

EAGE

EUROPEAN
ASSOCIATION OF
GEOSCIENTISTS &
ENGINEERS

Student Lecture Tour
Europe 2009-2010



What Energy Future after the World Oil Production Peak?

COURSE NOTE

Prof. Pierre-René Beauquis
Total Professeurs Associés

Mr Jean-Marie Masset
Total Professeurs Associés

Mr Roland Geoffrois
Total Professeurs Associés

Dr Philippe Julien
Total

Mr Pascal Breton
Total

Mr Pierre Mauriaud
Total

www.eage.org

SLT Europe

**The Student Lecture Tour (SLT) is
brought to you by the**

EAGE
STUDENT FUND



EAGE Student Membership

- Free subscription to the First Break magazine
- Free subscription to one online scientific journal
- Discount fee for participation in EAGE activities and events
- Free participation in the EAGE Student Lecture Tours throughout Europe, the Middle East and Russia/CIS
- First year no memberships dues - afterwards 25 Euro (for all qualifying free student members)

EAGE Student Membership

- Support to student conferences, workshops and field trips
- Student Programme at EAGE Conferences in particular at the regional conference (St. Petersburg 2010) and at the annual Conference (Barcelona 2010).
- Access to worldwide network of professionals (12.000 plus Members)

Join Us!

For more details visit our website at www.eage.org

Or contact the Student Coordinator at students@eage.org

St. Petersburg Student Conference Programme

- 4th International Conference & Exhibition Saint Petersburg 5 - 8 April 2010
- **TRAVEL GRANTS** available for students, apply now online!
- 1 Day parallel Student Programme including:
 - Student Short Courses
 - Lectures
 - Student Poster Presentations
 - Exhibition Tour
 - Geo-Quiz
 - Other activities to be announced
- Student Evening Party - Don't miss it!



Barcelona Student Conference Programme

- **TRAVEL GRANTS** available for students, apply now online!
- Opportunity to present a student poster. Apply now online!
- 72nd EAGE Conference & Exhibition in Barcelona 14 – 17 June 2010
- 3 Day parallel Student Programme including:
 - Student Court activities
 - Student Short Courses
 - Student Poster Presentations (evaluated)
 - Exhibition Tours
 - Young Professional Presentations
 - Trial Interviews
 - Geo-Quiz
- Student Evening Party - Don't miss it!



EAGE Student Chapters

Interested in Creating an EAGE Student Chapter?

Becoming part of a European based professional association for geoscientists and engineers with a worldwide membership

Student Chapters Include:

- 10 free student memberships
- Annual student event support
- Publishing opportunities
- Website exposure
- Online Geo-Quiz competition



Contact Student Coordinator
students@eage.org

SLT Europe 2009 & 2010

'What Energy Future after the World Oil Production Peak?'

Prof. Pierre-René Beauquis
Total Professeurs Associés



Mr Jean-Marie Masset
Total Professeurs Associés



Mr Roland Geoffrois
Total Professeurs Associés

Dr Philippe Julien - Total



Mr Pascal Breton - Total

Mr Pierre Mauriaud Total

What energy future after world oil production peak ?



What energy future after world oil production peak?

TABLE OF CONTENTS

- 1 Reminding oil fundamentals: a few key points**
- 2 Production constraints: oil and gas peaks**
- 3 Climate constraints: some key data**
- 4 Oil prices: yesterday, today, and tomorrow**
- 5 What future for energy: the oil industry in a new world**



What energy future after world oil production peak?

Key considerations about energy fundamentals

For the last 50 years :

- Oil has been the dominant source of primary commercial energy (40% of world total)
- Oil has been the economic regulator of all energy prices
- Oil has been the physical regulator of the world energy system
- OPEC has been the regulator of world oil system
- Saudi Arabia has been the regulator of OPEC

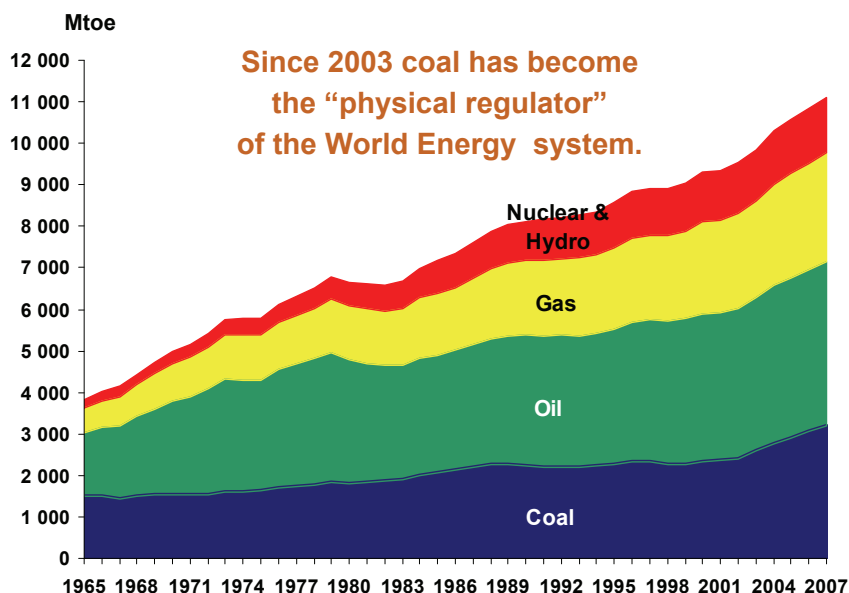
What about 2020 ? 2050 ? 2100 ?



3

What energy future after world oil production peak?

Key considerations about energy fundamentals

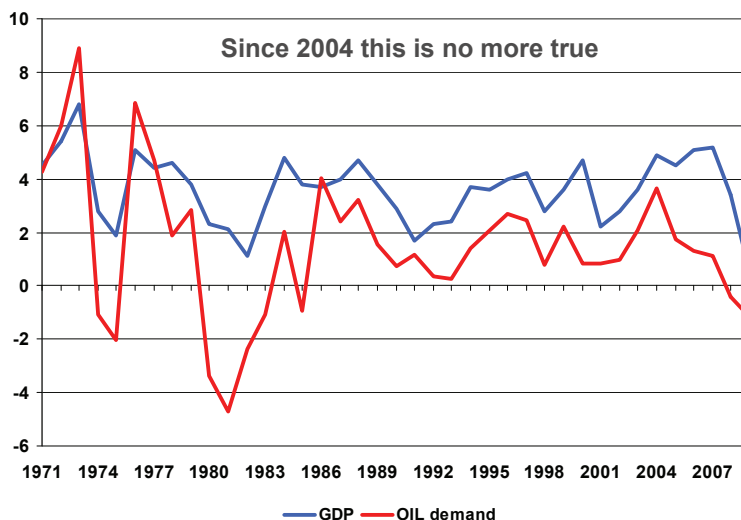


4

What energy future after world oil production peak?

GDP and demand for oil Annual growth rate (% , worldwide)

World Energy in the past was simple: oil was the “physical regulator”

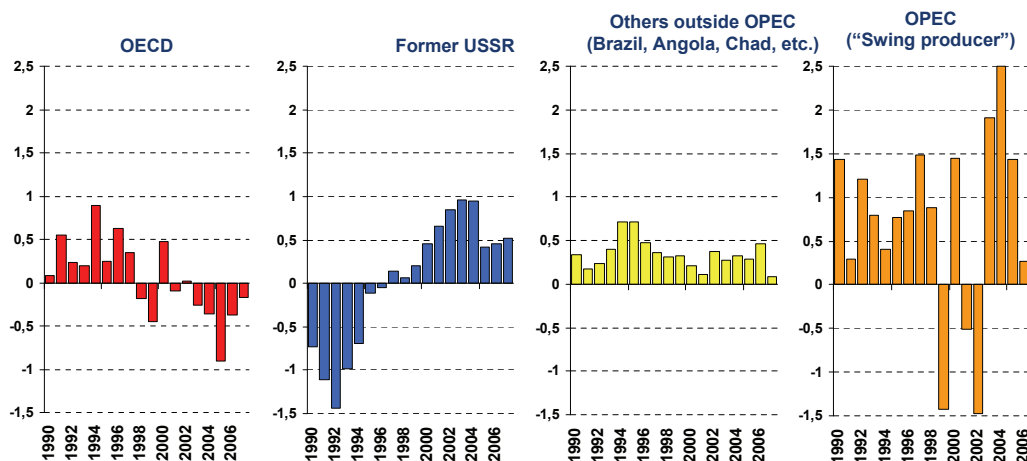


5

What energy future after world oil production peak?

Oil growth is coming from outside the OECD exclusively

Annual changes in oil production



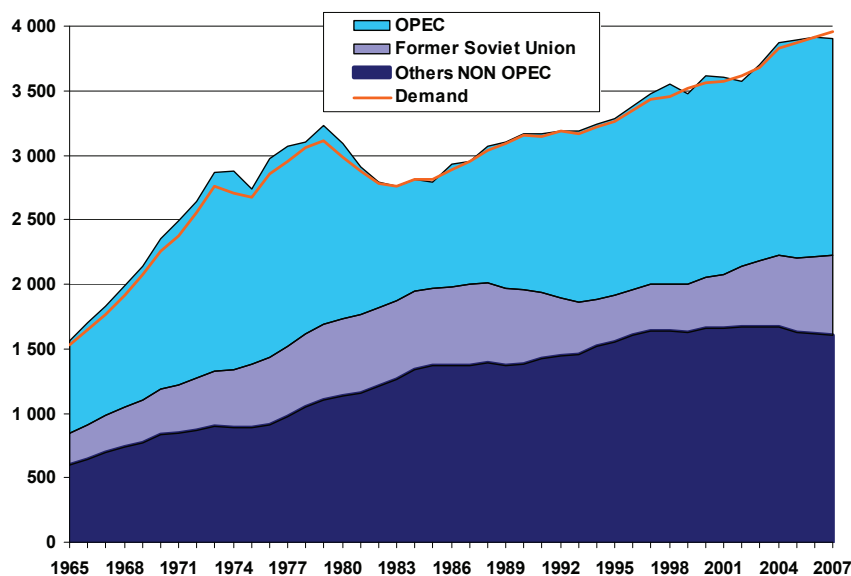
Since 1975 OPEC has become the
regulator of the World Oil system.



