CHAIR OF PETROLEUM
PRODUCTION AND PROCESSING

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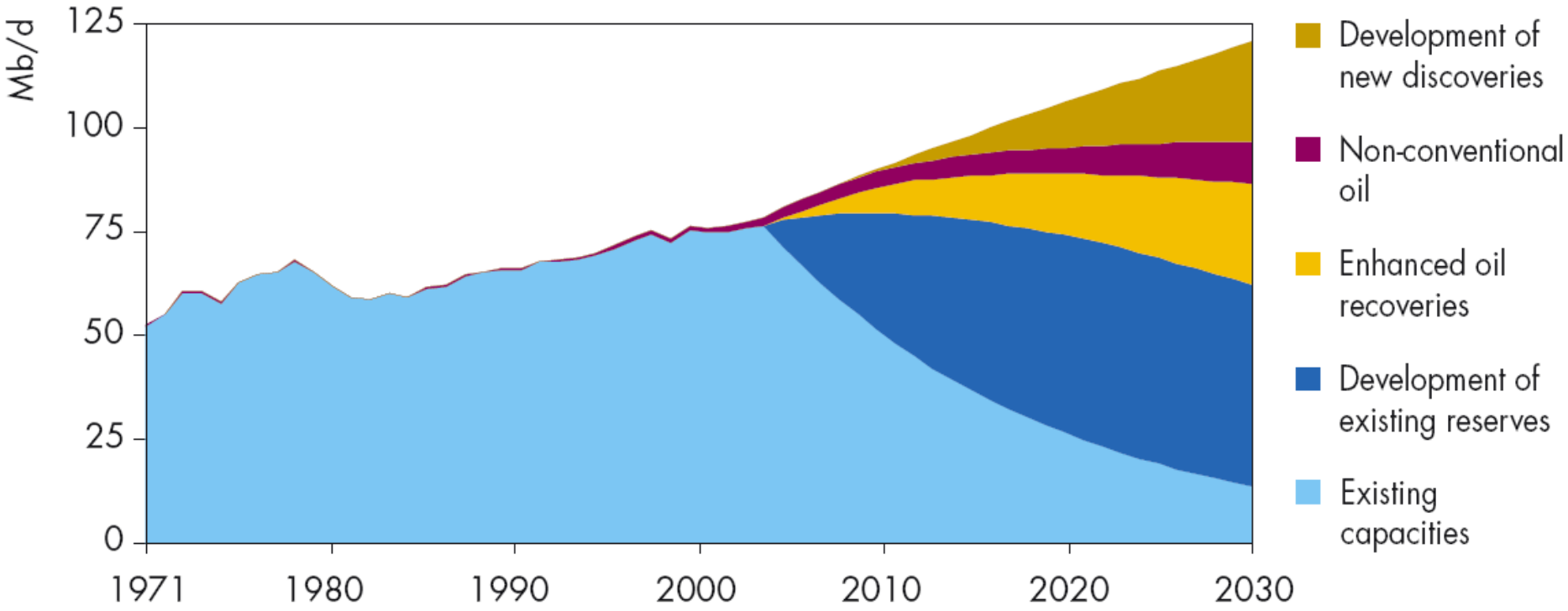
Die Versorgungssicherheit Europas mit Kohlenwasserstoffen

Univ. Prof. Dipl. Ing. Dr. Herbert Hofstätter

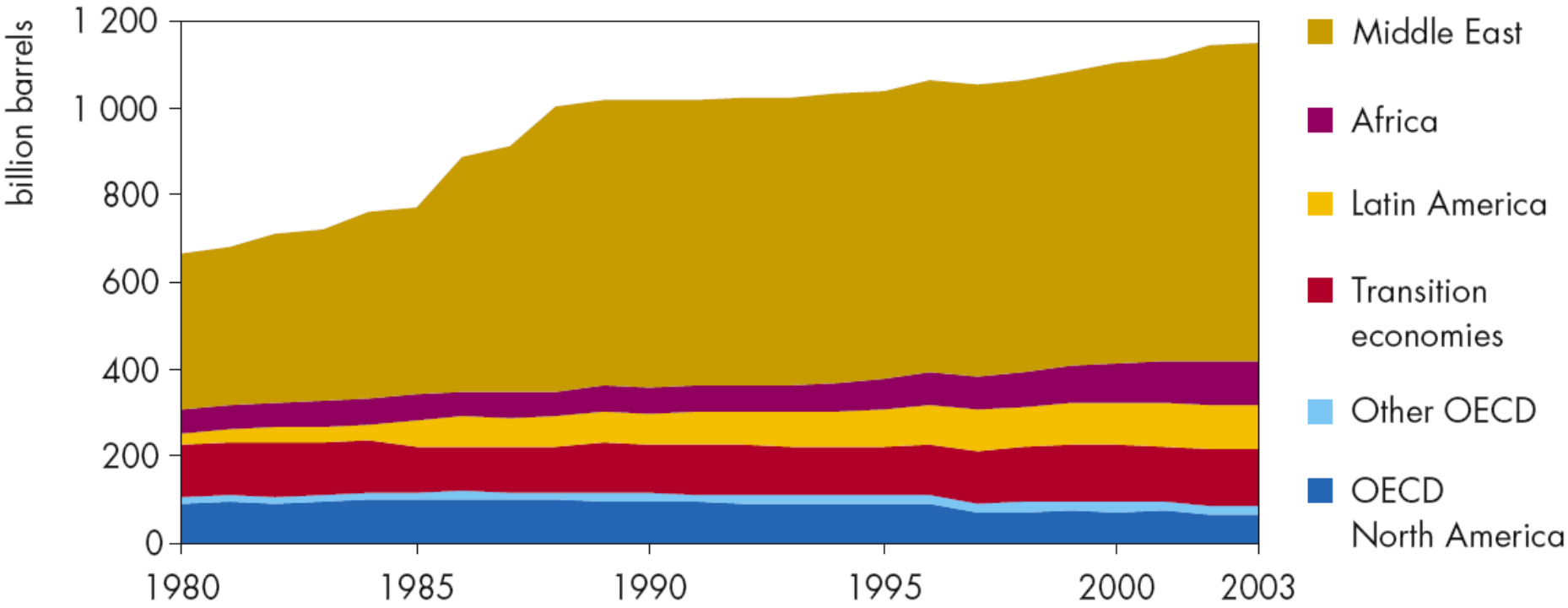
Graz, Februar 2010

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.

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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

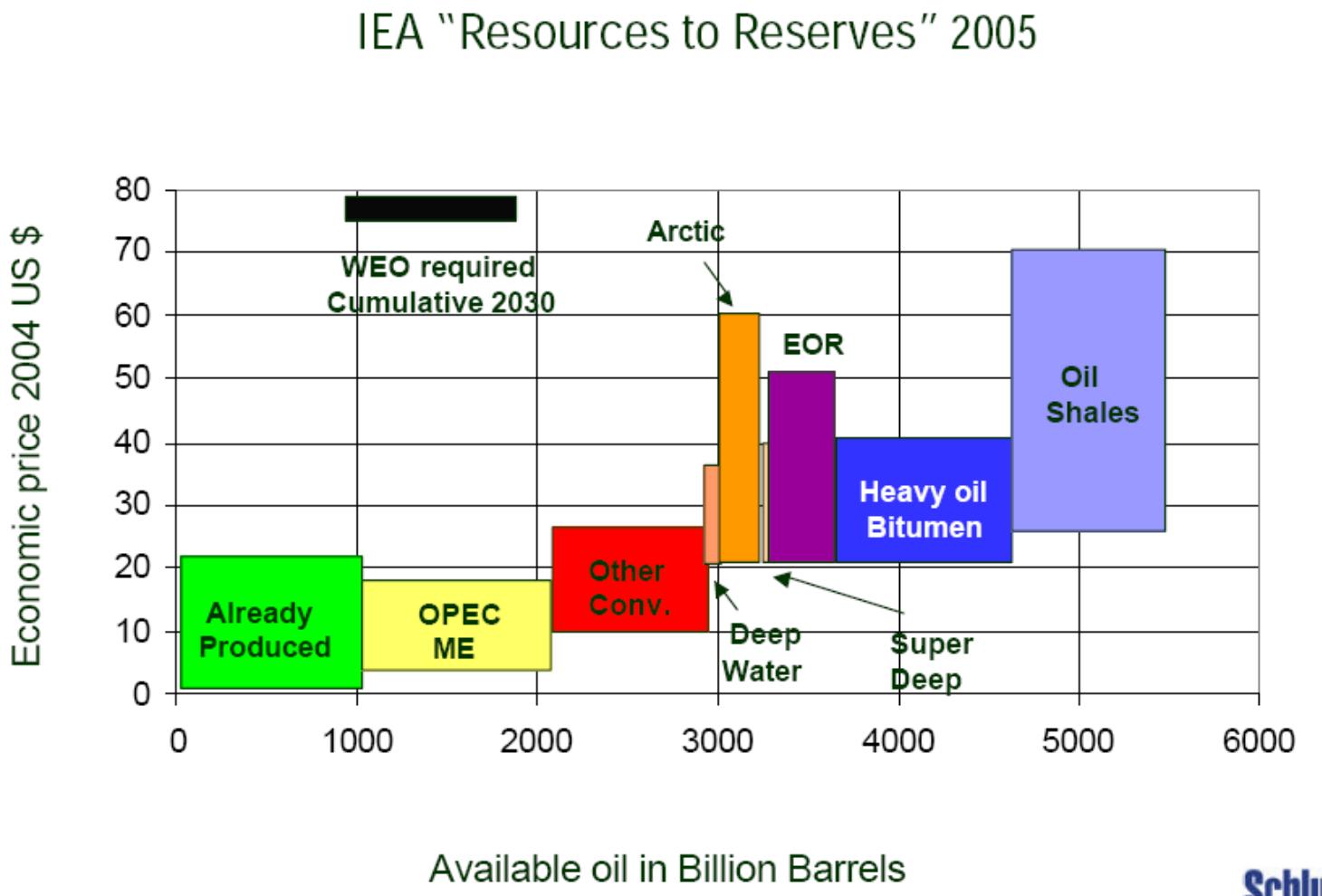
Reserves:

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 an reservoir, including both producible and non-producible hydrocarbons, is called oil/gas in place.

Resources:

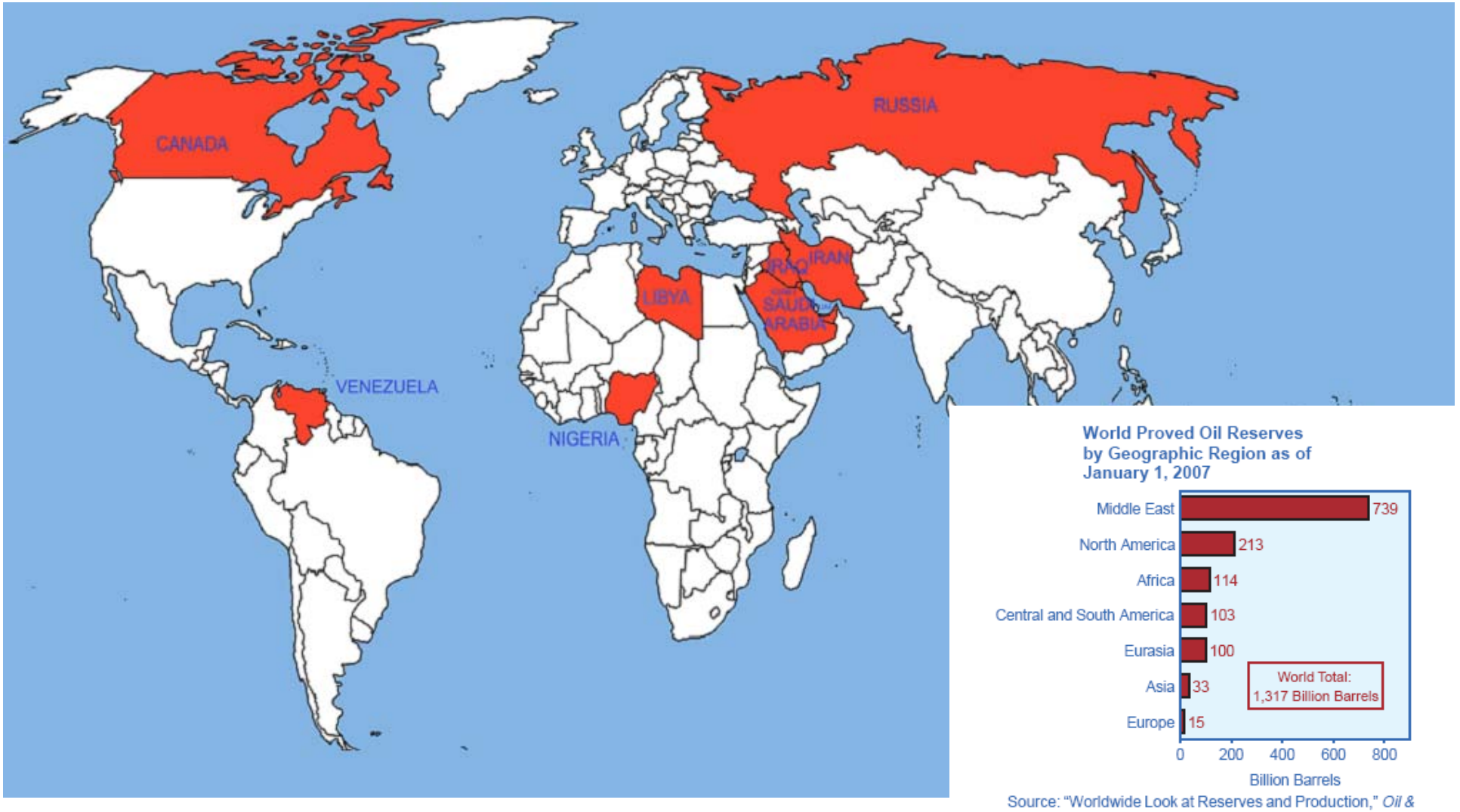
Resources are those quantities of hydrocarbons estimated, as of a given date, to be potentially recoverable from accumulations, but the applied project(s) are not yet considered mature enough for commercial development.

