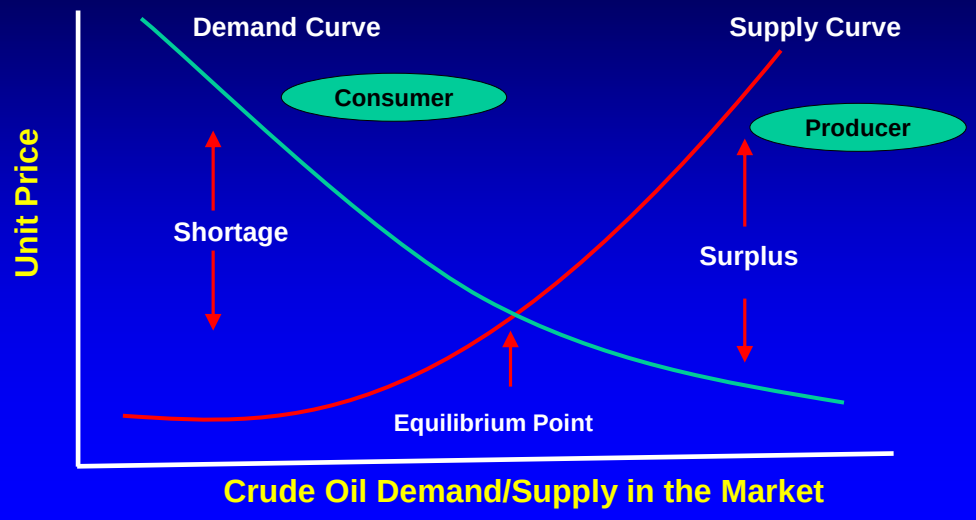
January 1999 Estimates

Supply and demand curve basics



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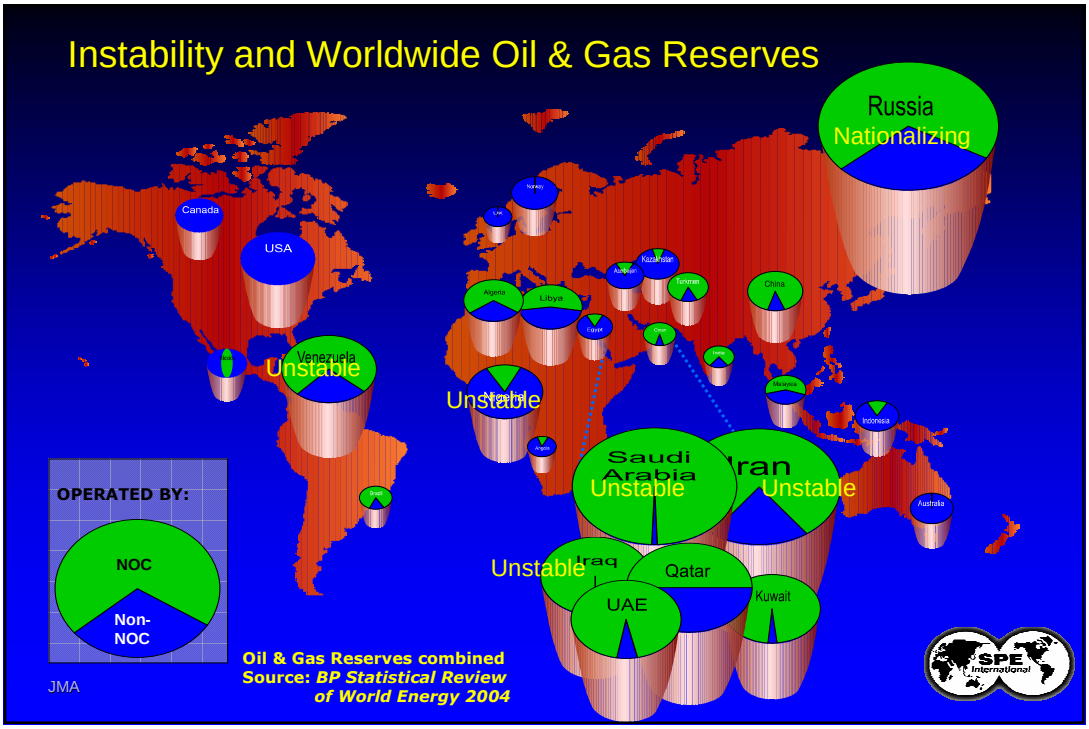

The spot and futures markets

- Fear that wars, political maneuvering and/or nationalizations will disrupt oil and gas supplies leads market traders to buy and hedge upwards to guarantee supply
- This probably accounts for as much as $ 50-100 of the price of a barrel of oil today
- Most producers would be happy with an oil price of $35 to $40 per barrel

“The Stone Age did not end for lack of stone, and the Oil Age will end long before the world runs out of oil.”

Sheikh Zaki Yamani

Source: “The End of the Oil Age” *The Economist, 25 October 2003.*

Myth: The oil and natural gas industry is environmentally insensitive.

Reality: The oil and natural gas industry operates in a safe and environmentally responsible manner. The oil and natural gas industry will be part of the CO_2 solution.... Let’s not get carried away now!

Drilling Site at Yariapo, Bolivia

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Source:www.planete-energies.com

Drilling Site at Yariapo, Bolivia after restoration

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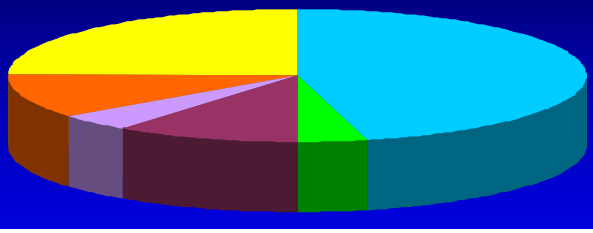
Source: www.planete-energies.com

Natural Seeps Contribute 46% of the Oil in Oceans Worldwide
E&P Accounts for Less Than 4% Worldwide



- Natural Seeps
- Offshore Oil & Gas Extraction
- Marine Transportation of Petroleum
- Atmospheric Deposition
- Municipal/Industrial Runoff
- Other Consumption Sources

Source: National Research Council, "Oil in the Seas," Table 3.2, 2002

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