6

What energy future after world oil production peak?

Crude oil production - Mt



30-4789

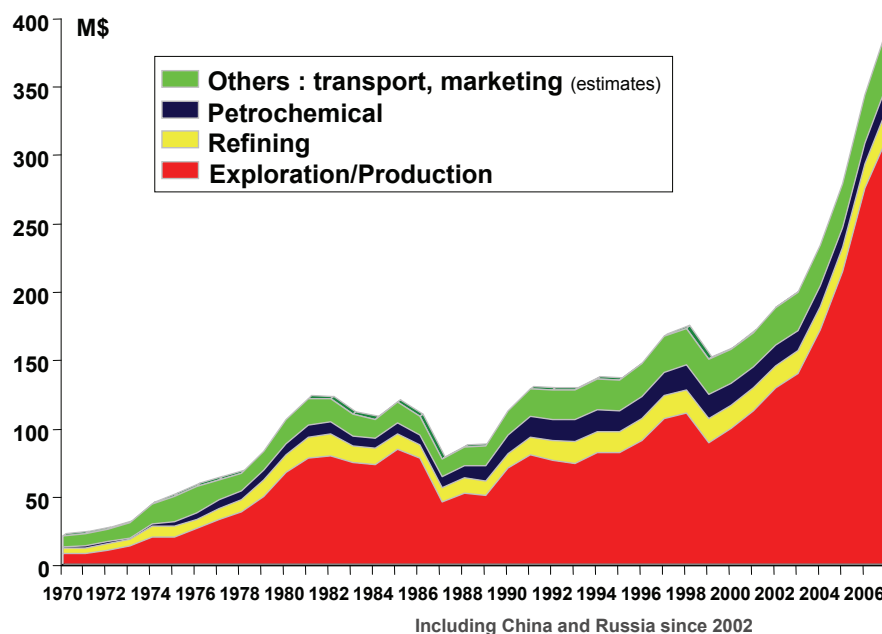


7



What energy future after world oil production peak?

Upstream: E&P represent 80% of the global oil industry investment



30-4789

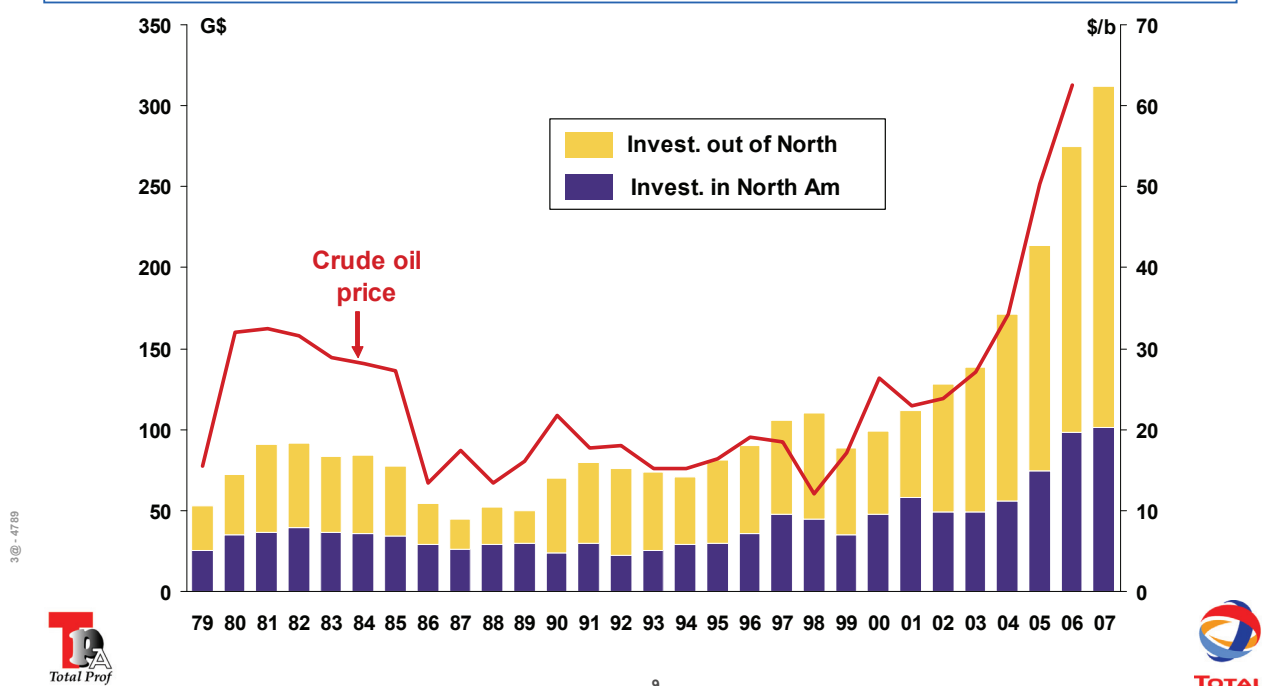


8



What energy future after world oil production peak?

History of investment in exploration-production



What energy future after world oil production peak?

The key paradoxes of the oil industry

- At 100 \$/b crude oil, the upstream worldwide average technical costs represent 15% (while 10% are for the producing companies and around 75% for the producing countries « government take »).
- At the 100 \$/b this « crude oil cost » represent an average 30% of the pumps prices in the E.U. (10% downstream costs for refining and distribution and around 60% for the consuming countries « government take »).

What energy future after world oil production peak?

TABLE OF CONTENTS

- 1 Reminding oil fundamentals: a few key points
- 2 Production constraints: oil and gas peaks
- 3 Climate constraints: some key data
- 4 Oil prices: yesterday, today, and tomorrow
- 5 What future for energy: the oil industry in a new world

30 - 4789

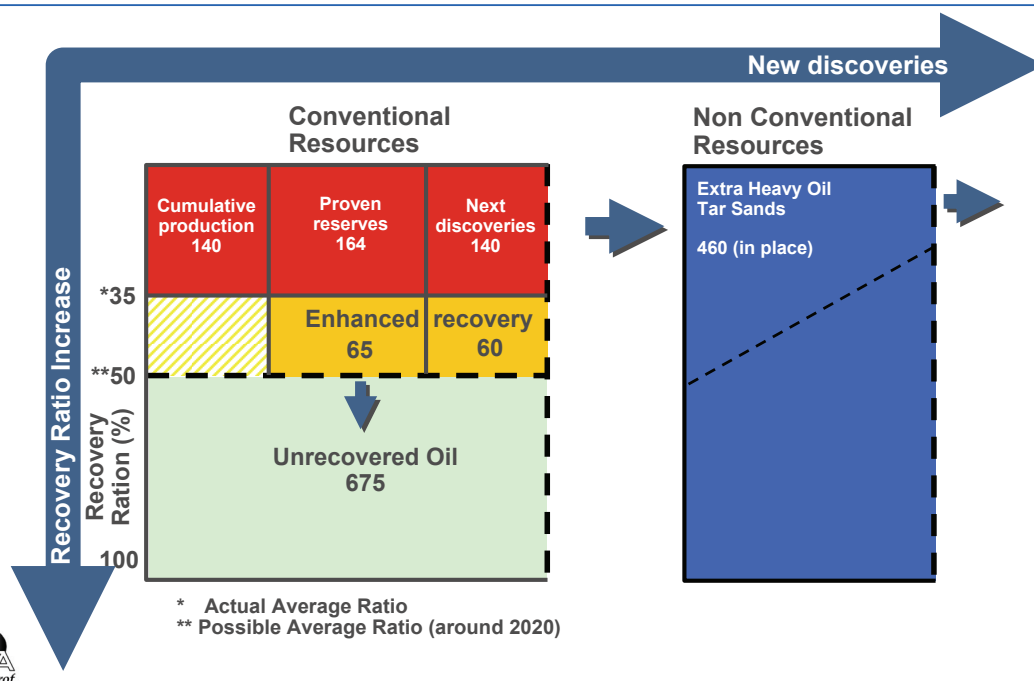


11



What energy future after world oil production peak?

Oil resources (Gt)



30 - 4789

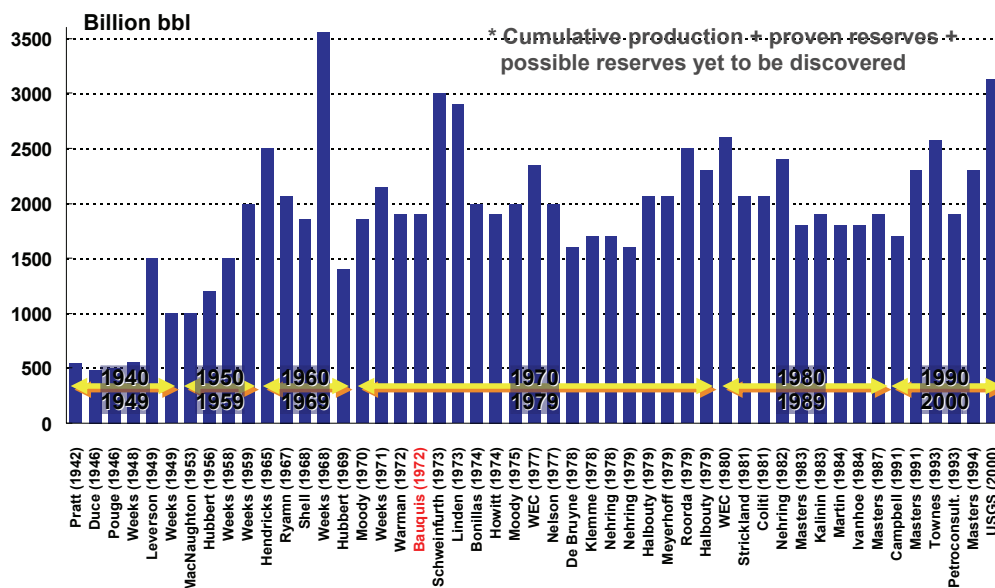


12



What energy future after world oil production peak?