WORLD GLOBAL ENERGY SUPPLY



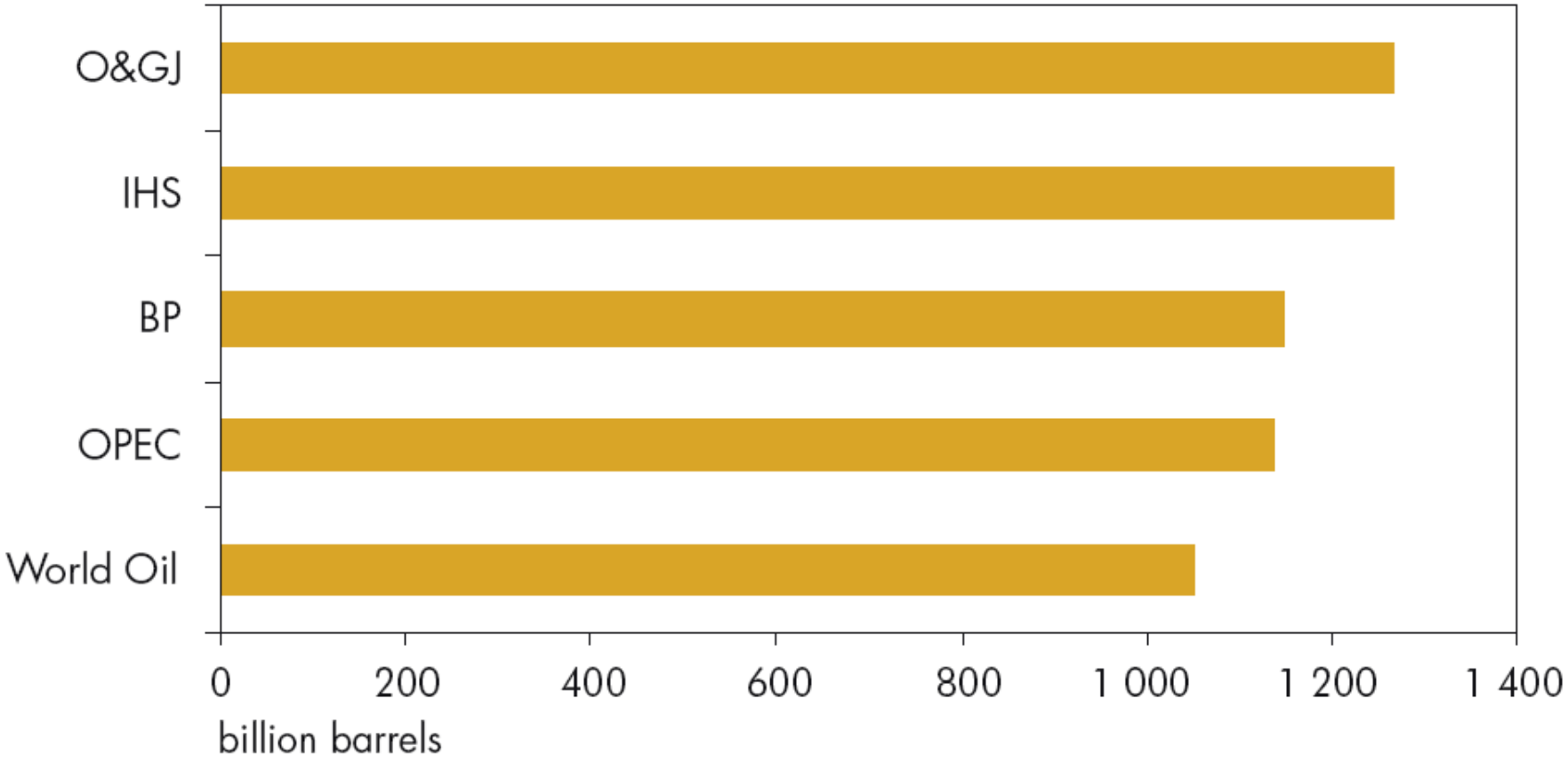
Schlumberger

LARGEST OIL RESERVES



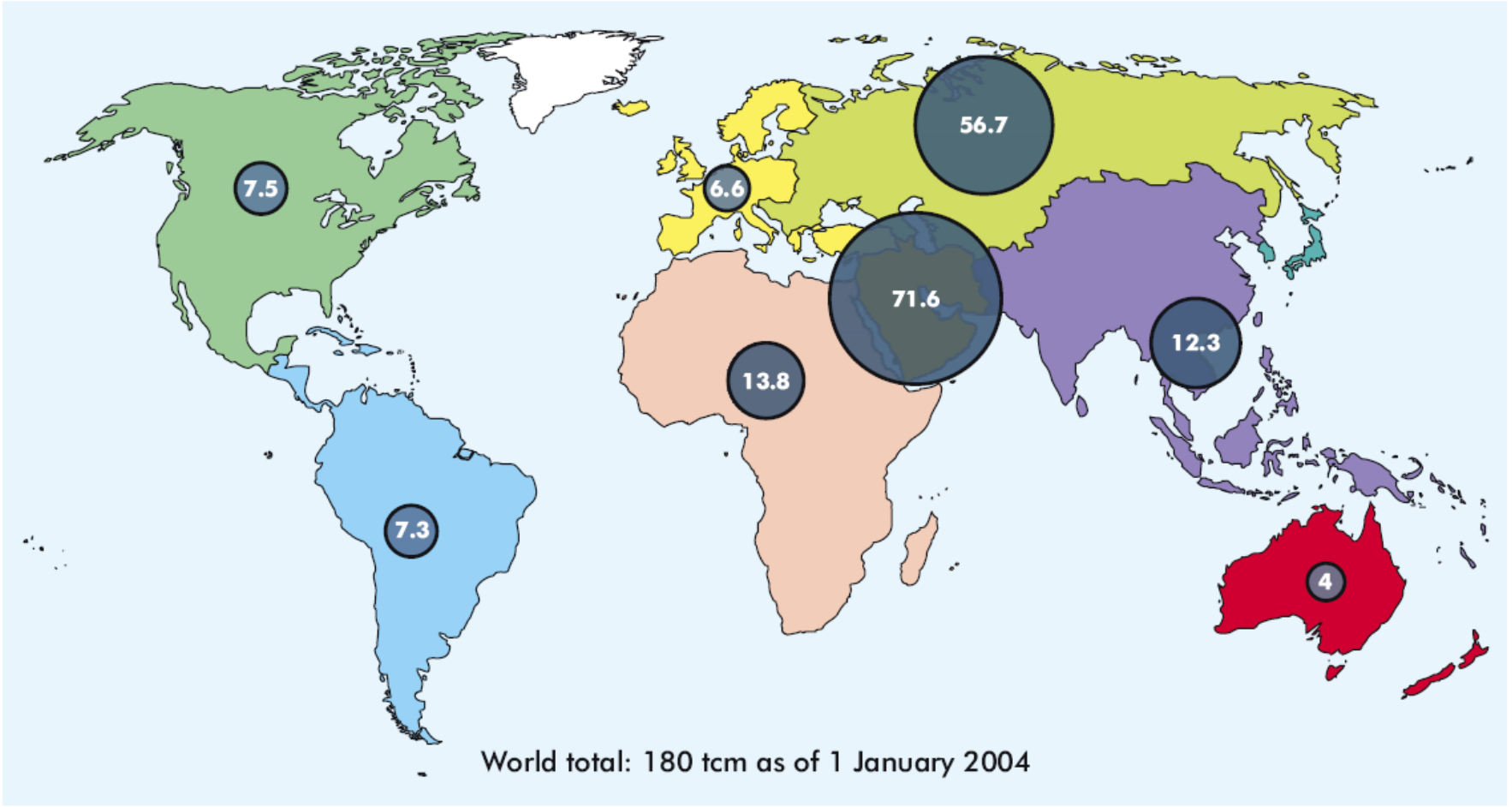
Source: "Worldwide Look at Reserves and Production," *Oil & Gas Journal*, Vol. 104, No. 47 (December 18, 2006), pp. 24-25.

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



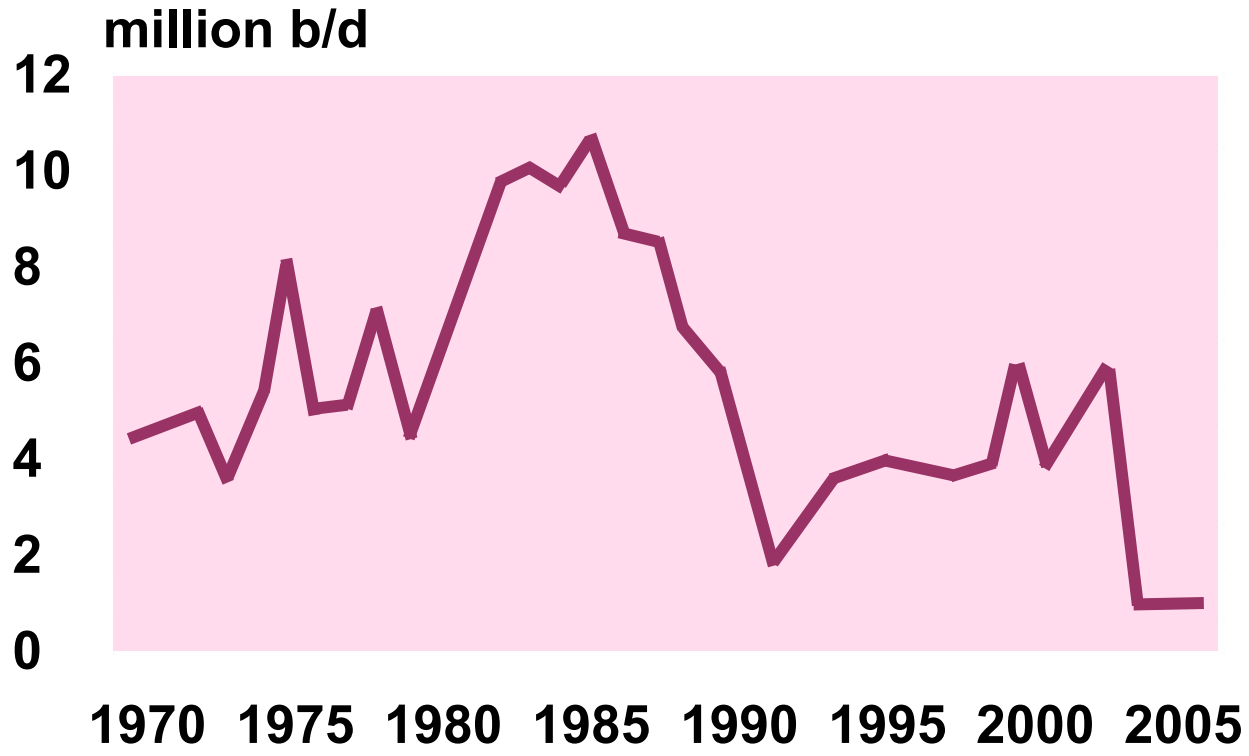
Source: WEO-2004, IEA.

World proven reserves of natural gas in trillion cubic metres



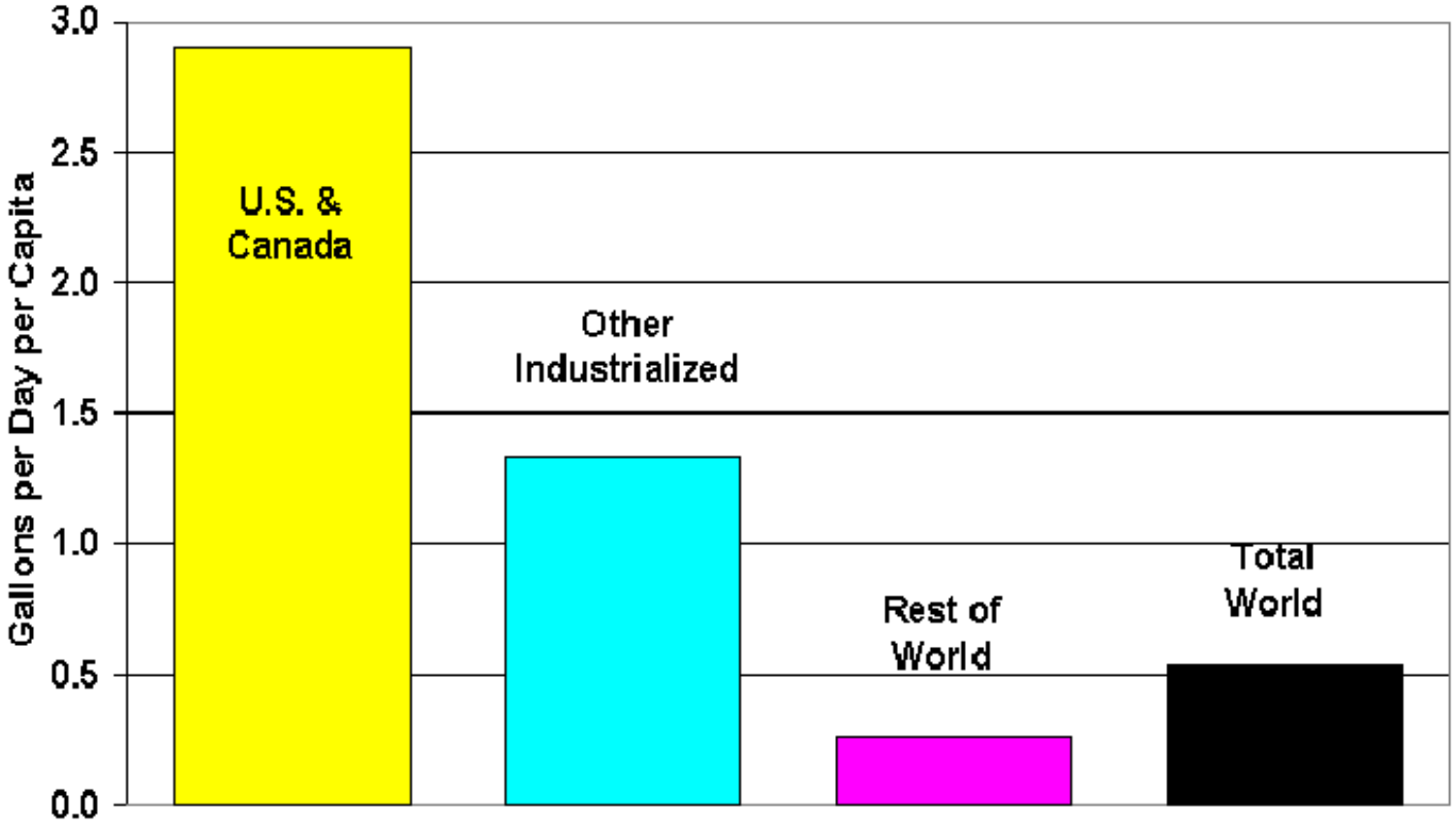
Source: WEO-2004, IEA.

