Die Versorgungssicherheit Europas mit Kohlenwasserstoffen

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World oil production by source in million barrels per day

Source: WEO-2004, IEA.
Evolution of proven oil reserves as a function of time

Source: WEO-2004, IEA.
History:

- 1920  US Geological Survey announced peak oil
- 1939  US Department of Interior: Oil reserves for 13 more years
- 1972  Club of Rome: Limits of growth
- 1977  US President Jimmy Carter: „We are running out of oil

- Reserves = f (Price, world economics, availability, cost, salaries, technical or fiscal measures, political boundaries, speculations etc.)
DEFINITIONS

Reserves:

Reserves are the estimated quantities of hydrocarbons that are claimed to be recoverable under existing economic and operating conditions. The total estimated amount of hydrocarbons in a reservoir, including both producible and non-producible hydrocarbons, is called oil/gas in place.

Resources:

Resources are those quantities of hydrocarbons estimated, as of a given date, to be potentially recoverable from accumulations, but the applied project(s) are not yet considered mature enough for commercial development.
IEA “Resources to Reserves” 2005

Available oil in Billion Barrels

Economic price 2004 US $

- Already Produced
- OPEC ME
- Other Conv.
- EOR
- Heavy oil Bitumen
- Oil Shales
- Arctic
- Deep Water
- Super Deep

WEO required Cumulative 2030

Schlumberger
LARGEST OIL RESERVES

World Proved Oil Reserves
by Geographic Region as of
January 1, 2007

- Middle East: 739
- North America: 213
- Africa: 114
- Central and South America: 103
- Europe: 15
- Russia: 33
- Asia: 100

World Total: 1,317 Billion Barrels

Crude oil and NGL reserves at end-2003, according to various sources

Source: WEO-2004, IEA.
World proven reserves of natural gas in trillion cubic metres

World total: 180 tcm as of 1 January 2004

Source: WEO-2004, IEA.
WORLD OIL SPARE CAPACITY

Source – International Energy Agency; SWP
GLOBAL CONSUMPTION OF OIL PER CAPITA

- U.S. & Canada
- Other Industrialized
- Rest of World
- Total World

Gallons per Day per Capita
World hydrocarbon resources

Based on USGS and IEA data.
OIL AND GAS RESERVES
TOTAL WORLD OIL RESERVES

- Oil Sands Bitumen: 30%
- Conventional Oil: 30%
- Extra Heavy Oil: 25%
- Heavy Oil: 15%
SANDSTONE RESERVOIR ROCK
RESIDUAL OIL

Oil remaining in small pores

Water having displaced oil in large pores

Water on rock grain surfaces (water wet rock)
Example of cores of oil-bearing rock

Photo courtesy of Neil O'Donell, Keyano College, Ft. McMurray, Alberta (Canada), with thanks to Maurice Dusseault, University of Waterloo (Canada).
Oil Recovery Factors:

1979: 20%
2000: 35%
> 2000: 50%

Average increase of the RF: 0.2 – 1% / year
1% Increase = Annual consumption
IMPACT OF TECHNOLOGY ON NORTH SEA PRODUCTION

Source: European Network for Research in Geo-Energy - ENERG - courtesy of Shell.
EXAMPLE OF CONVENTIONAL WELL CONSTRUCTION

Courtesy of Schlumberger.
Sketch of casing (blue) being expanded by an expanding tool pulled from bottom to top
FUTURE OIL AND GAS DEEPWATER POTENTIAL UN THE WORLD

Source: Wood Mackenzie; courtesy of Shell.
EVOLUTION OF DEEPWATER TECHNOLOGY

Cognac 1978
Bullwinkle 1988
Conoco 1989
Petrobras 1989
Auger 1993
Mars 1996
Ram-Powell 1997
Ursa 1999
Petrobras 1997
Mensa 1997
Petrobras 1999
Na Kila 2003
2030 ???

600 m
800 m
1000 m
1200 m
1400 m
1600 m
1800 m
2000 m
2200 m
2400 m
3500 m

Courtesy of Shell.
EVOLUTION OF DRILLING TECHNOLOGY

- Vertical wells
- Deviated wells
- Horizontal wells
SCHEMATICS OF MULTILATERAL WELLS

Multilateral Well Configurations

- Multibranched
- Forked
- Laterals into horizontal hole
- Laterals into vertical hole
- Stacked laterals
- Dual-opposing laterals

Layered reservoirs

Fractured reservoirs

Shallow or depleted reservoirs

Courtesy of Schlumberger.
3 D SEISMIC

Courtesy of Schlumberger.
Water, in blue, has swept out the oil but left some channels still containing oil (high concentration in yellow and red, lower concentration in green). The oil may have been left behind because, for example, the channels have lower permeability.

This illustration, not based on factual data, is reproduced from Yeten 2002, courtesy of Fikri Kuchuk, Schlumberger.
HEAVY OIL
HEAVY OIL - RESOURCES

Barrels in place:
- 1 billion
- 10 billion
- 100 billion
- 1 trillion

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SCHEMATIC OF SAGD

Courtesy of Encana Corp. and Maurice Dusseault, University of Waterloo, Canada.
DISTRIBUTION OF OIL SHALES

Totalling 1,060 billion barrels of recoverable oil

USA: 620 Bbbl
Brazil: 300
Russia: 40
Congo: 40
Australia: 15
Canada: 15
Europe: 15
China: 10
Rest of the World: 5

After Encyclopaedia Britannica 2005.
Coal bed methane gas production in the United States, by basin

Note: 1 billion cubic feet is approximately 28 million cubic metres or 180,000 boe.

Courtesy of Gas Technology Institute, United States.
United States coal bed methane resources - 20 trillion cubic metres

Figure 4.2

Courtesy of Gas Technology Institute, United States.
Hydrates existence domain as a function of pressure and temperature

Courtesy of S. Dalimore, National Resources Canada.
MAP OF CONFIRMED METHANE HYDRATE PRESENCE

Courtesy of S. Dallimore, National Resources Canada.
• They are classified by

  • **location** (e.g.: "West Texas Intermediate, WTI")
  • **relative weight or viscosity** ("light", "intermediate" or "heavy")
  • **sulphur content** ("sweet" or "sour"): sour crude oil requires more expensive refining)

• Each crude oil has unique molecular characteristics which are understood by the use of crude oil assay analysis in petroleum laboratories.

• At the stockmarkets a few crude oils are traded only; other oils are either up- or devalued, according to these references.
GAS FROM RUSSIA FOR EU – 2008

Stand: 2008

Gas pipelines
existing
--- Under construction

Liquefied Natural Gas Terminal
existing
--- under construction
Oil flows and major chokepoints, 2003

Source: WEO-2004, IEA.
ENERGY DEPENDENCY – NATURAL GAS

[Bar chart showing energy dependency by country, with the United Kingdom and Czech Republic being circled.]
ENERGY DEPENDENCY – OIL
More than 50% of the work force will leave the Industry within 10 years
.... and then it gets awfully quiet
CONCLUSION

• The problems with hydrocarbons is nowadays rather capacity than reserves.

• Geopolitical development is the highest risk for security of supply with hydrocarbons.

• European security of supply with fossile energy is a big issue.

• Lack of skilled engineers and geoscientists (outrunning on resources).

• High potential in usage of new technologies to increase the recovery factor.
Visions ...