Historical views on ultimate reserves



Source: IFP/DSEP adapted from Martin (1985) and Campbell (1992) - Updated 2000

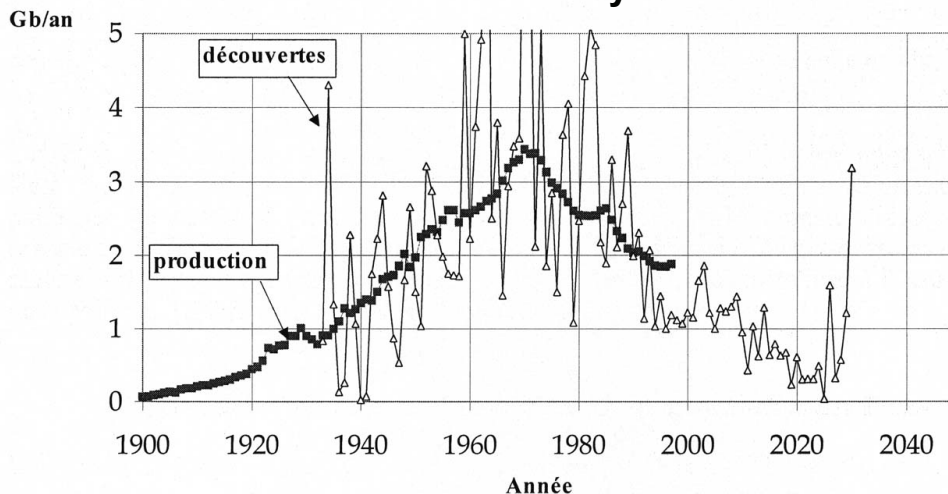


13

What energy future after world oil production peak?

The irreversible decline of Oil productions in the USA

Peak oil is not a theory: it's a fact...



(*) Discoveries are registered as per their initially declared sizes and their timing is « forwarded » by 33 years
Source : King Hubbert 1956 - Updated by Jean Laherrere



14

What energy future after world oil production peak?

History of important discoveries in the world

A few figures illustrating Peak Oil and Peak Gas

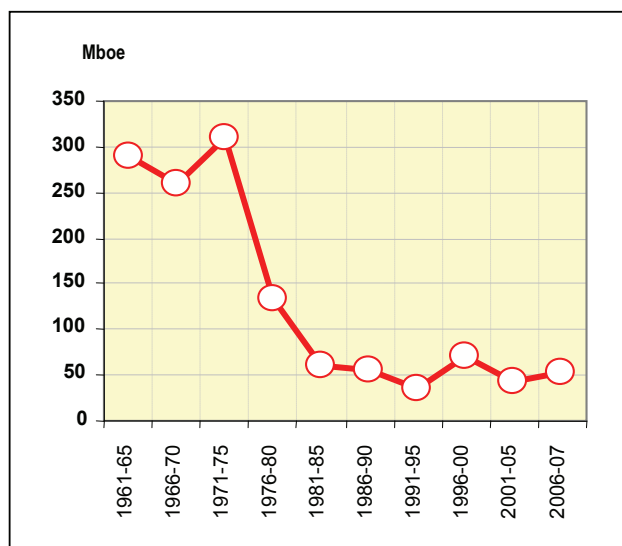
Size	Number of Discoveries			
Mboe	1960s	1970s	1980s	1990s
50 - 100	235	261	300	314
100 - 200	105	162	113	90
200 - 500	179	208	170	154
500 - 1000	90	95	66	52
+1000	129	116	90	20



15

What energy future after world oil production peak?

The declining average size of discoveries

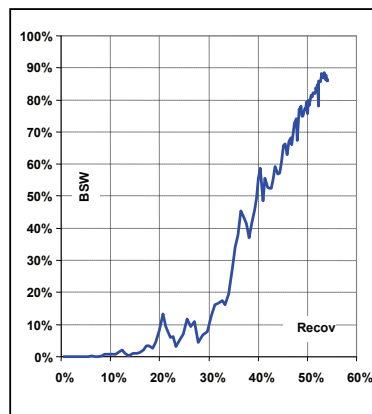
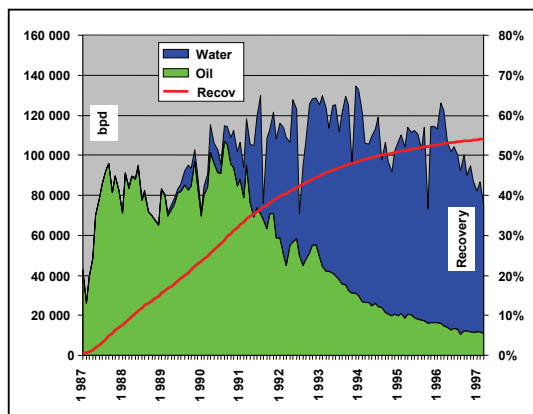


16

What energy future after world oil production peak?

Production profiles liquids: North Sea clastics

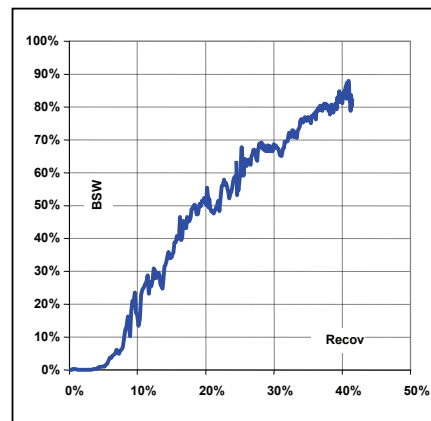
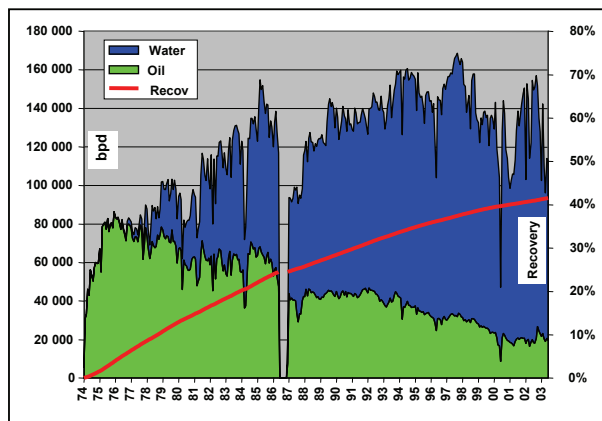
(Sand clastics are « oil wet »)



What energy future after world oil production peak?

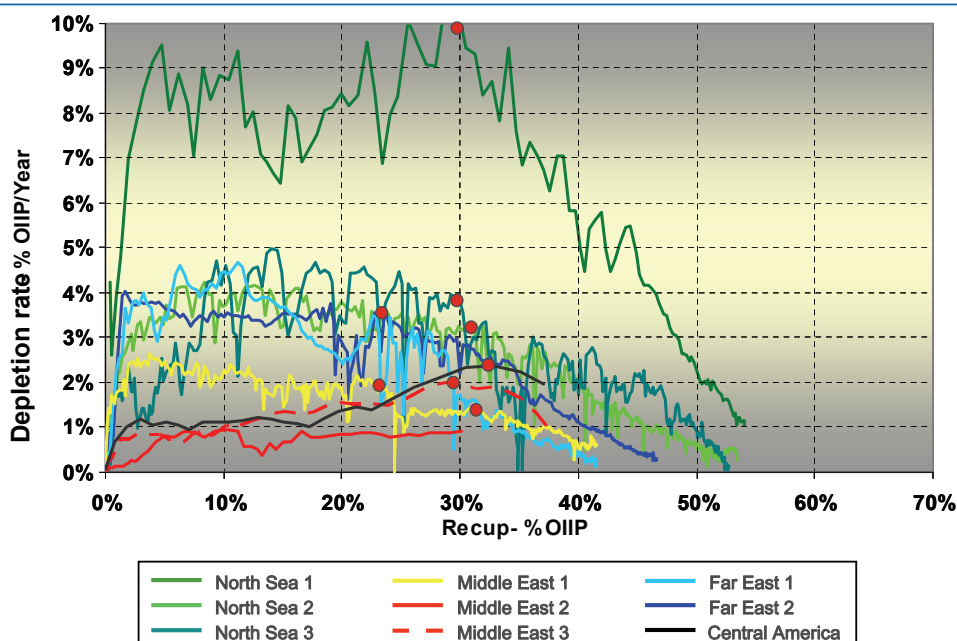
Production profiles liquids: Middle East carbonates

(Carbonates are « water wet »)



What energy future after world oil production peak?