WORLD OIL SPARE CAPACITY

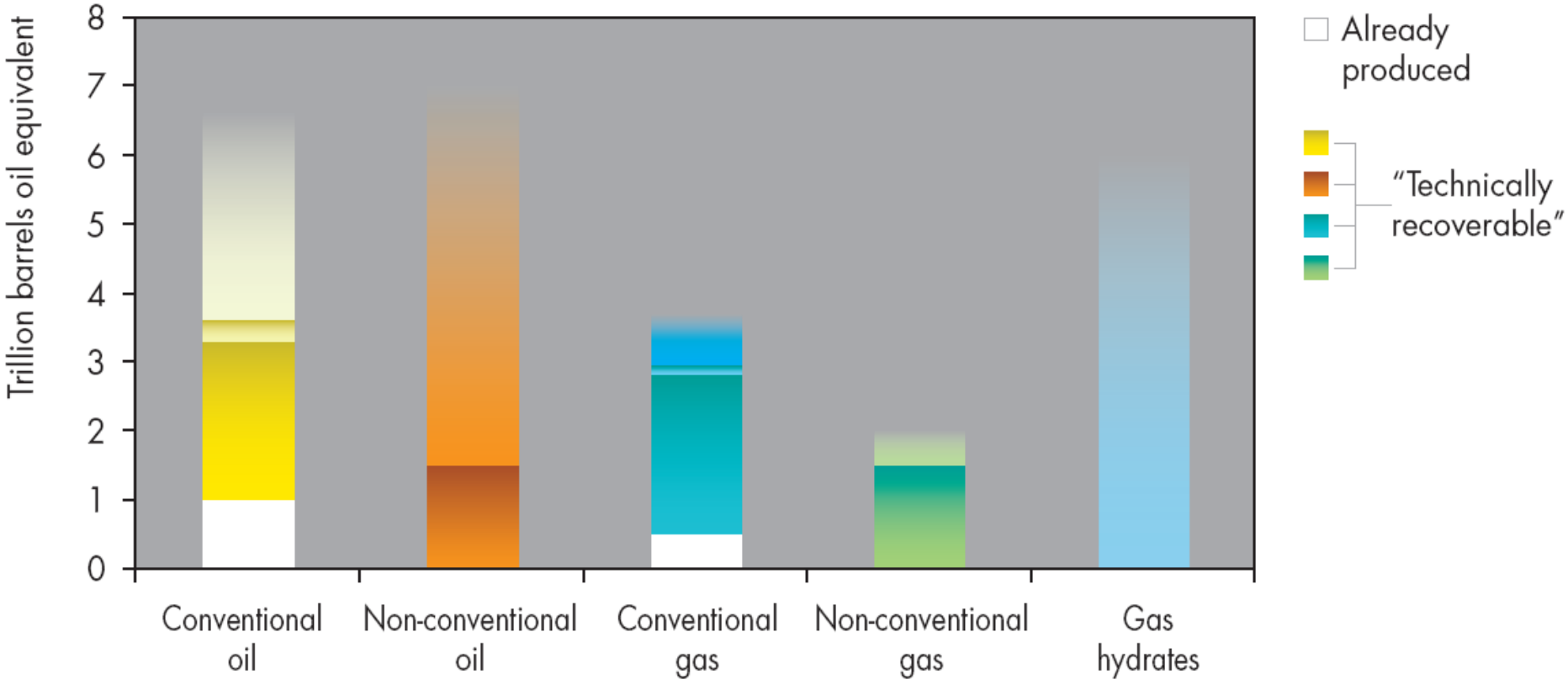


Source – International Energy Agency; SWP

GLOBAL CONSUMPTION OF OIL PER CAPITA

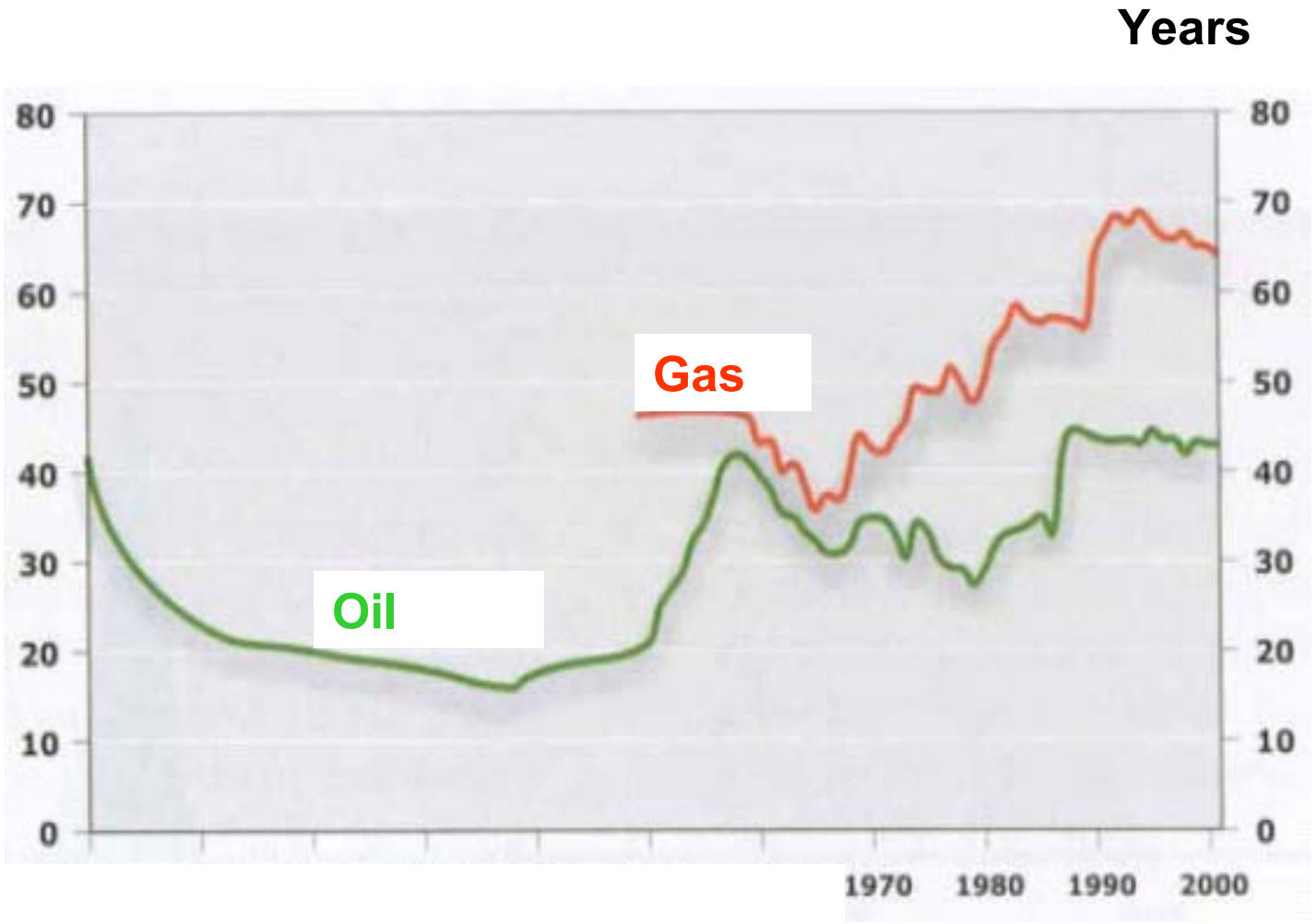


World hydrocarbon resources

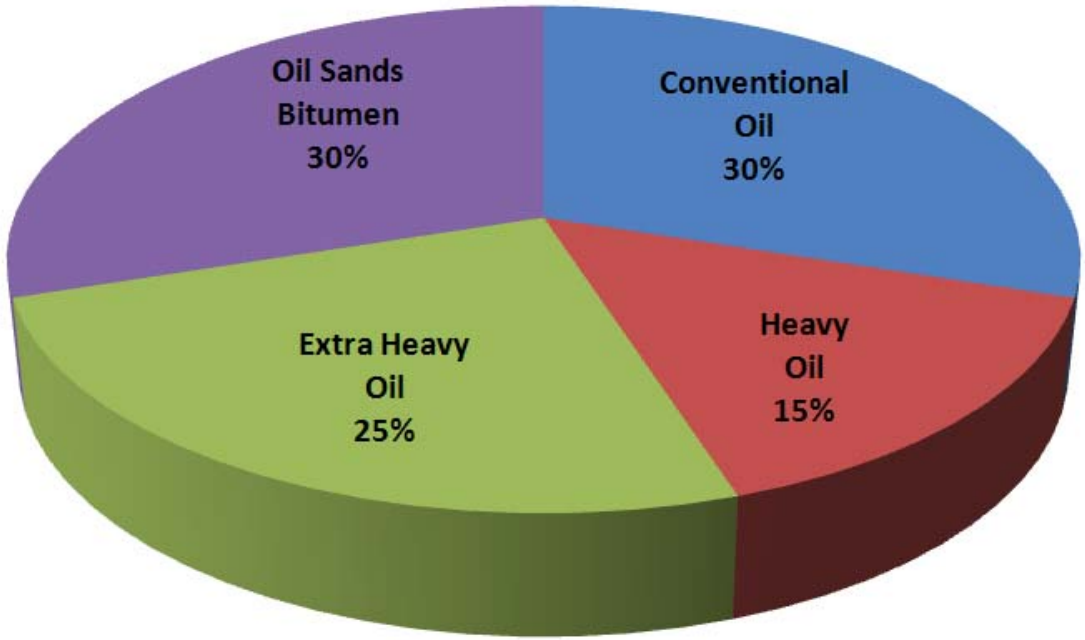


Based on USGS and IEA data.

OIL AND GAS RESERVES



TOTAL WORLD OIL RESERVES



SANDSTONE RESERVOIR ROCK

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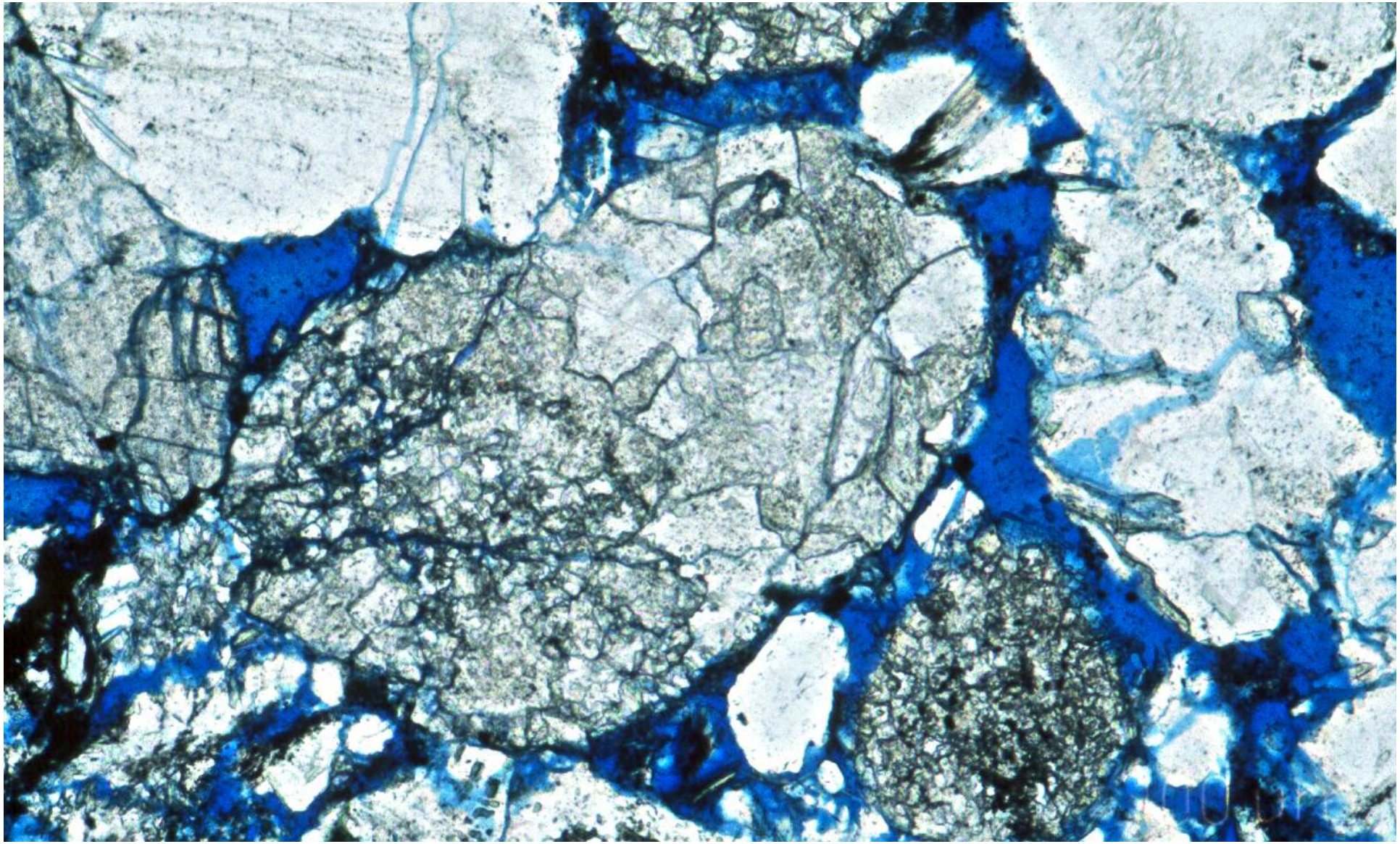
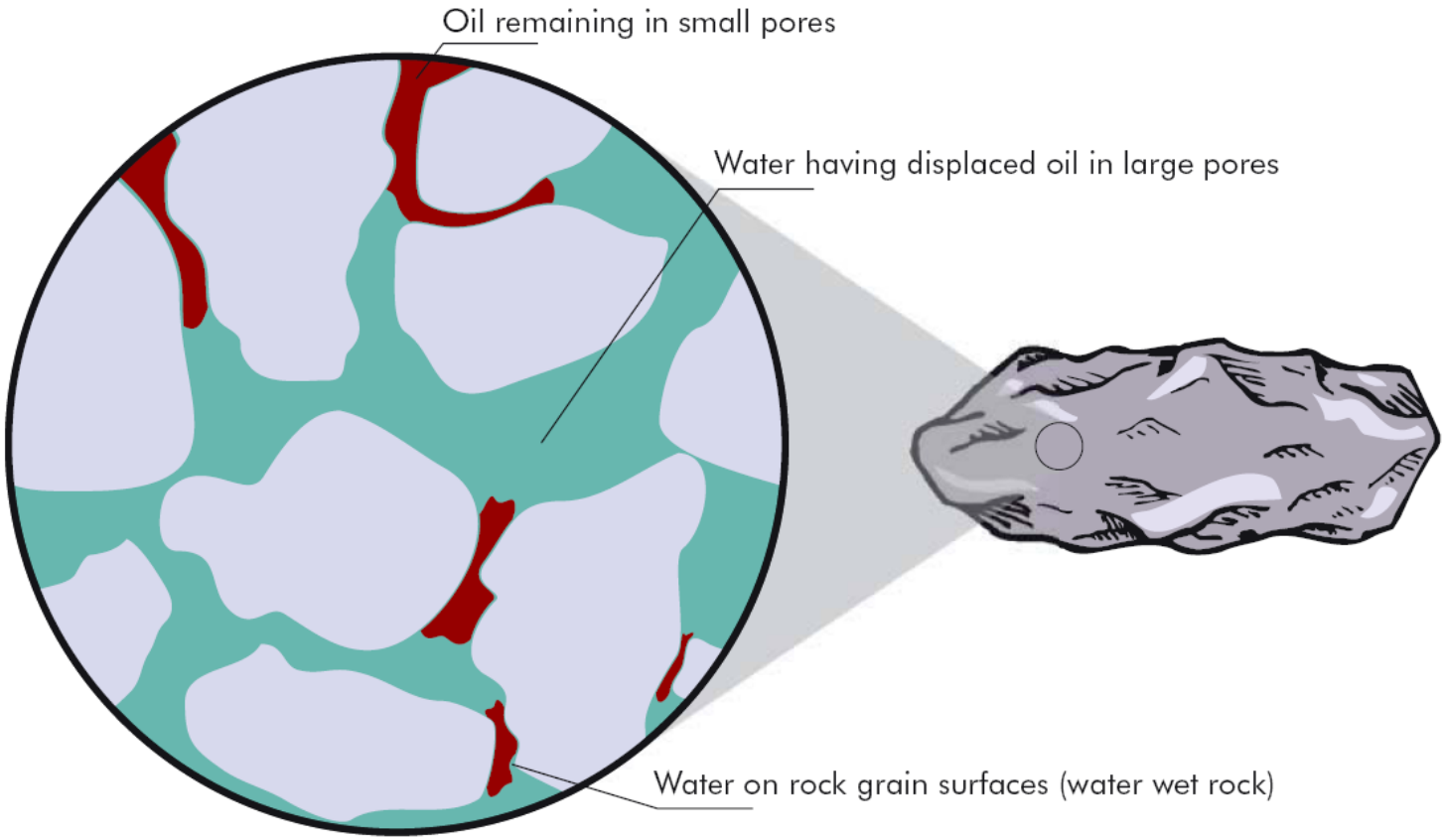


RESIDUAL OIL



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).

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Oil Recovery Factors:

1979: 20%

2000: 35 %

> 2000: 50%

Average increase of the RF : 0,2 – 1% / year

1% Increase = Annual consumption

AZERBAIJAN TODAY

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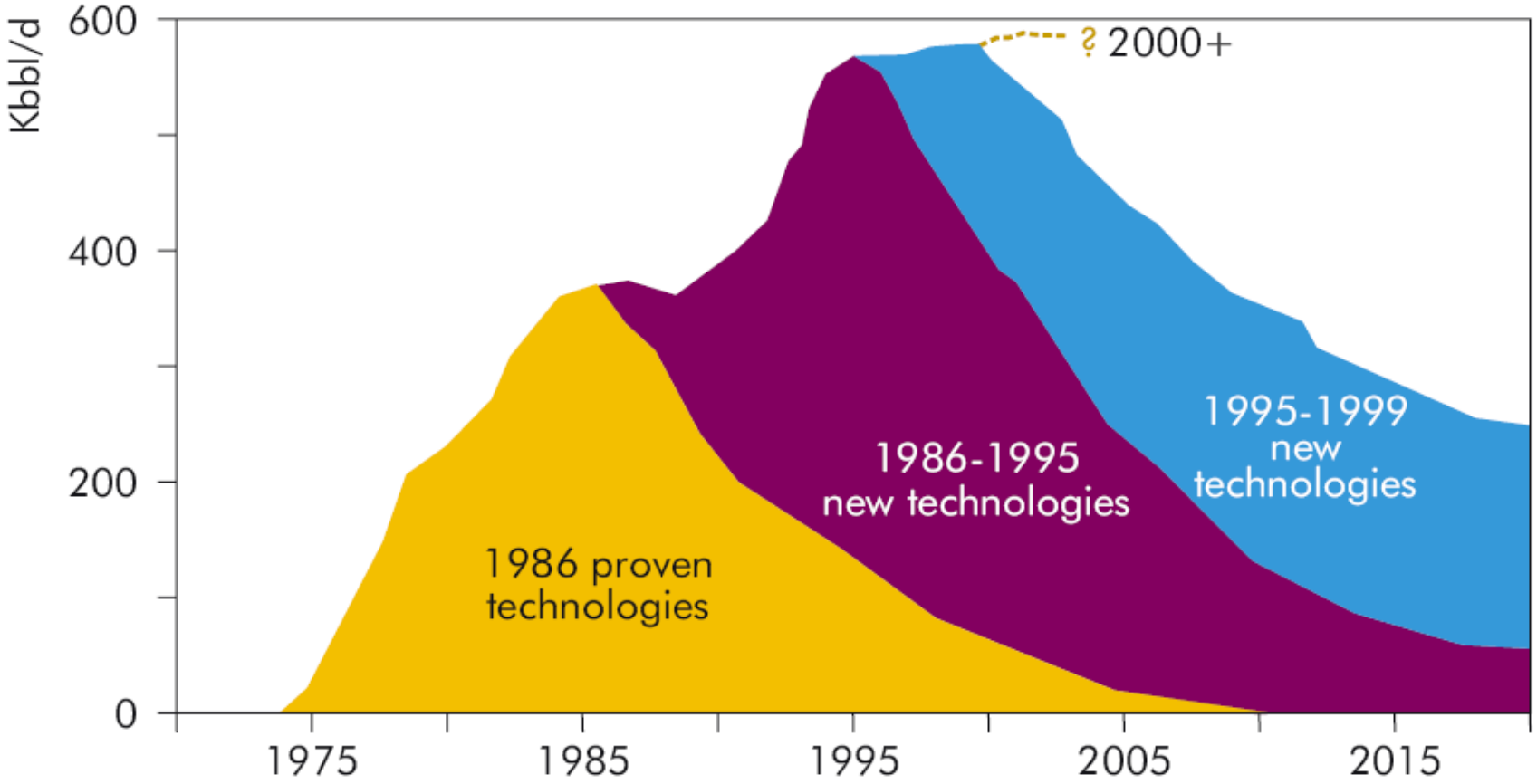
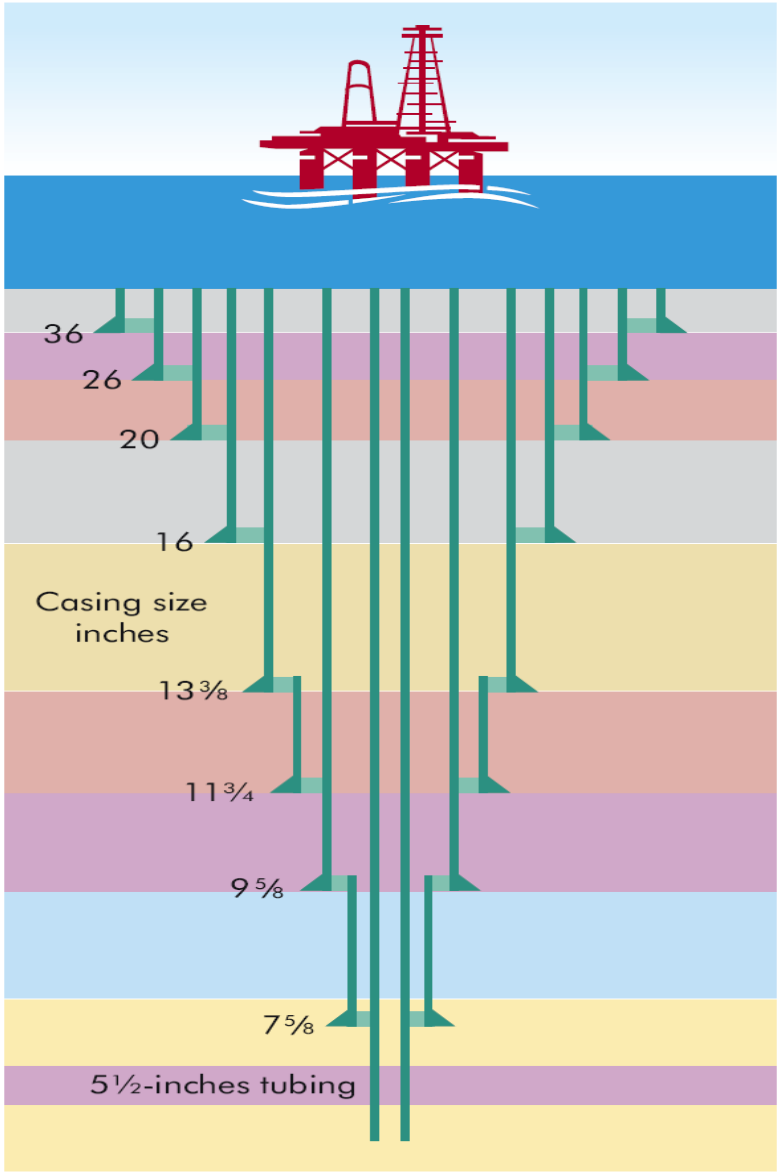
IMPACT OF TECHNOLOGY ON NORTH SEA PRODUCTION



Source: European Network for Research in Geo-Energy - ENeRG - courtesy of Shell.

EXAMPLE OF CONVENTIONAL WELL CONSTRUCTION



Courtesy of Schlumberger.

EXPANDABLE TECHNOLOGY

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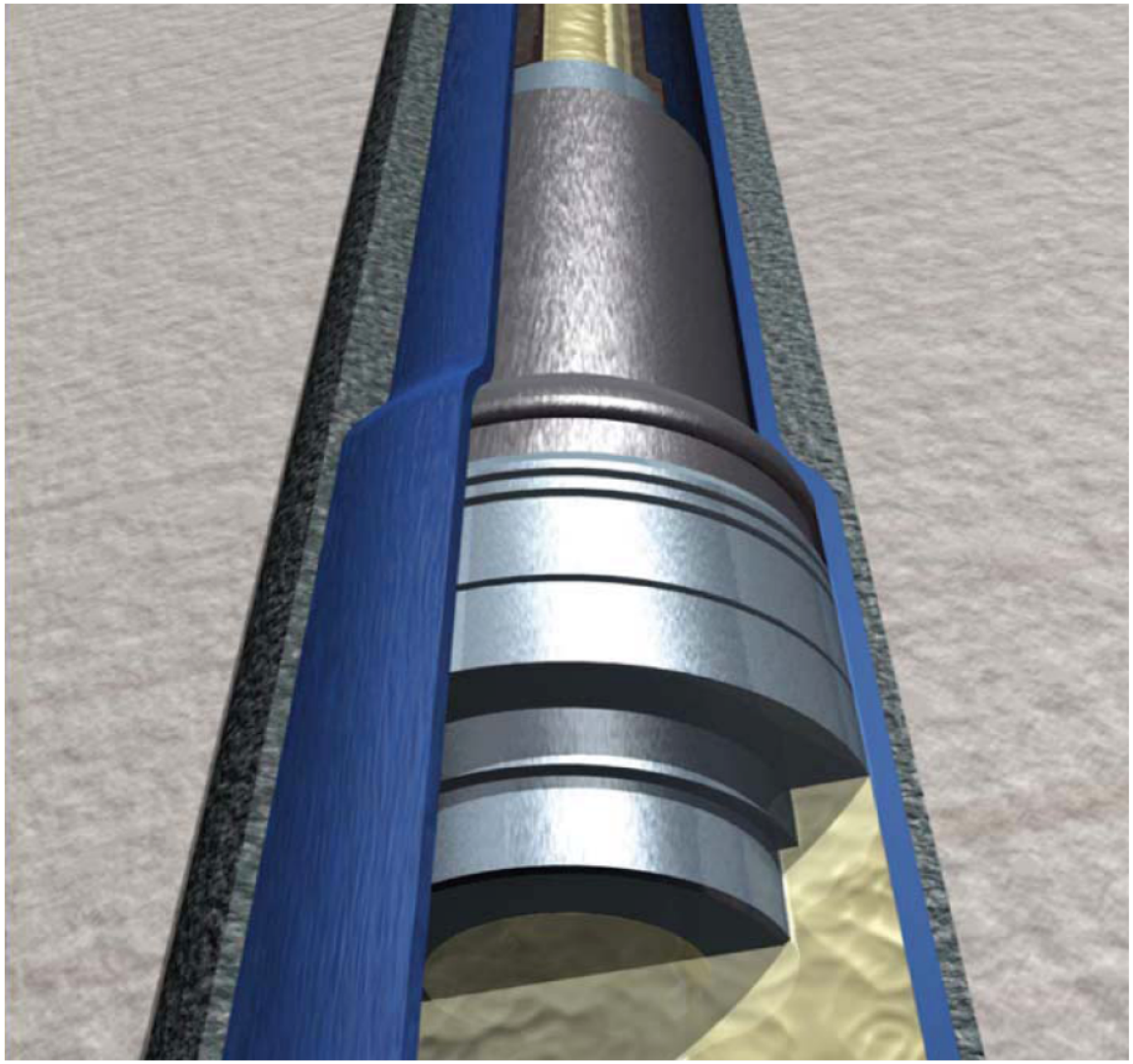
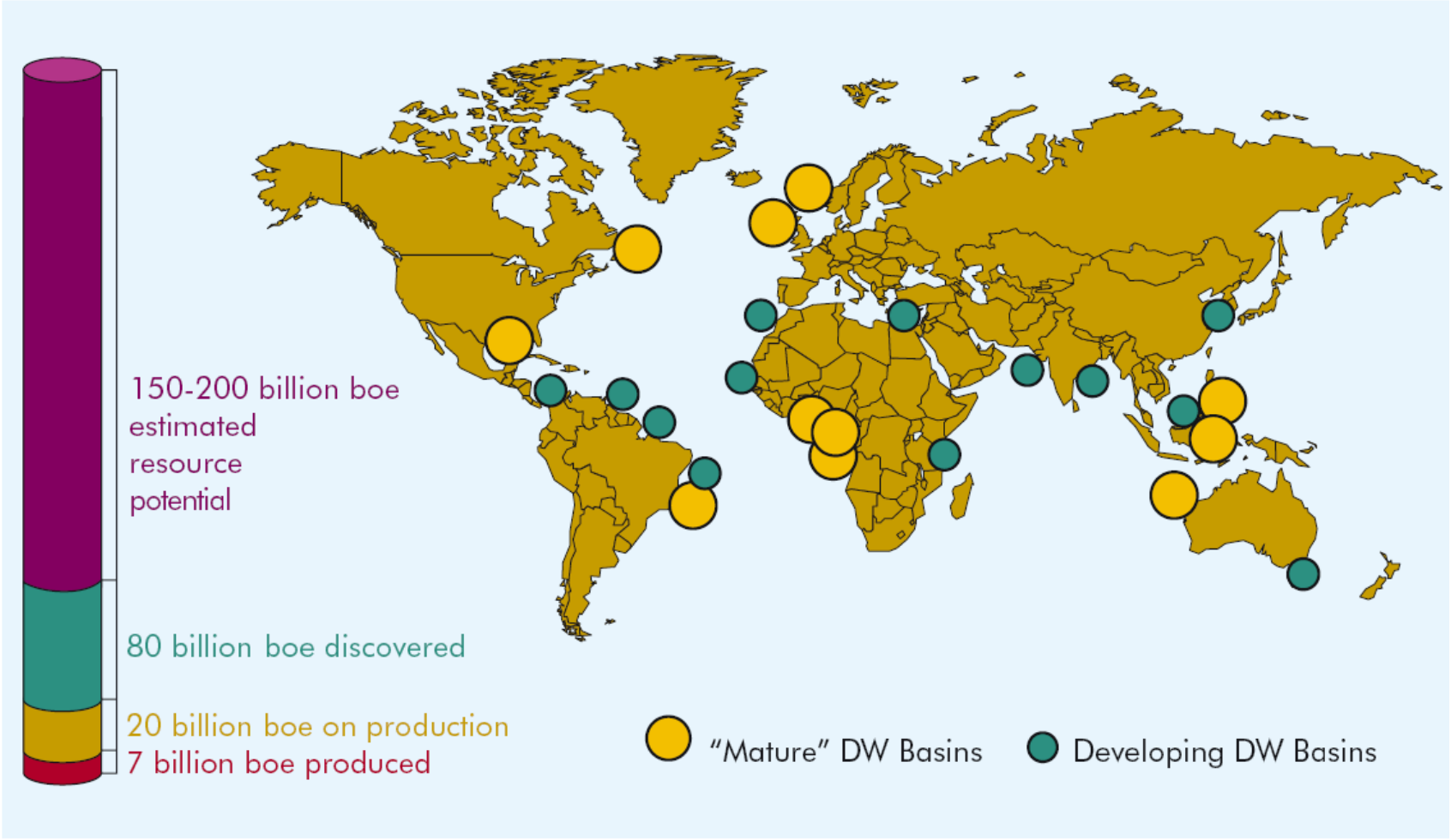
Sketch of casing (blue) being expanded
by an expanding tool pulled from bottom to top



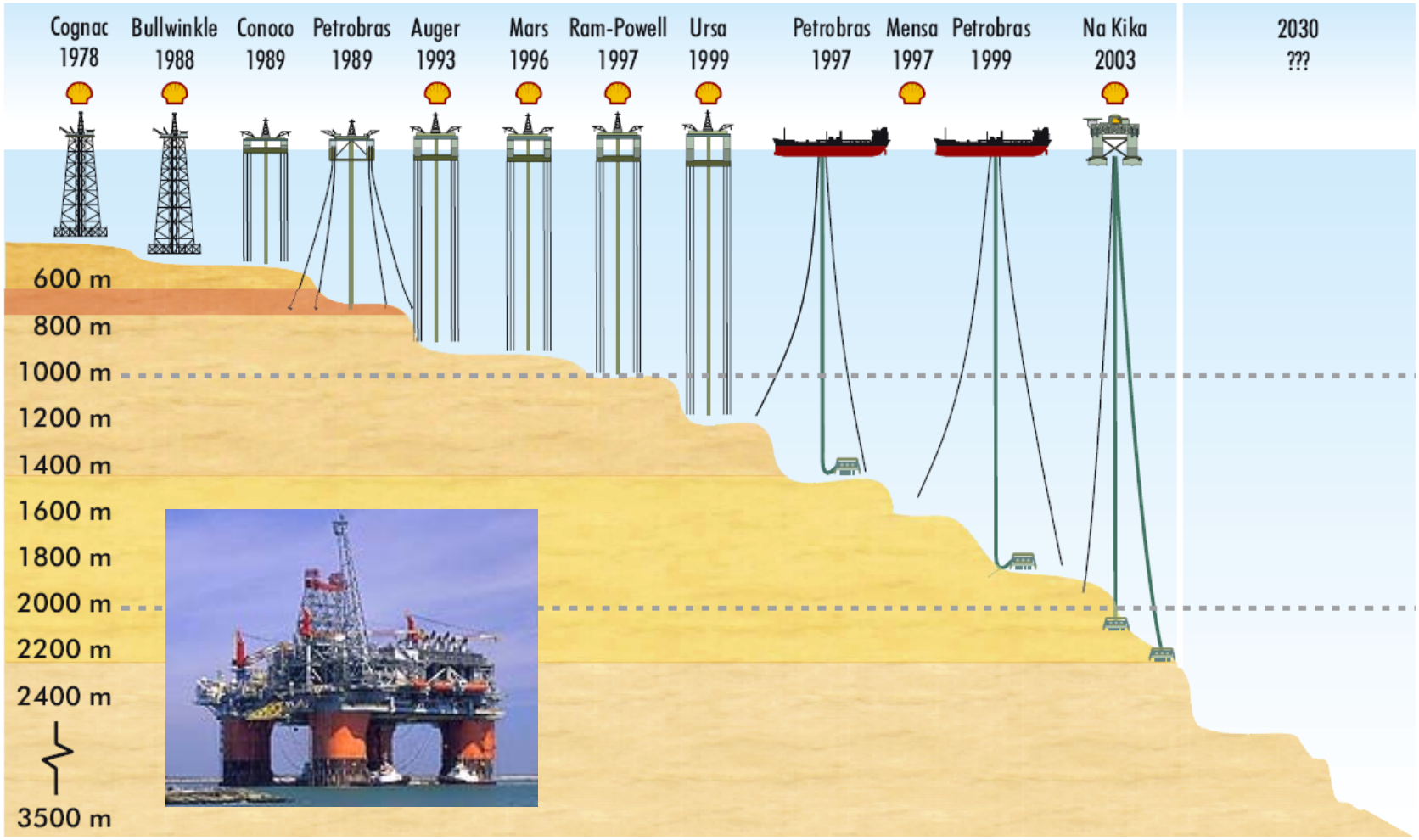
Courtesy of Shell.