Depletion rate versus recovery factors for various type of oil fields

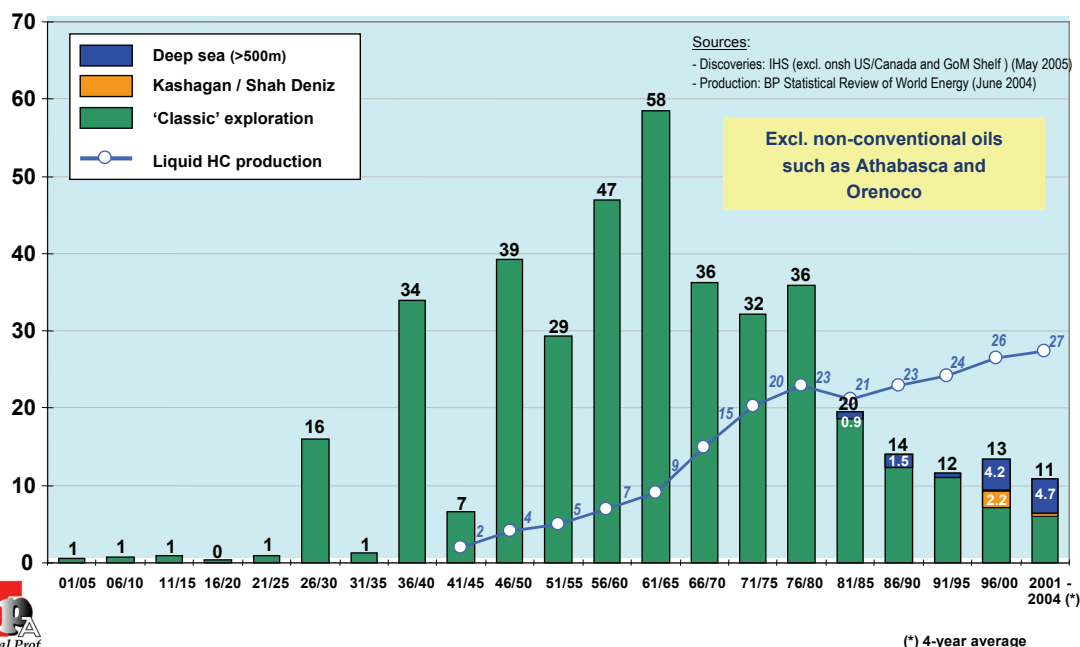


19

What energy future after world oil production peak?

Oil and condensate discoveries and worldwide production of liquid hydrocarbons

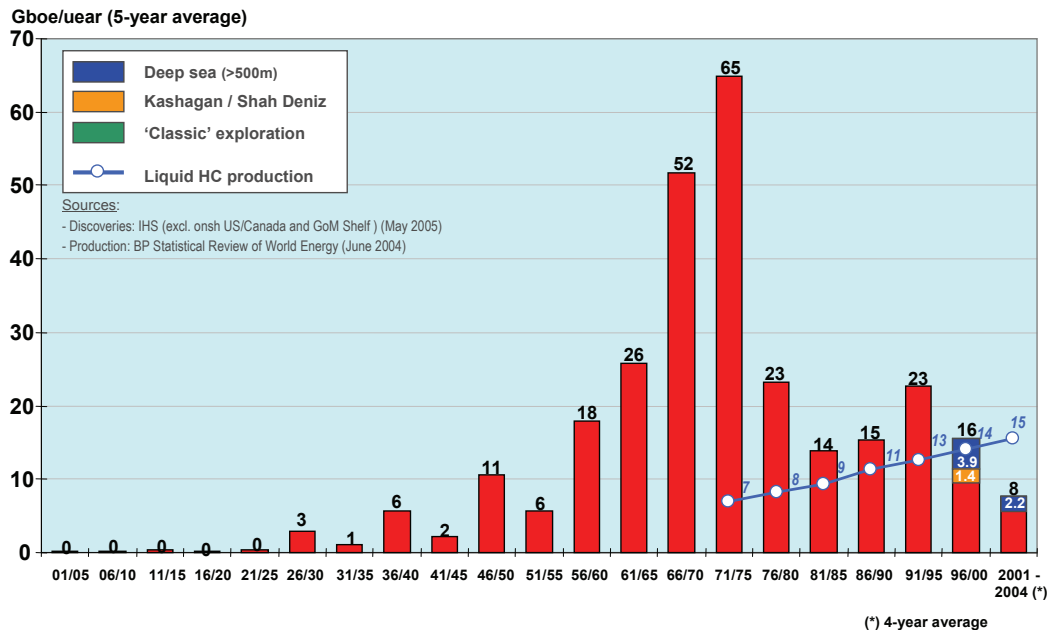
Gboe/year (5-year average)



20

What energy future after world oil production peak?

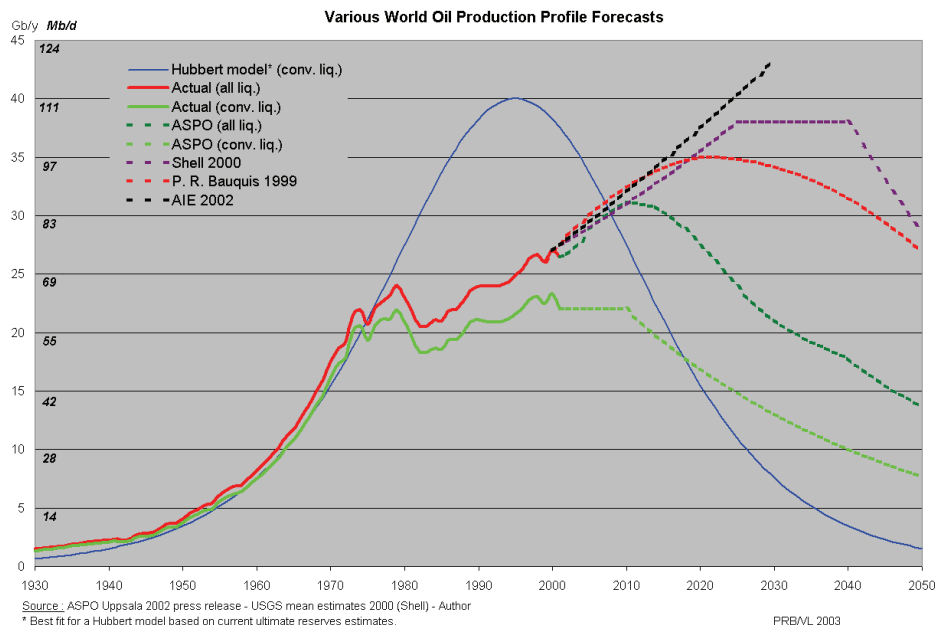
Gas-hydrocarbon discoveries and production worldwide



21

What energy future after world oil production peak?

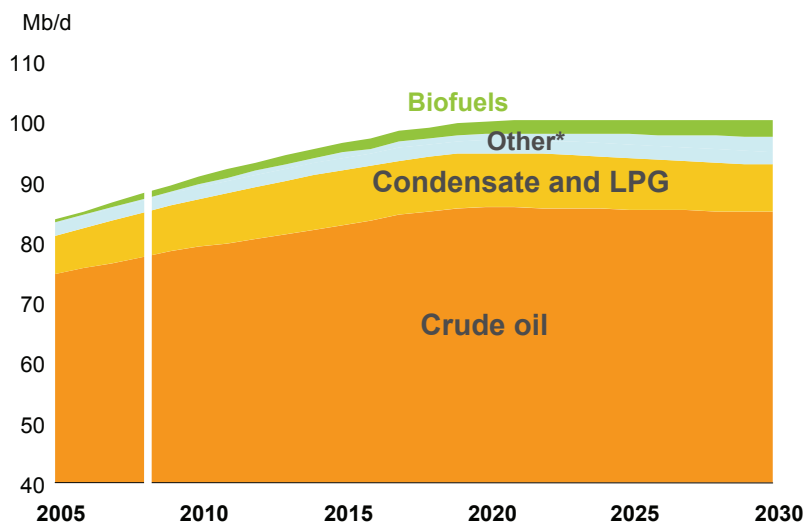
Various World Oil Profile Forecasts



22

What energy future after world oil production peak?

The « TOTAL view » mi 2009 of future World Petroleum Production



What energy future after world oil production peak?

Summary of opinions about "peak oil"

- ▶ Since June 2006 it can be considered that views about Peak Oil in France have become reasonably similar :
 - TOTAL : Thierry Desmarest – around 2020 / around 100 Mb/d
 - ASPO France : J. Laherrère – around 2015 / less than 100 Mb/d
 - P.R. Bauquis – around 2020 / around 100 Mb/d
 - IFP : Y. Mathieu – ondulated plateau 20150/2030 – less than 100 Mb/d
- ▶ This point of view is widely different from those among the "optimists" who believe that Peak Oil is not "reserves related" but a political problem : insufficient investments and restrictive policies about investments by OPEC countries, Russia and Mexico :
 - Exxon Mobil – June 2006 – "no sign of peak oil"
 - Aramco – June 2006 – "no reserve problem"
 - ENI (Maugeri – Early 2006 – "no foreseeable oil peak"
 - BP : John Browne – May 2006 – "There is no reserves problem"
 - Mike Lynch (ex MIT) – "similar and above 120 Mb/d"
 - CERA (Cambridge Energy Research Associates) – 2007 study "Denying peak-oil"
 - USGS, DOE, EIA, IEA...
- ▶ IEA started changing their views in 2006 and accentuated this change in 2007 : they now seem to realize that peak oil is not only a political or "above ground" problem but also a geological one.

What energy future after world oil production peak?