FUTURE OIL AND GAS DEEPWATER POTENTIAL UN THE WORLD



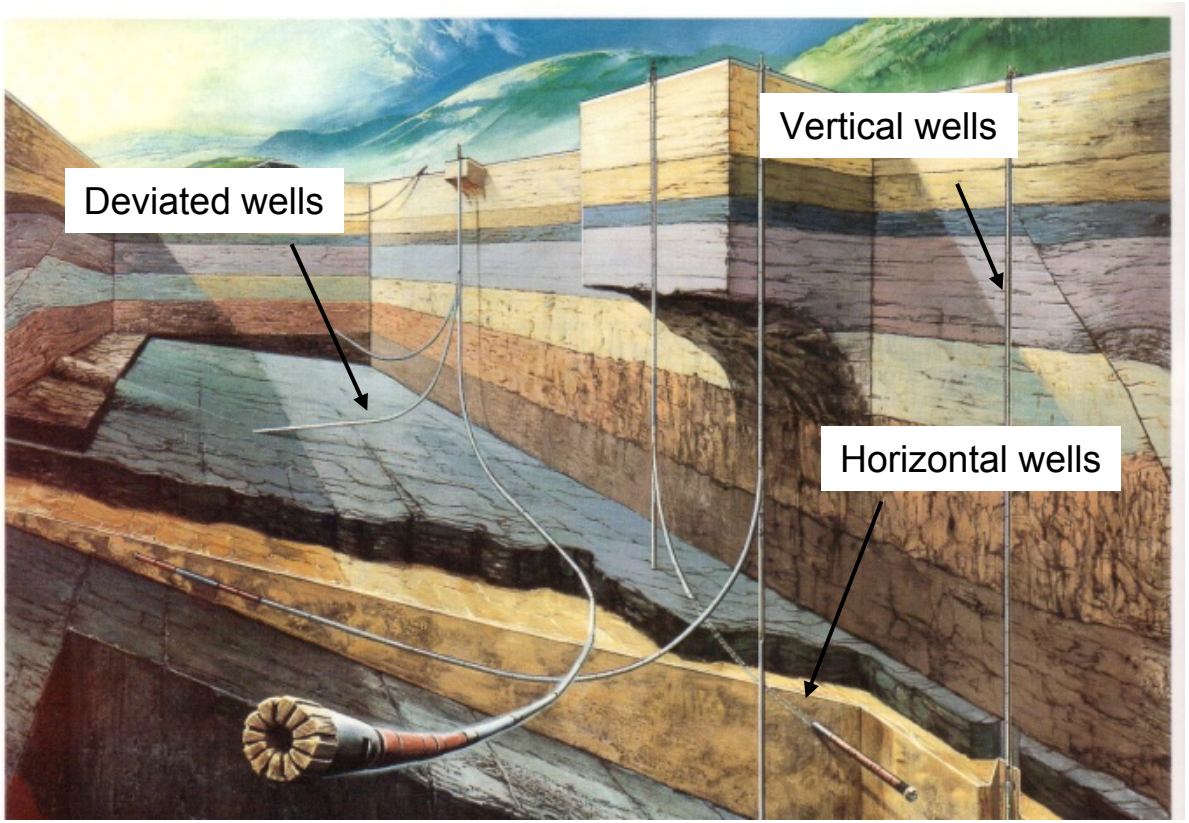
Source: Wood Mackenzie; courtesy of Shell.

EVOLUTION OF DEEPWATER TECHNOLOGY

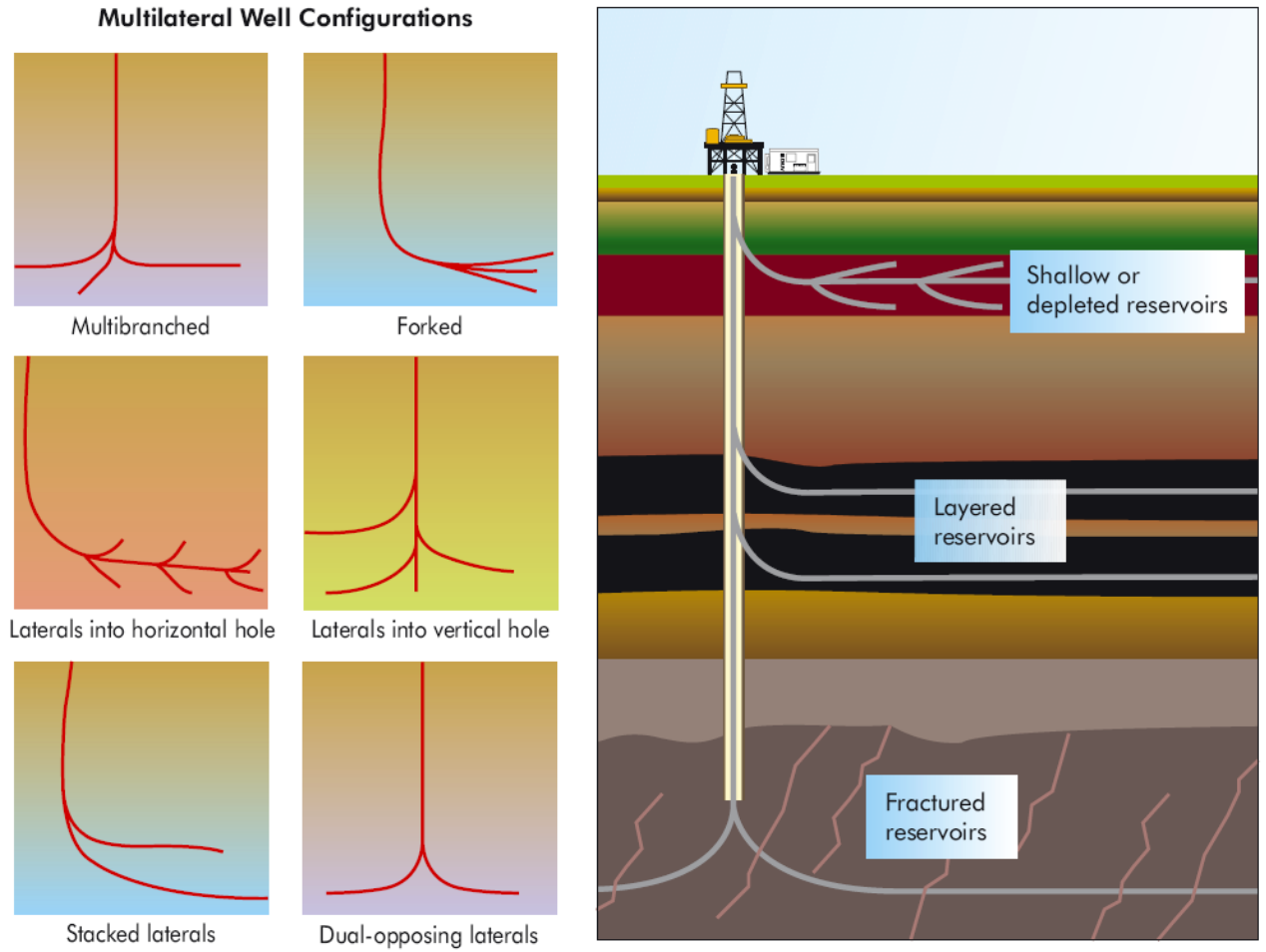


Courtesy of Shell.

EVOLUTION OF DRILLING TECHNOLOGY

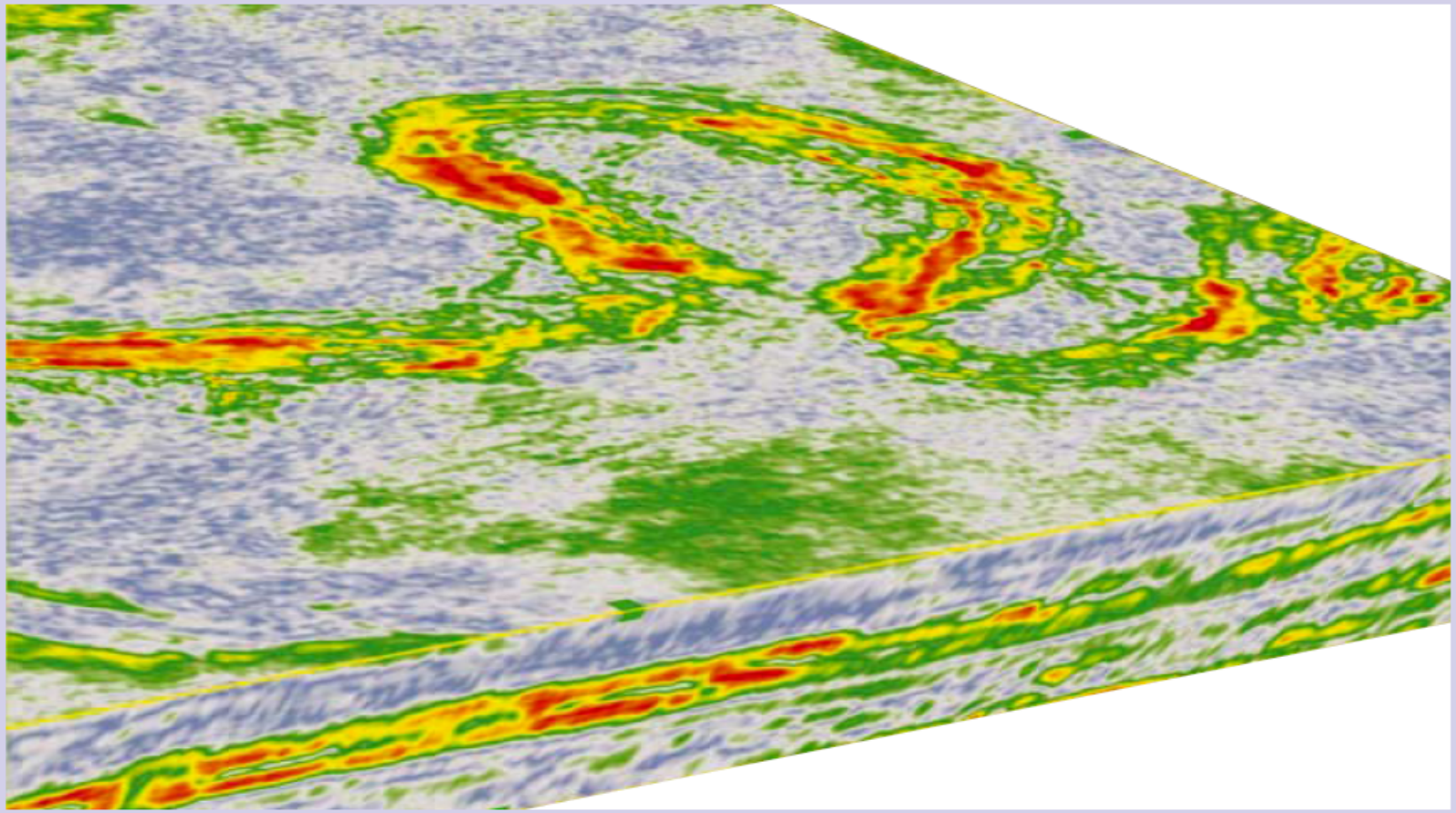


SCHEMATICS OF MULTILATERAL WELLS



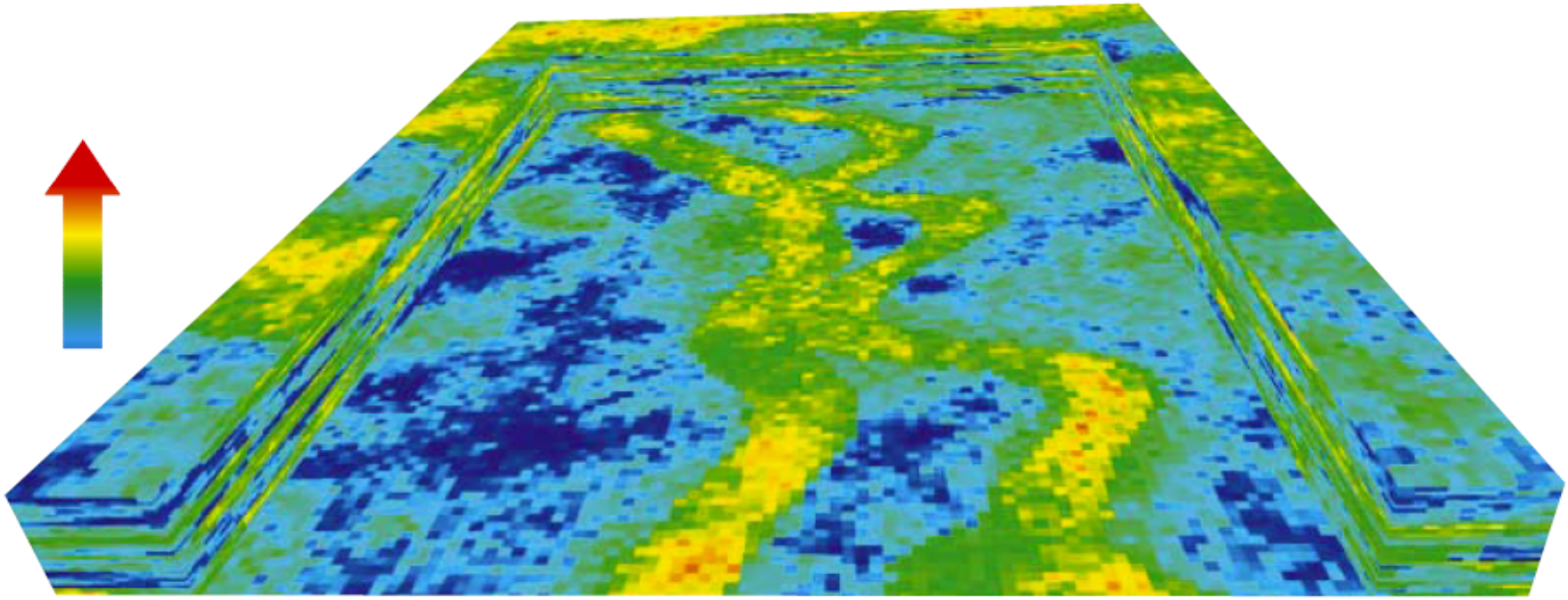
Courtesy of Schlumberger.

3 D SEISMIC



Courtesy of Schlumberger.

RESERVOIR SIMULATION - BYPASSED OIL

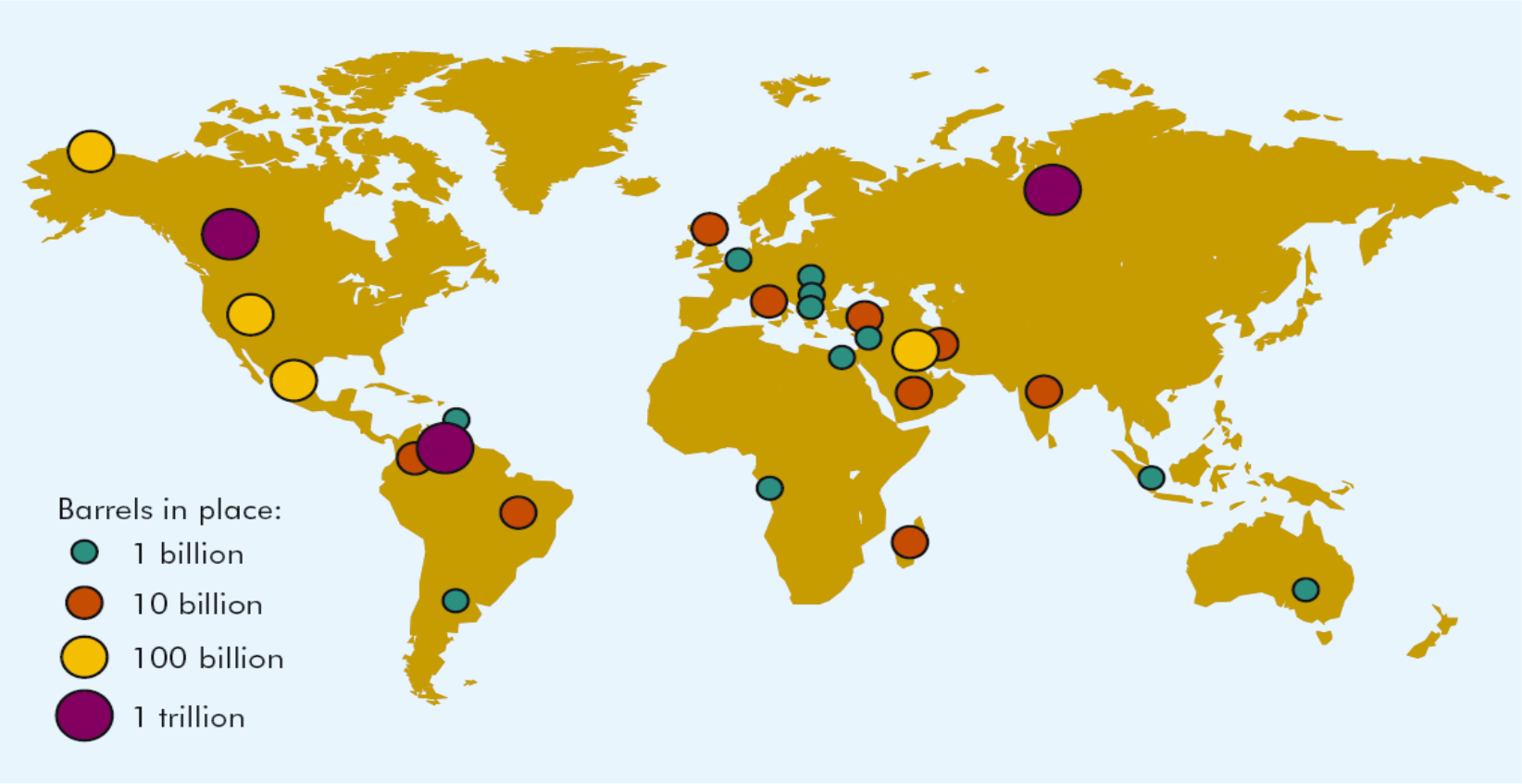


Water, in blue, has swept out the oil but left some channels still containing oil (high concentration in yellow and red, lower concentration in green). The oil may have been left behind because, for example, the channels have lower permeability.

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

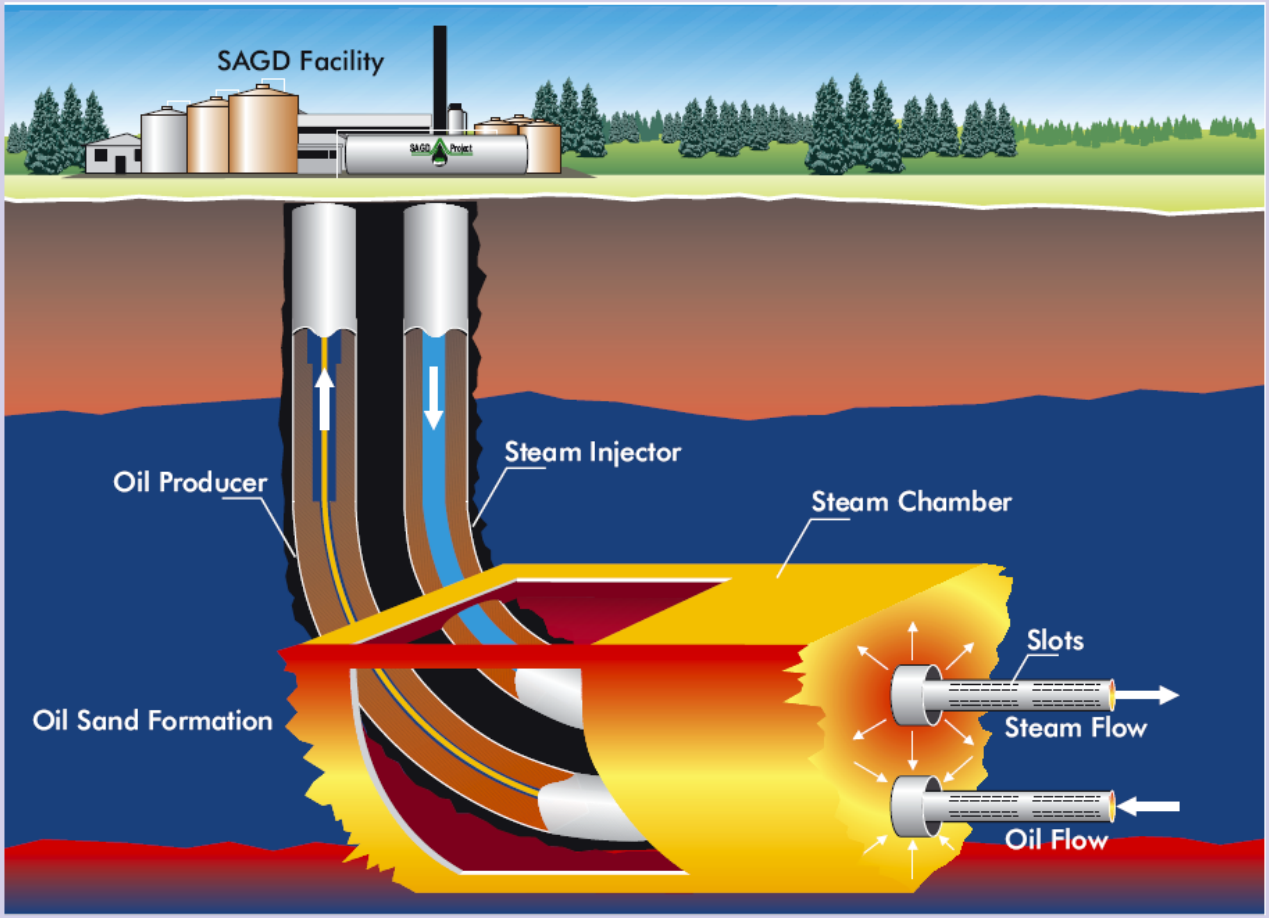
HEAVY OIL

HEAVY OIL - RESOURCES



*Reproduced with kind permission from the Energy Institute, originally published in Modern Petroleum Technology (**www.energyinstpubs.org.uk**), with thanks also to Maurice Dusseault, University of Waterloo, Canada, for pointing out this figure.*

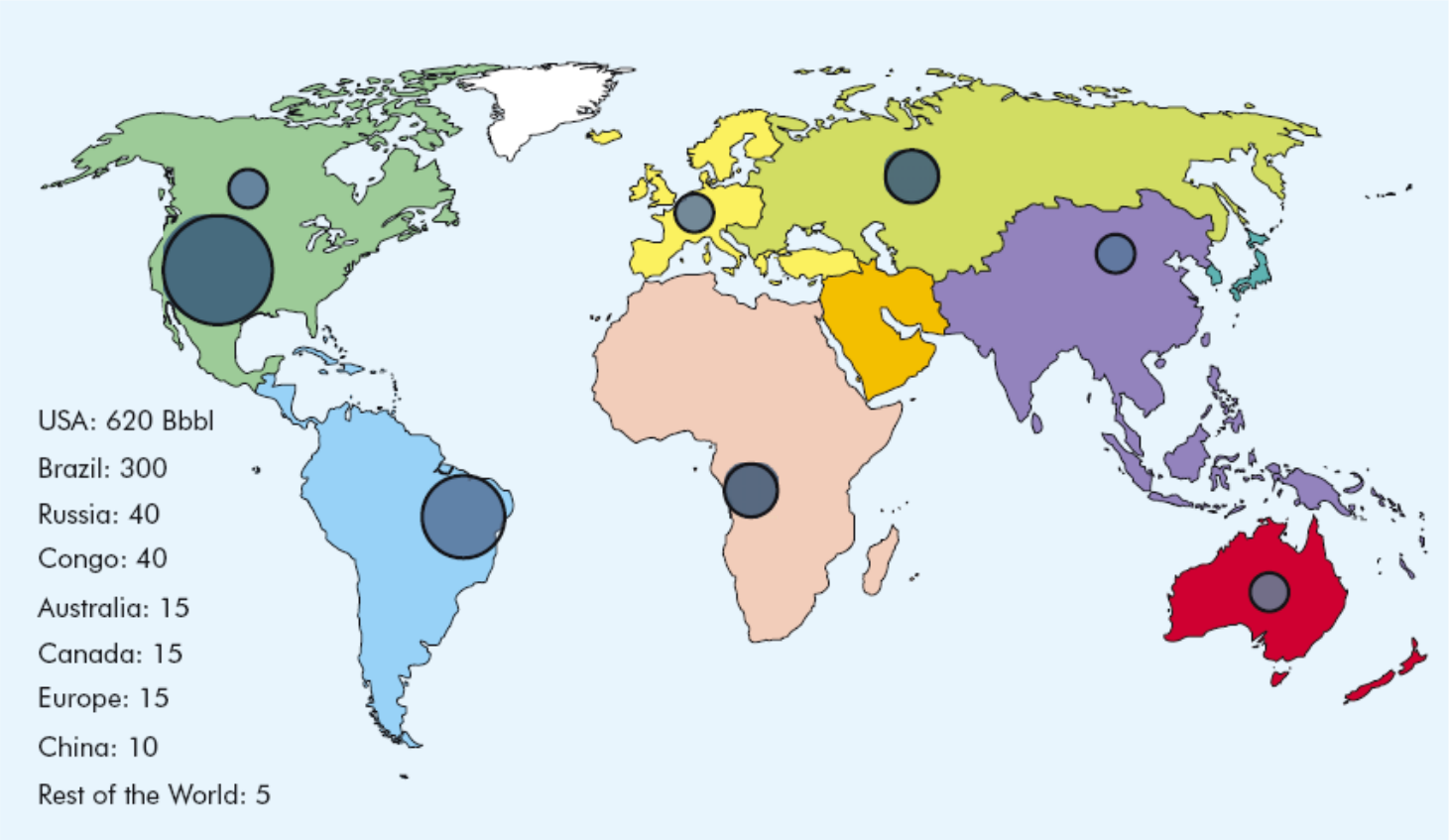
SCHEMATIC OF SAGD



Courtesy of Encana Corp. and Maurice Dusseault, University of Waterloo, Canada.

DISTRIBUTION OF OIL SHALES

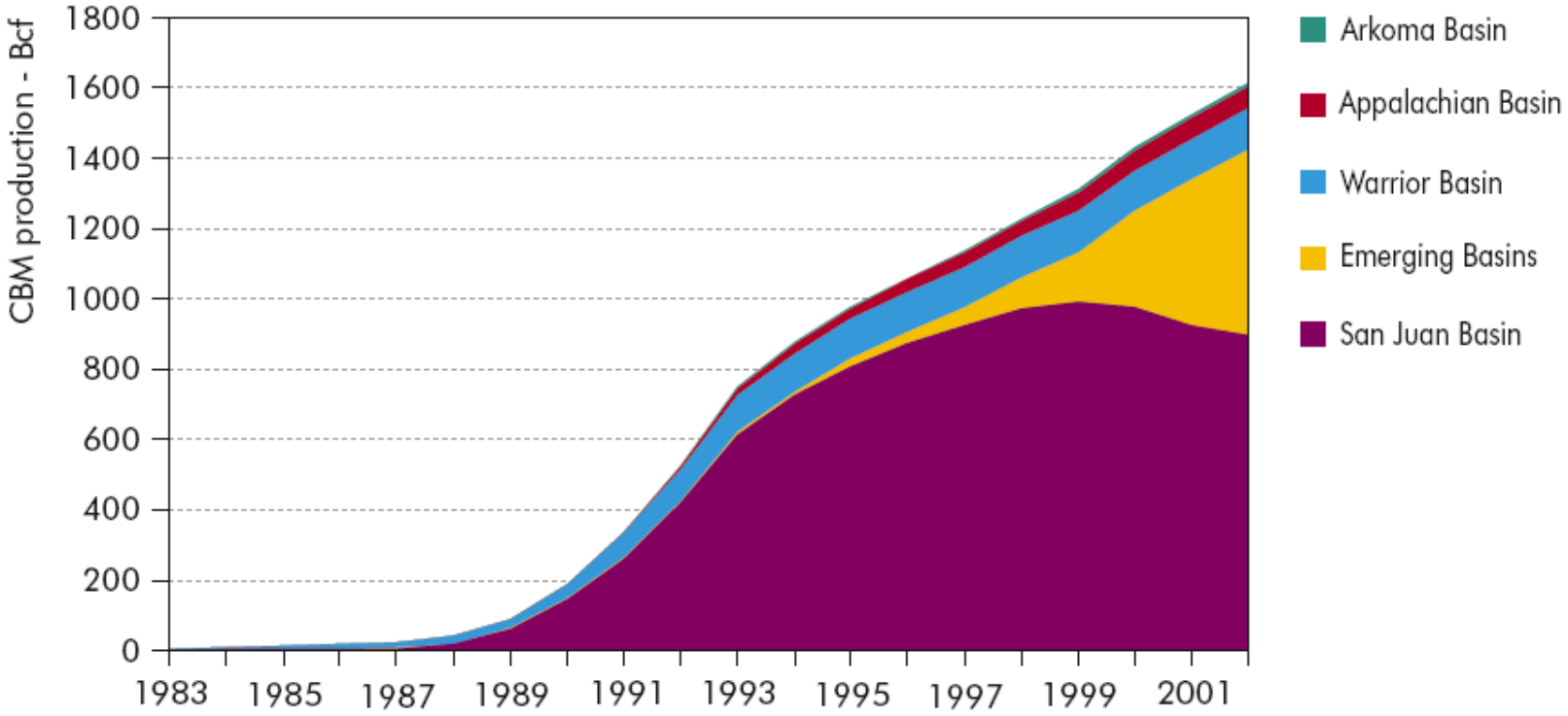
totalling 1 060 billion barrels of recoverable oil



After Encyclopaedia Britannica 2005.

US – COALBED METHANE GAS PRODUCTION

Coal bed methane gas production in the United States, by basin

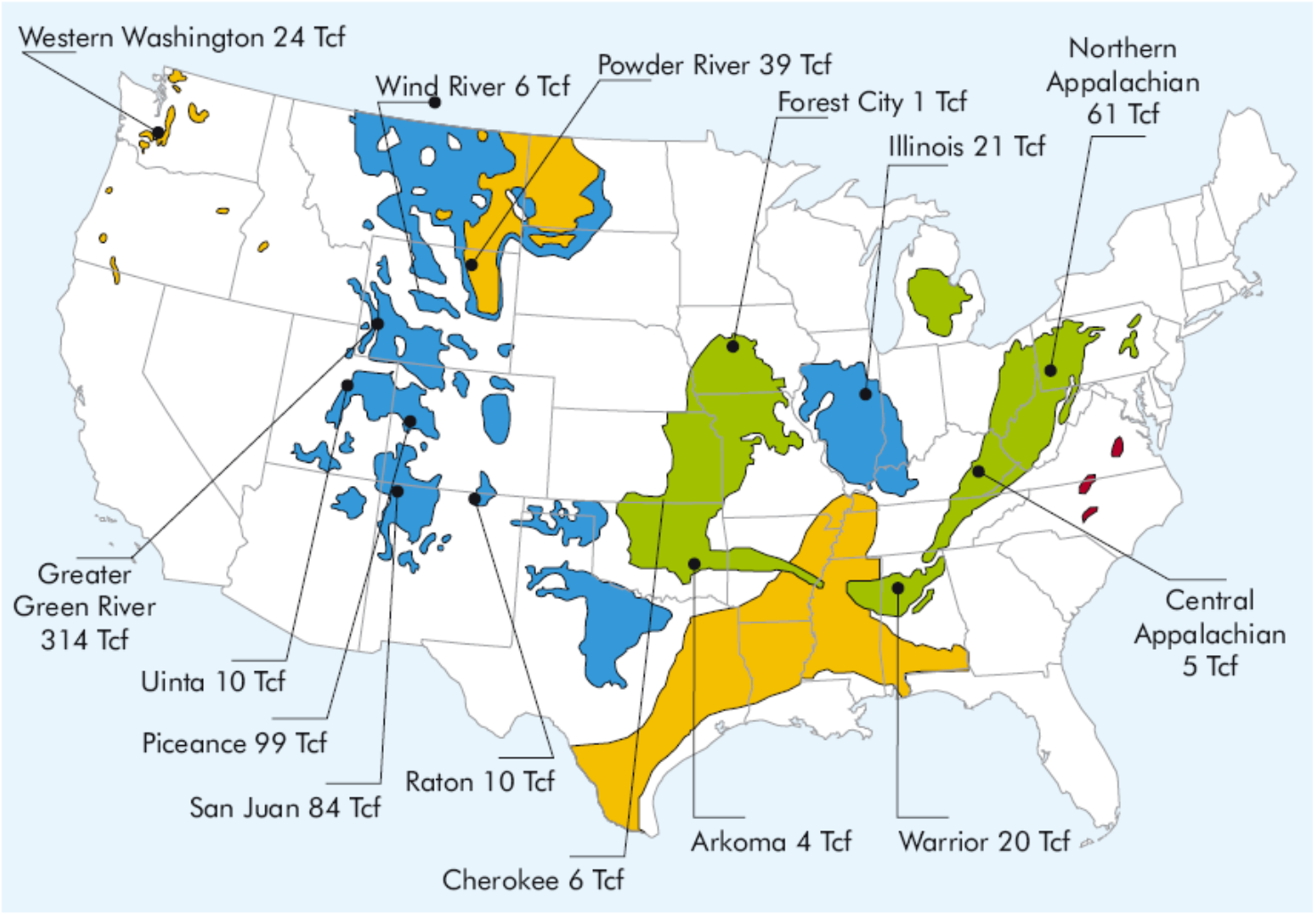


Note: 1 billion cubic feet is approximately 28 million cubic metres or 180 000 boe.