Key considerations about peak oil impact

- ▶ Oil and gas will still be produced beyond the end of the 21st century
- ▶ However the oil production peak (between 2015 and 2025, most probably) and gas production peak will trigger radical changes
- ▶ Paradoxically, it will be the oil and gas industries golden age (high prices, little political interference in those prices).
- ▶ After the oil peak, oil and gas prices will see a change of logic: they will become related to those of their substitutes (reversal from the past).
- ▶ As soon as world oil production starts declining, OPEC will lose its price-policing role but could keep other roles.



25



What energy future after world oil production peak?

TABLE OF CONTENTS

- 1 Reminding oil fundamentals: a few key points
- 2 Production constraints: oil and gas peaks
- 3 Climate constraints: some key data
- 4 Oil prices: yesterday, today, and tomorrow
- 5 What future for energy: the oil industry in a new world



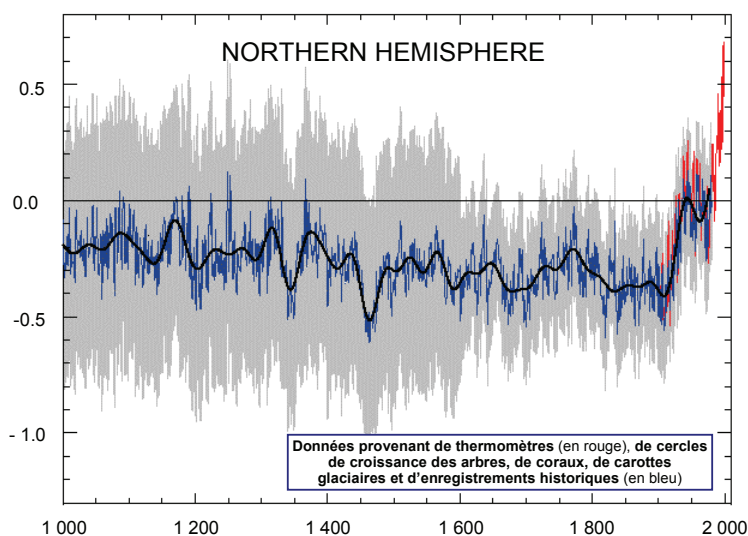
26



What energy future after world oil production peak?

Climate change: the earth's evolving temperature

- ▀ Variation in global temperatures over 1000 years (in °C)
The zero reference is the period 1961-1990



30 - 4789

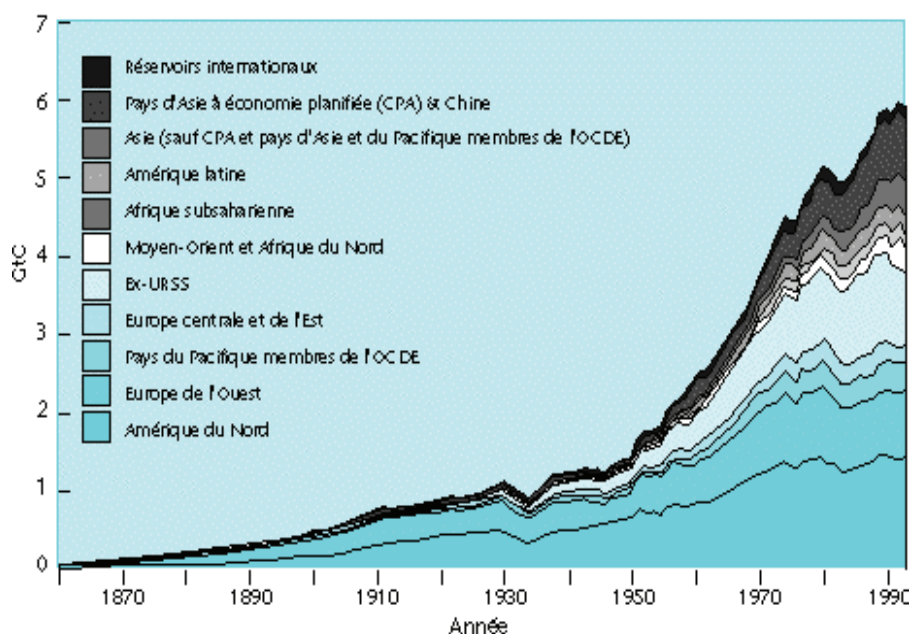


27



What energy future after world oil production peak?

Anthropic emissions of carbon dioxide



30 - 4789

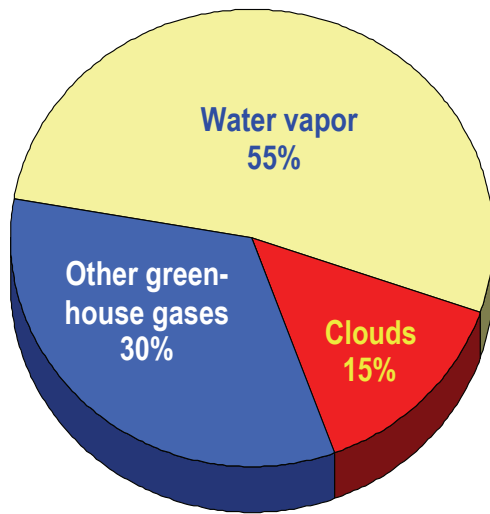


28

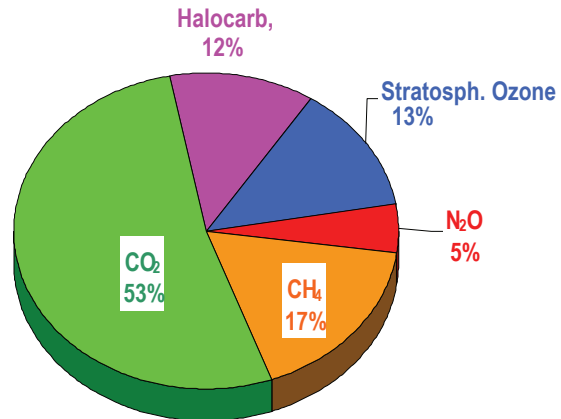


What energy future after world oil production peak?

Atmospheric contributions to greenhouse effect



Natural
(155 W/m²)



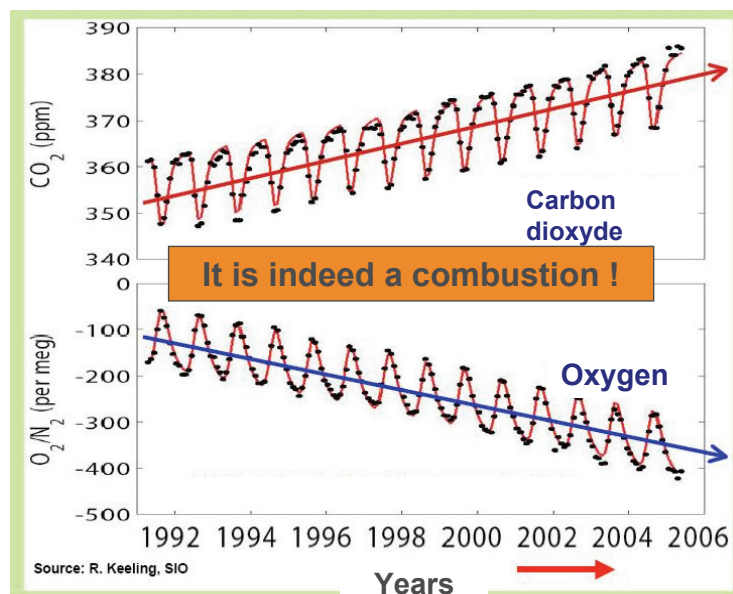
Anthropic
(2.8 W/m²)



29

What energy future after world oil production peak?

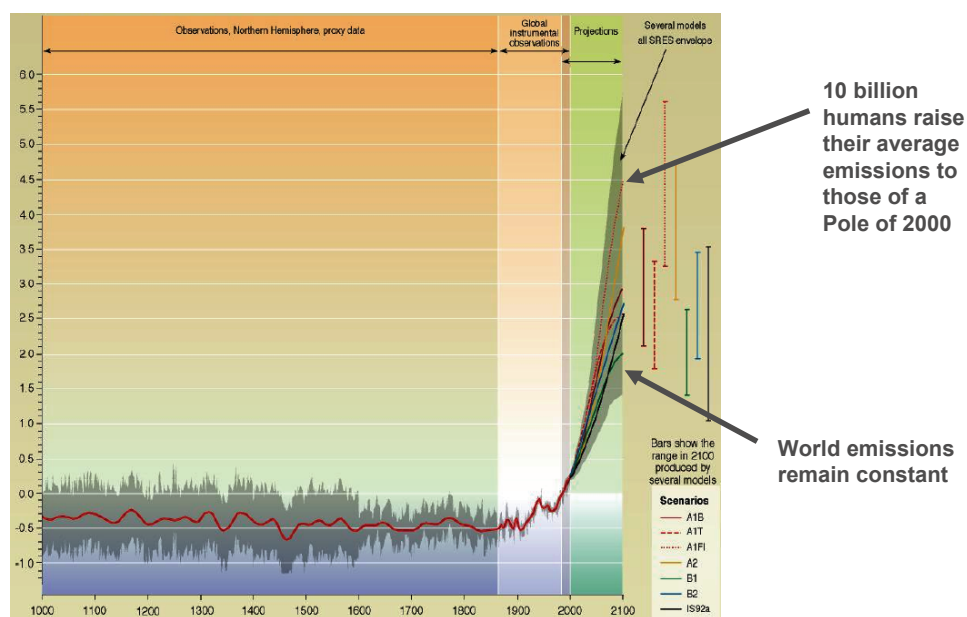
Human activities modify greenhouse effect



30

What energy future after world oil production peak?

Projections are heavily scenario-dependant



What energy future after world oil production peak?

For those who do not believe in Science...



What energy future after world oil production peak?

Climate change: what can an oil company do about it ?