Courtesy of Gas Technology Institute, United States.

US CBM RESOURCES

United States coal bed methane resources - 20 trillion cubic metres

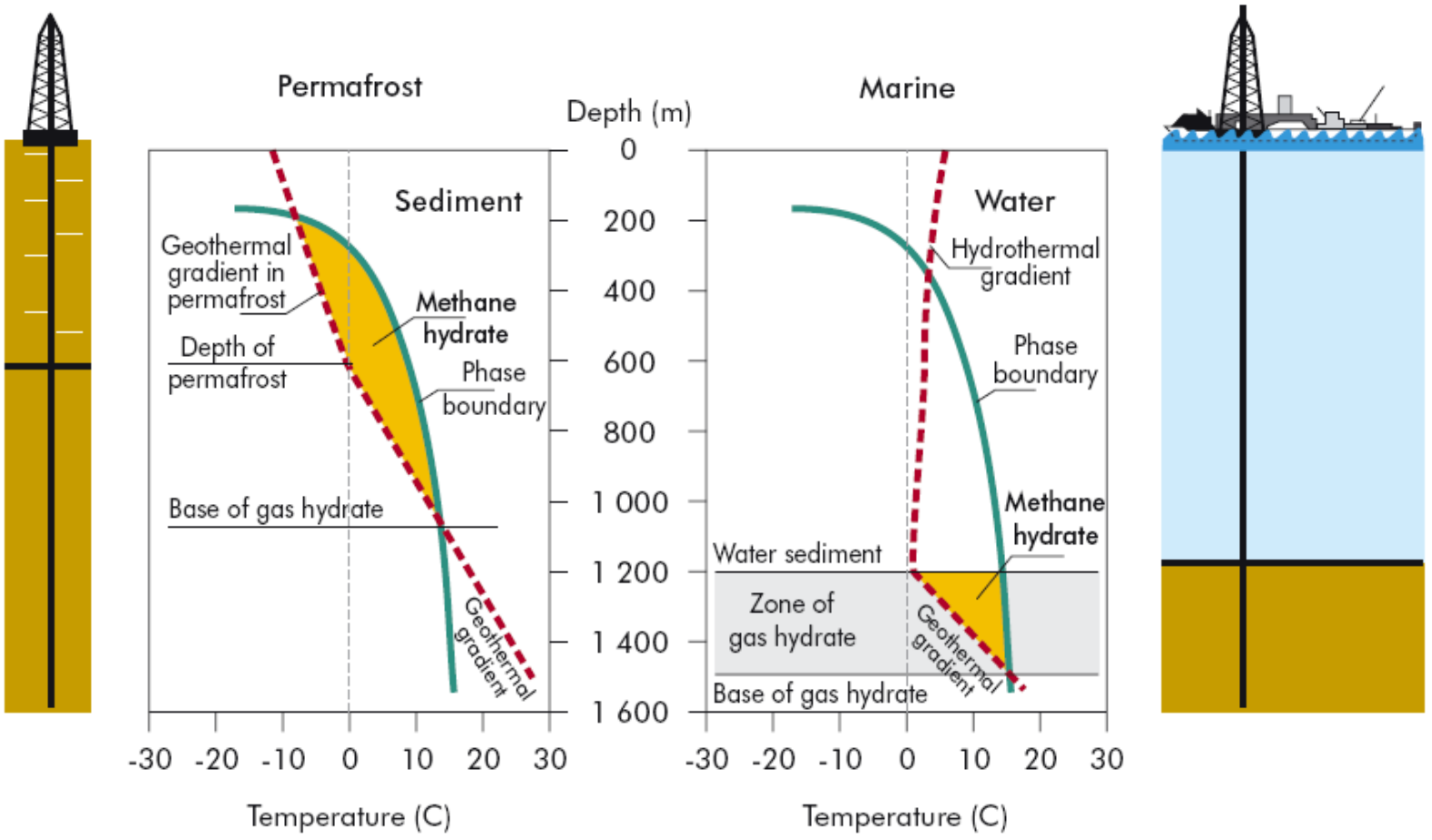


Courtesy of Gas Technology Institute, United States.

Figure 4.2

GAS HYDRATES

Hydrates existence domain as a function of pressure and temperature

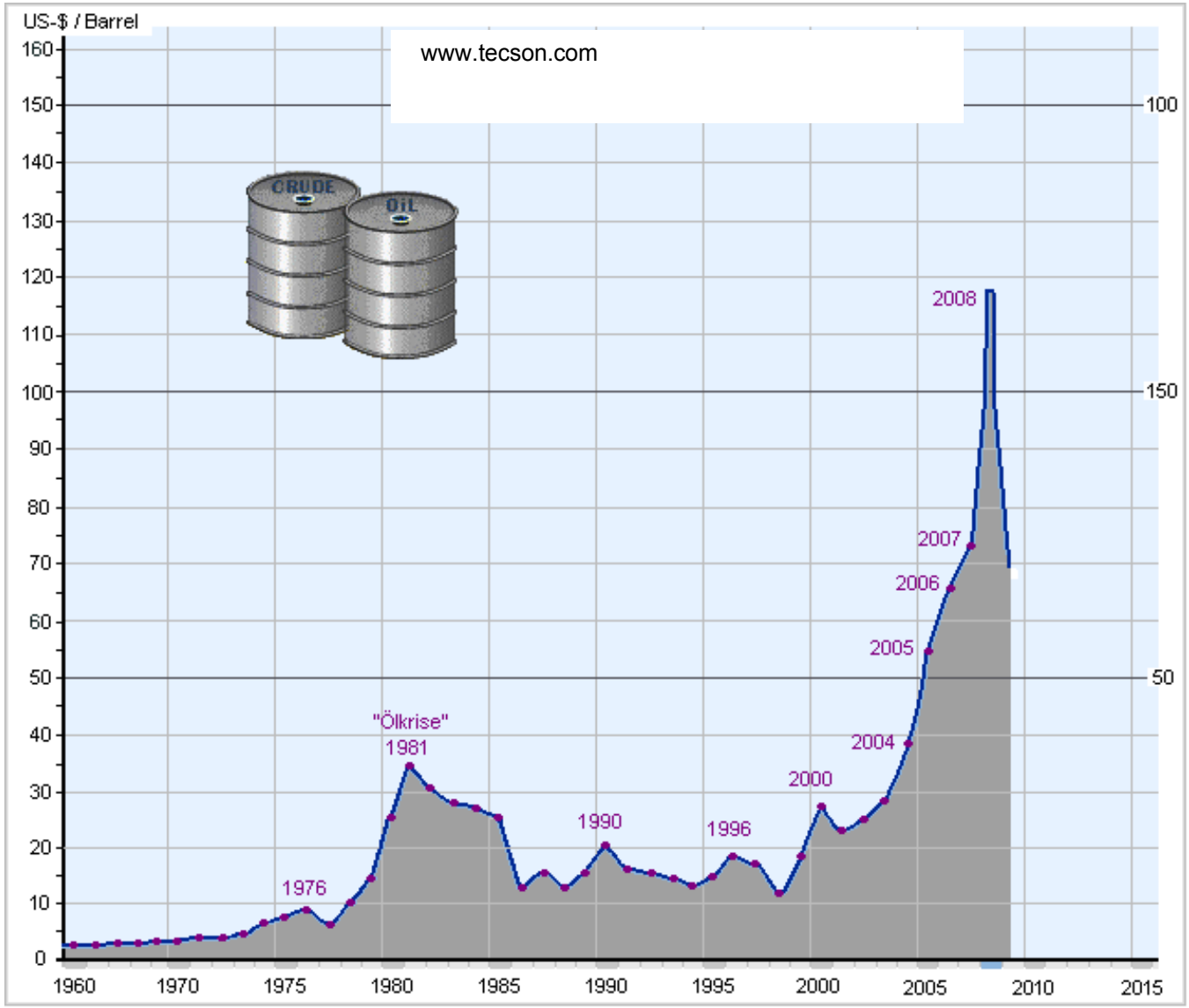


Courtesy of S. Dallimore, National Resources Canada.

MAP OF CONFIRMED METHANE HYDRATE PRESENCE

Courtesy of S. Dallimore, National Resources Canada.

OIL PRICES


US-$ / Barrel
www.tecson.com
CRUDE
OIL
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
100
150
50
2008
2007
2006
2005
2004
2000
1996
1990
"Ölkrise"
1981
1976
1960
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015

CRUDE OIL CLASSIFICATION

- 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

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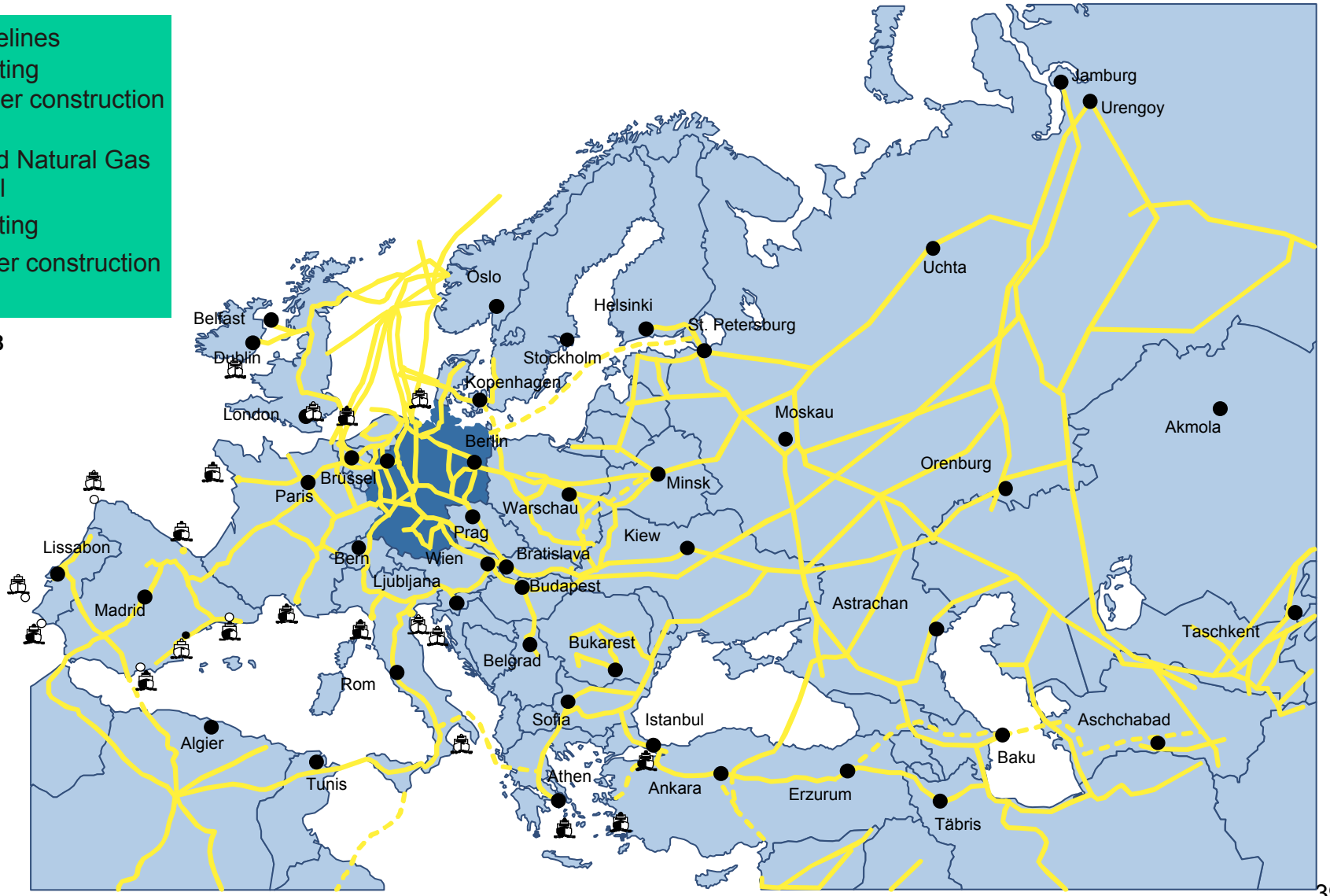
Gas pipelines
existing
Under construction

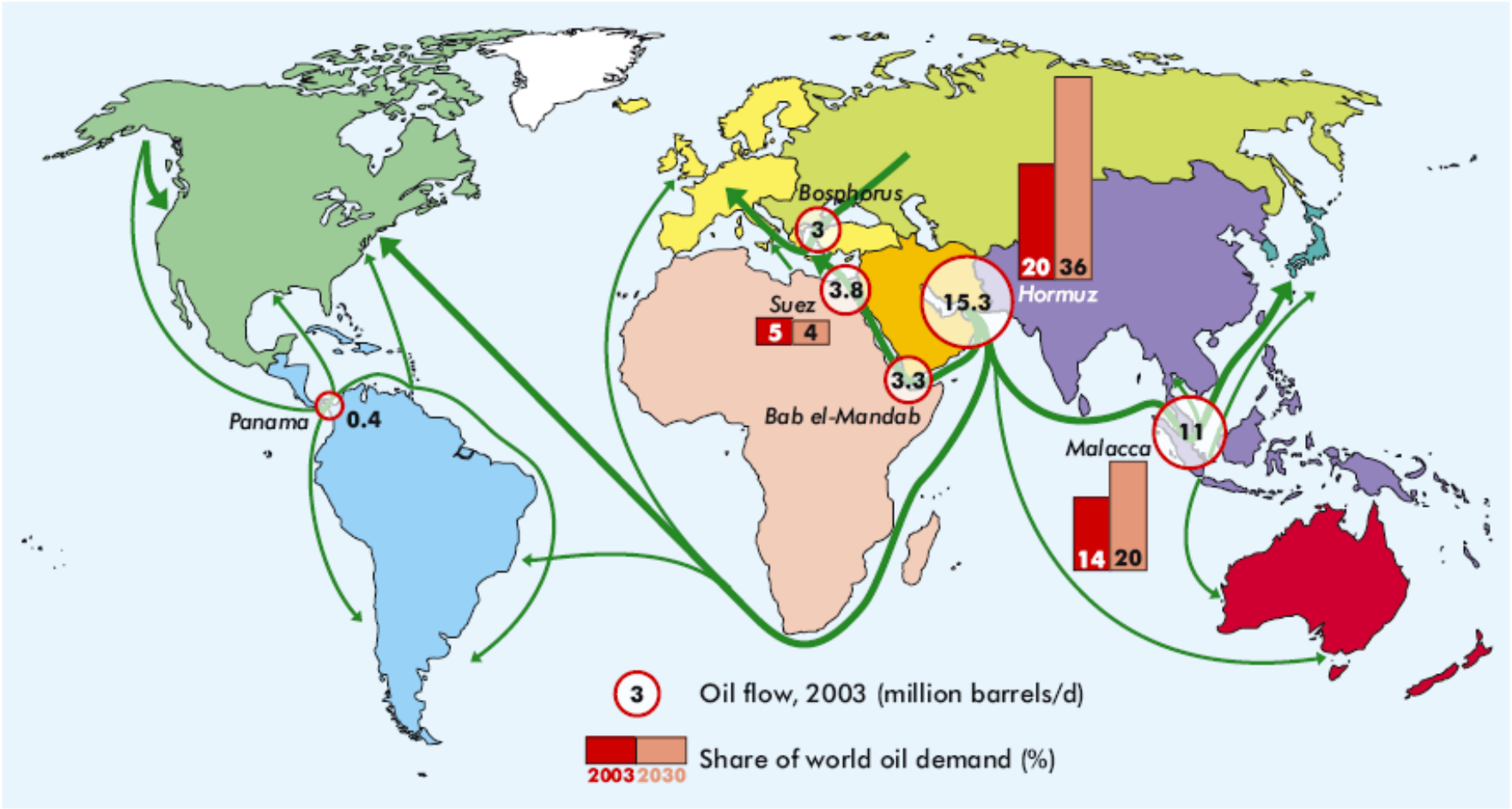
Liquefied Natural Gas Terminal
existing
under construction

Stand: 2008



OIL FLOWS

Oil flows and major chokepoints, 2003



Source: WEO-2004, IEA.