- ▶ Promote a better understanding of climate change mechanisms and use it's industrial competences to develop potential solutions
- ▶ Better control greenhouse gas emissions from it's own facilities
- ▶ Help its clients to manage their greenhouse gas emissions
- ▶ Promote alternatives: renewable energies non CO₂ or low CO₂ emitting and nuclear energy
- ▶ Imagine and validate efficient and reliable solutions to capture and sequesterate CO₂ (Lacq Pilot scheme and others)

- ... while continuing to meet the world's energy demand (deep offshore, unconventional oil, mature fields, LNG...)



33

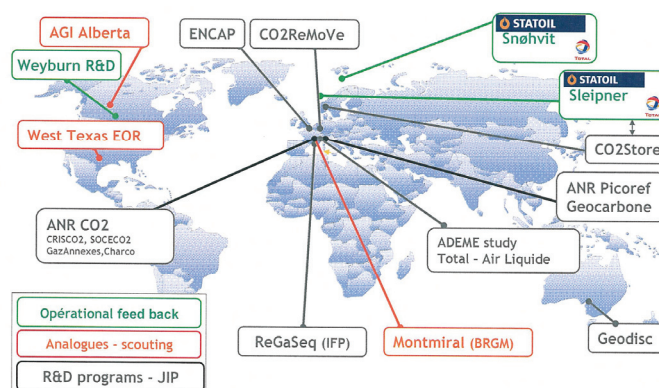


What energy future after world oil production peak?

Capture and Storage of CO₂

▶ Dedicated CCS program and partnership since 2001

- Capture technology development:
IPCC – 20-40% of world CO₂ emissions by 2050
- CO₂ injection and storage
 - Storage integrity
 - Well integrity
 - Long term fate of CO₂
 - P&R, monitoring



34



What energy future after world oil production peak?

TABLE OF CONTENTS

- 1 Reminding oil fundamentals: a few key points
- 2 Production constraints: oil and gas peaks
- 3 Climate constraints: some key data
- 4 Oil prices: yesterday, today, and tomorrow
- 5 What future for energy: the oil industry in a new world

30 - 4789

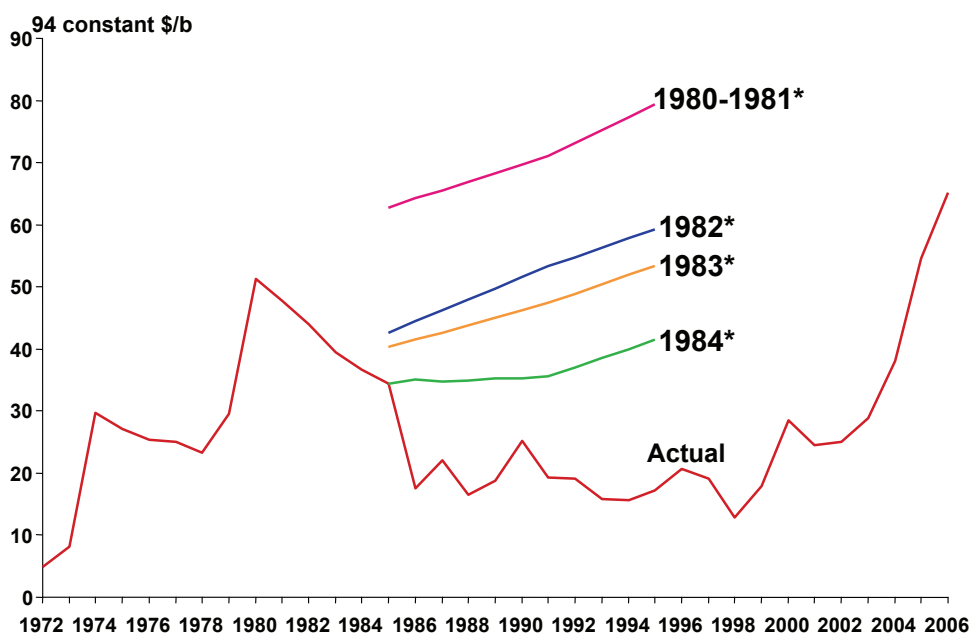


35



What energy future after world oil production peak?

Brent price evolution forecasts



30 - 4789

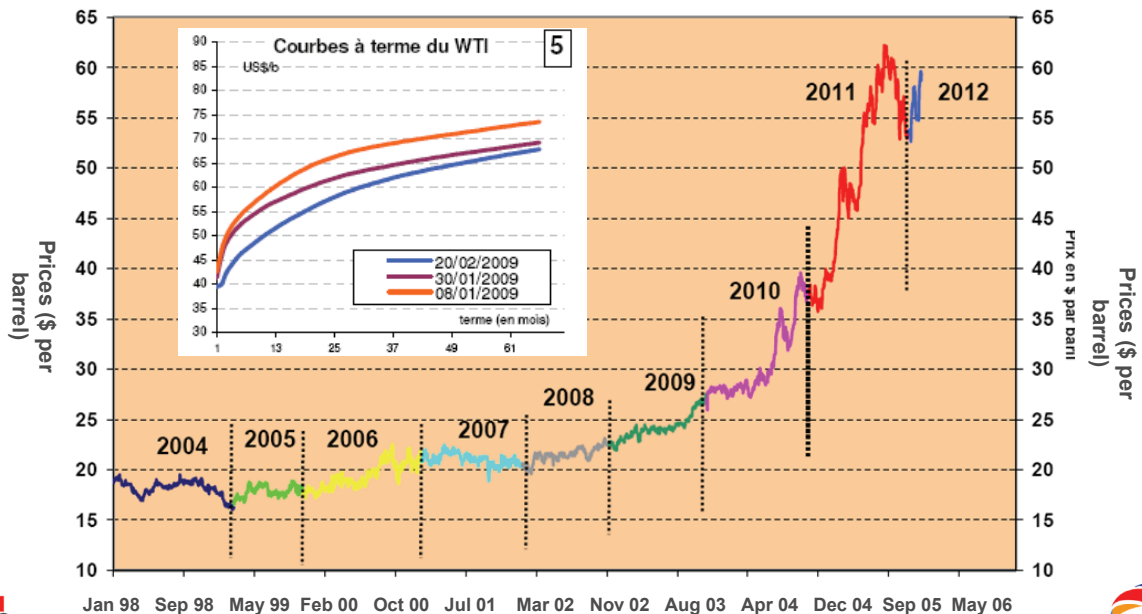


36



What energy future after world oil production peak?

Long-term WTI barrels (NYMEX): 6-year futures market, New York



37

What energy future after world oil production peak?

What is driving oil prices ?

It depends upon which newspaper you read...

- Financial press → stocks, stocks, market anticipations...
- Economic press → investment, economic growth,....
- Green/red press → speculation, speculation, greed....

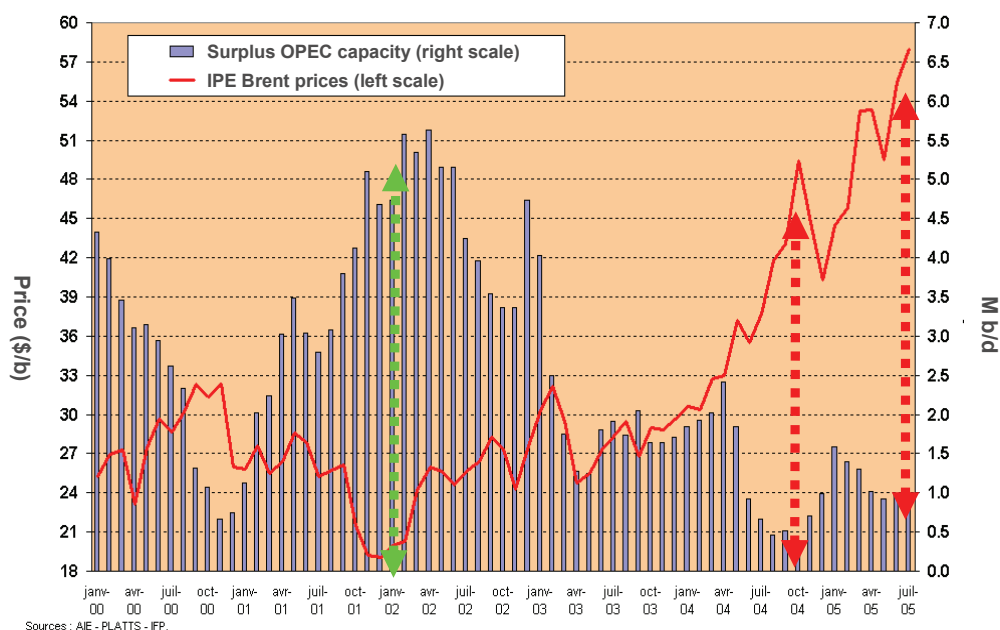
All these explanations are very partially relevant:
world unused surplus capacity is the Key factor



38

What energy future after world oil production peak?

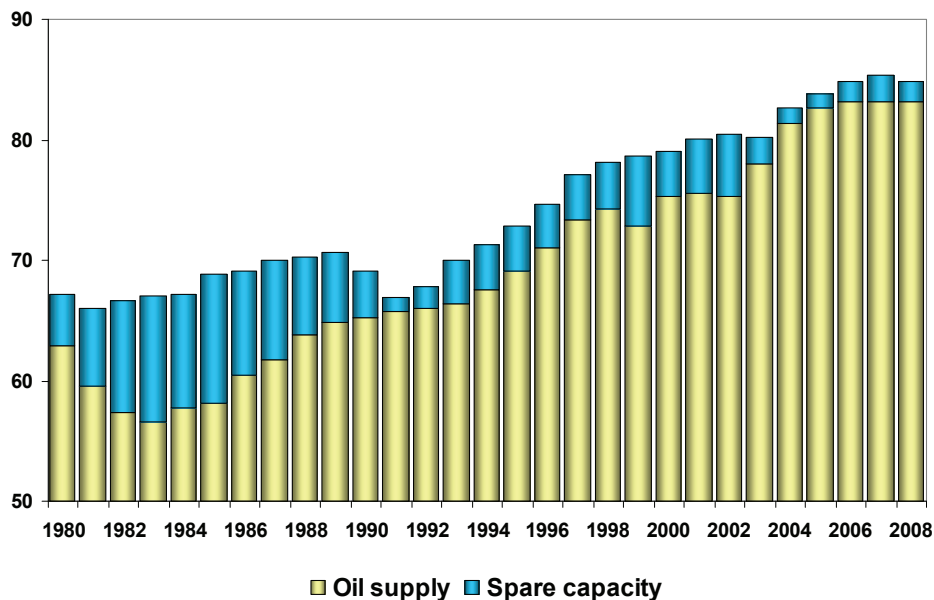
The price impact of OPEC surplus production capacity



39

What energy future after world oil production peak?

World excess production capacities: 100% within OPEC

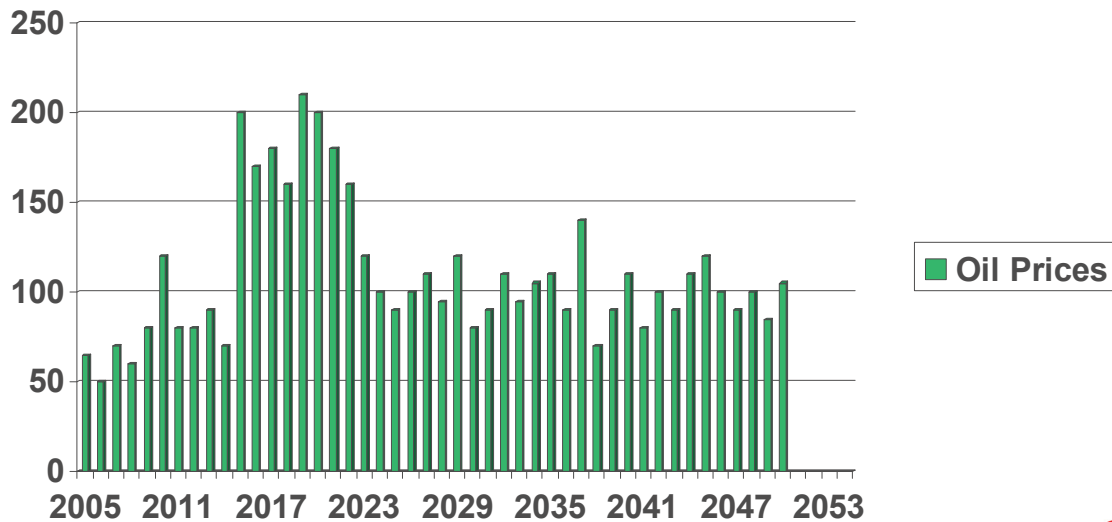


40

What energy future after world oil production peak?

Oil Prices 2005 – 2050 (Arabian Light in US \$ 2000/bbl)

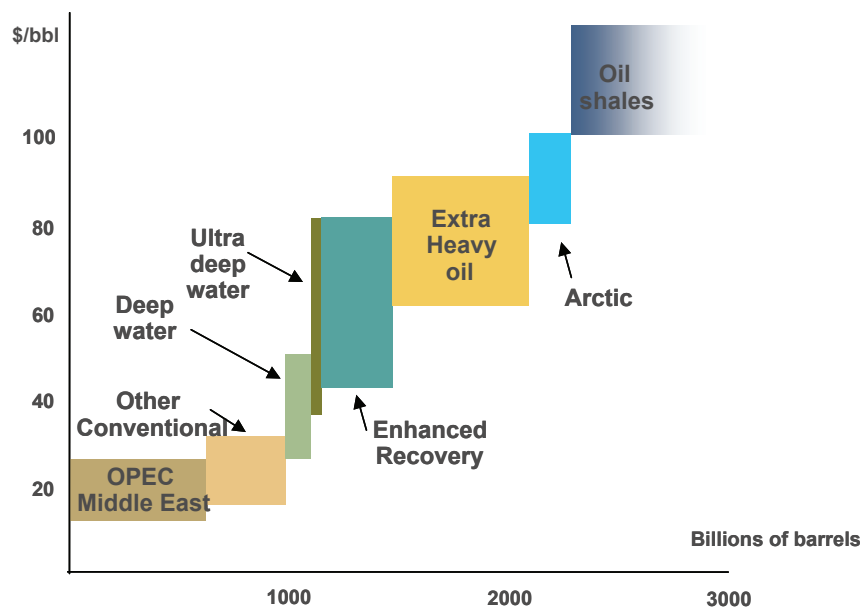
A dream view presented in Cambridge by P.R. B on 15/03/06



41

What energy future after world oil production peak?

Production costs are increasing...
...necessitating a relatively high oil price



42

What energy future after world oil production peak?

Key considerations about future oil and energy prices

- ▶ **High oil prices are a favorable factor:**
 - To ensure stability and economic growth of oil producers
 - To ensure energy conservation of oil importers
 - To ensure development of energy substitutes (Renewable and Nuclear)
 - To ensure development of “High Tech.” costly oil.
- ▶ **High oil prices means around 100 \$ bbl in US 2000 \$ (order of magnitude)**
- ▶ **However before prices could stabilize in this price range a new oil shock with temporary very high prices (200 to 400 \$ / bbl) is a likely scenario**

30 - 4789



43



What energy future after world oil production peak?

TABLE OF CONTENTS

- 1 Reminding oil fundamentals: a few key points
- 2 Production constraints: oil and gas peaks
- 3 Climate constraints: some key data
- 4 Oil prices: yesterday, today, and tomorrow
- 5 What future for energy: the oil industry in a new world

30 - 4789



44



What energy future after world oil production peak?

The 4 main drivers for oil industry structural changes

- geopolitics
- Peak oil and Peak gas
- Carbon emission costs (climate issue)
- The financial/economic crisis

30 - 4789

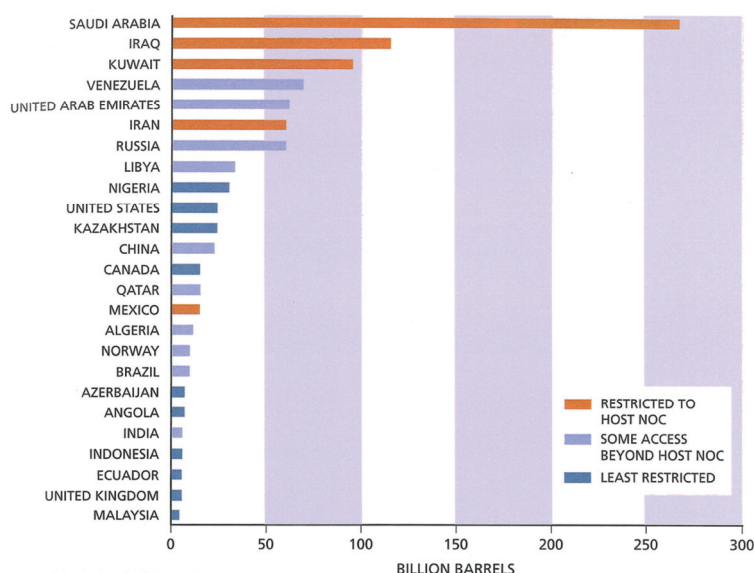


45



What energy future after world oil production peak?

Geopolitics: Access to Proved reserves



Note: NOC = National Oil Companies.
Source: U.S. Department of Energy.

30 - 4789

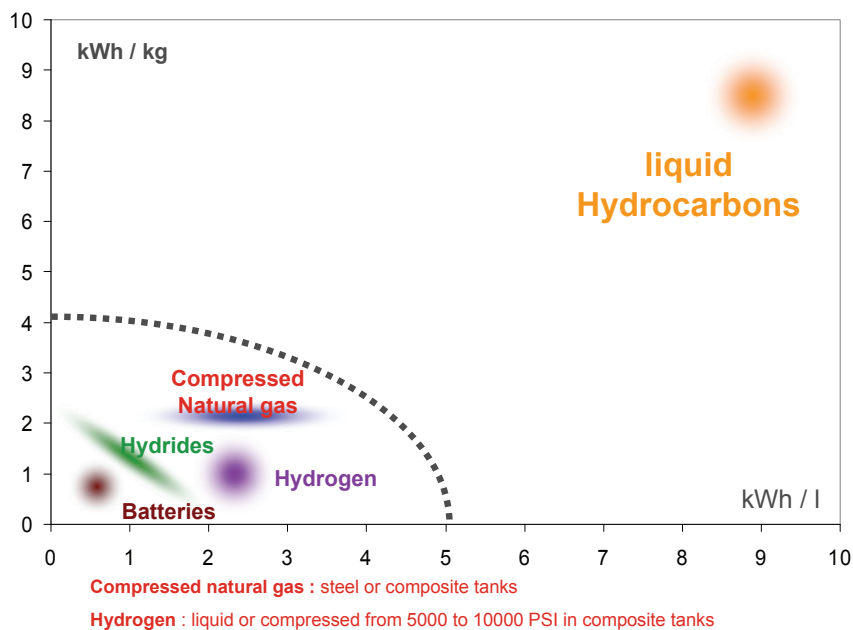


46



What energy future after world oil production peak?