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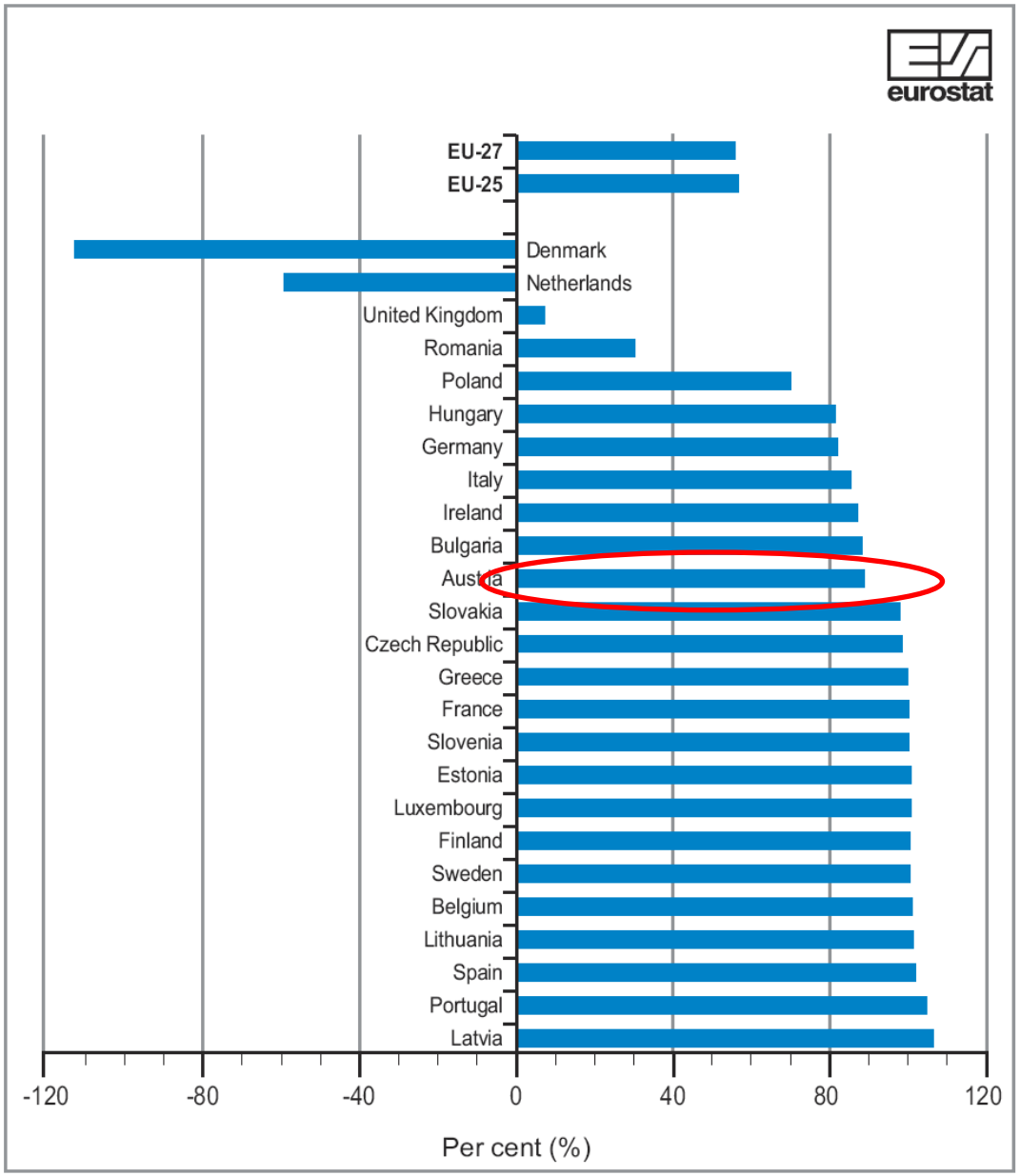
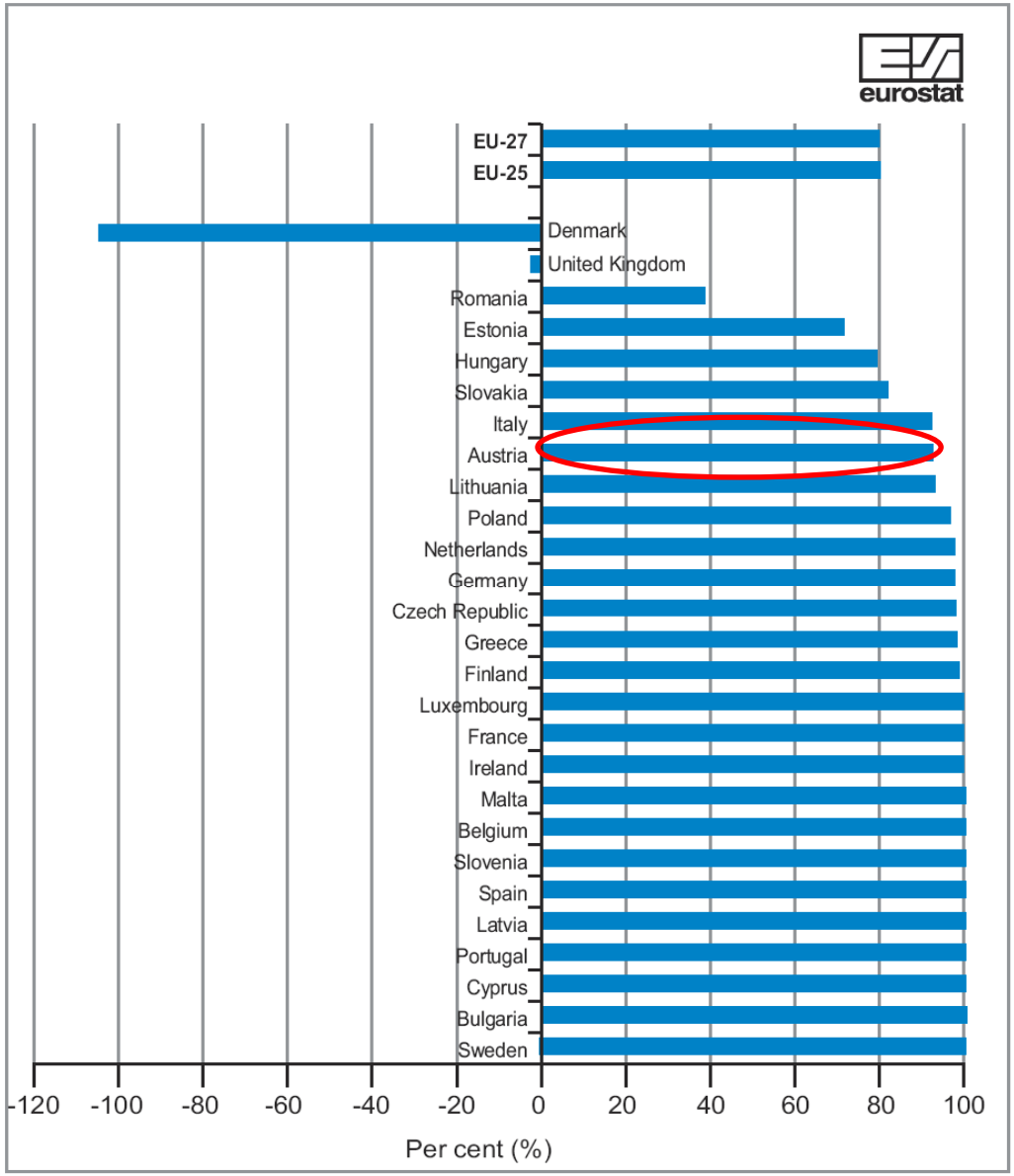
Rocky Time for Energy Markets: Global Energy Security Threats

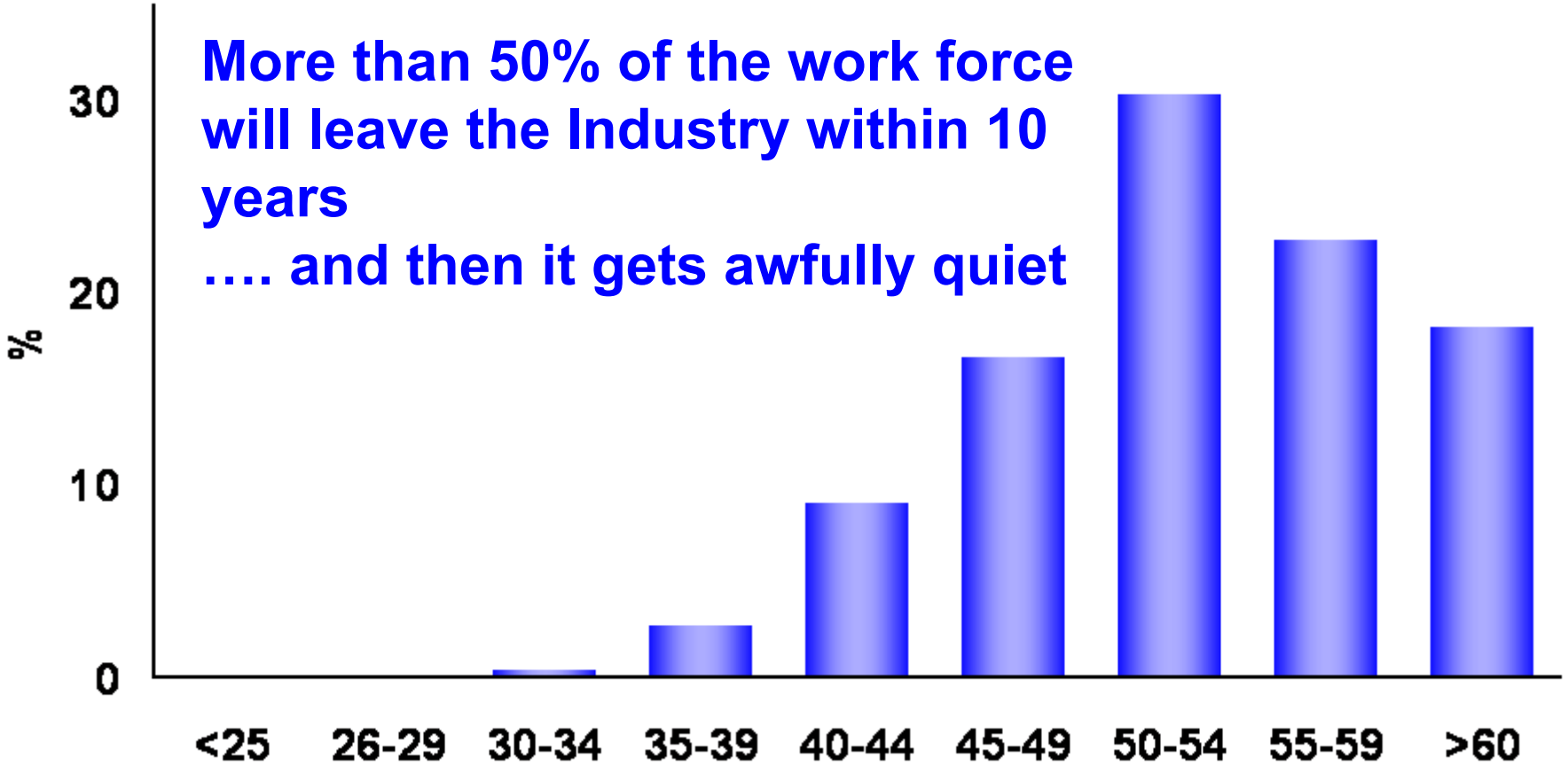
ENERGY DEPENDENCY – NATURAL GAS



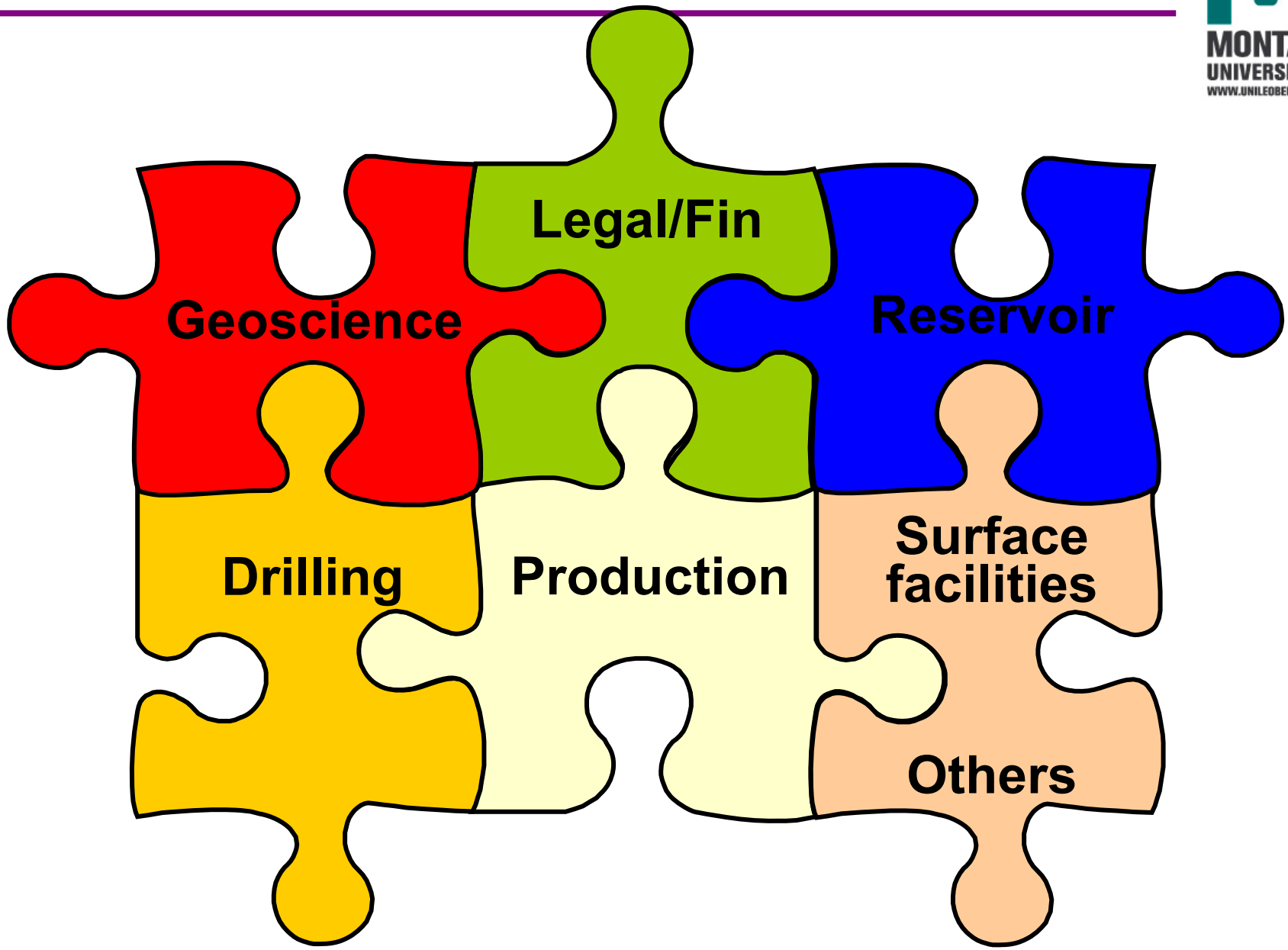
ENERGY DEPENDENCY – OIL



THE BIG CREW CHANGE



THE PETROLEUM FAMILY



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 …