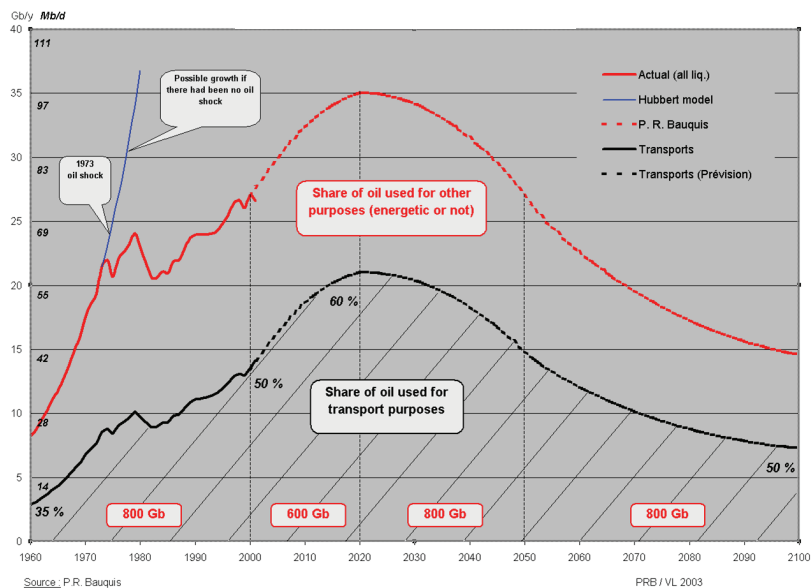
Liquid hydrocarbons: an energy compactness that no other sources can match, neither today nor in the future



47

What energy future after world oil production peak?

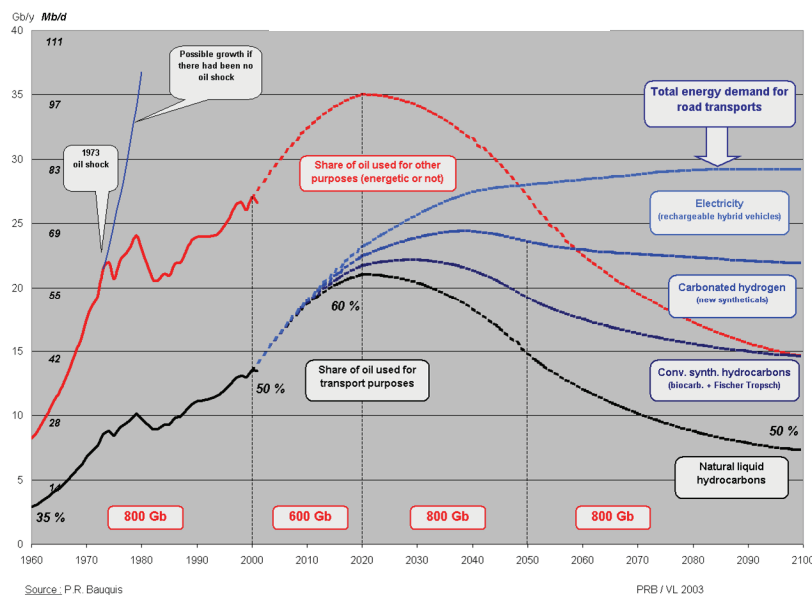
World Oil Production Profile and Transports Share



48

What energy future after world oil production peak?

Which Energy for Road Transports 1960 – 2000 - 2100



49

What energy future after world oil production peak?

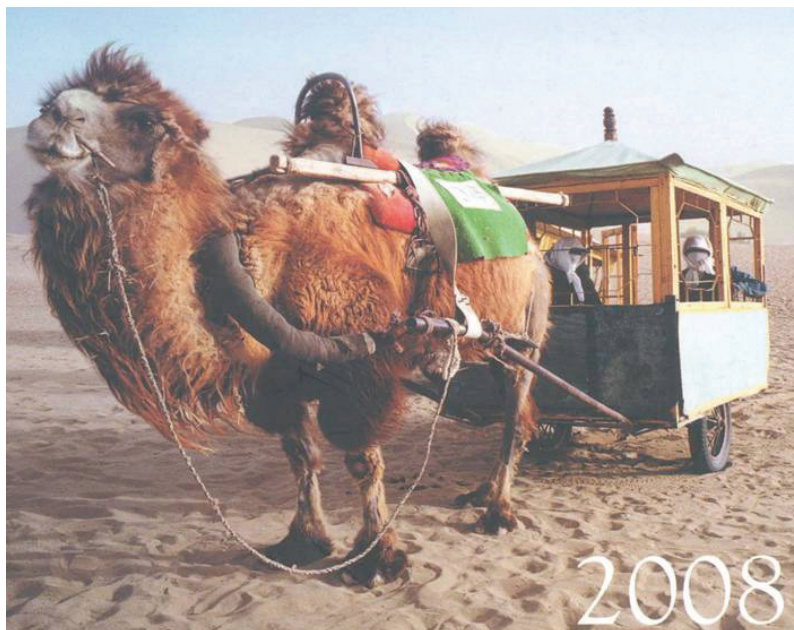
Primary energy for transport in 2000 and 2100 (in percentages)		
Primary energy sources	2000	2100
Oil	98	25
Biomass	<1	5-10
Nuclear	<1	60
Others	<1	5-10
Total:	100	100



50

What energy future after world oil production peak?

For the future of automobile, if you believe neither in « peak oil » nor in « climate change », alternative strategies are available....



30 - 4789

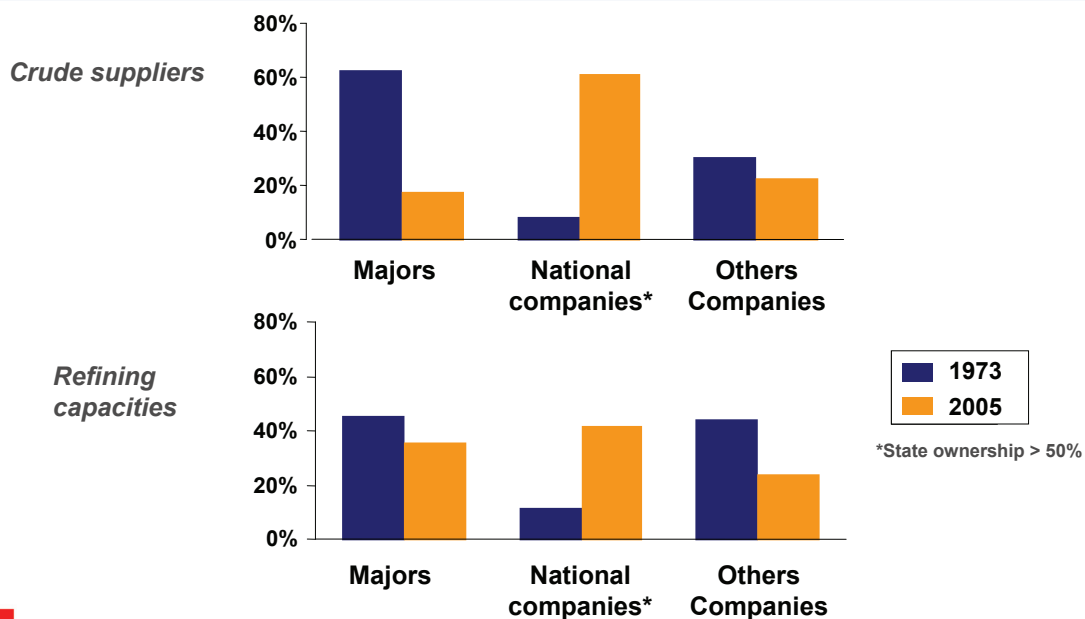


51



What energy future after world oil production peak?

The oil industry structure in the past and today



30 - 4789

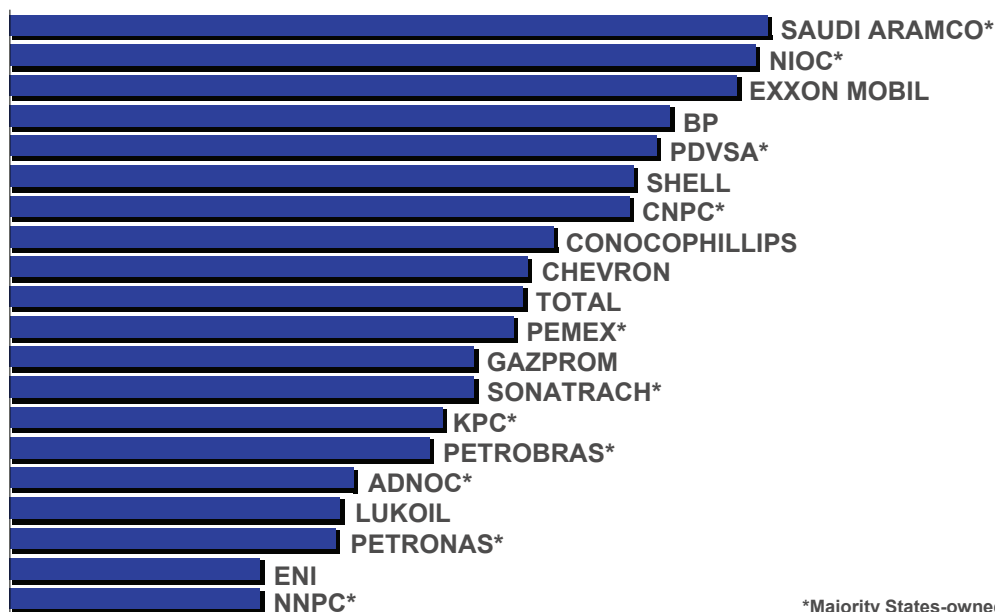


52



What energy future after world oil production peak?

PIW ranking of top 20 oil companies



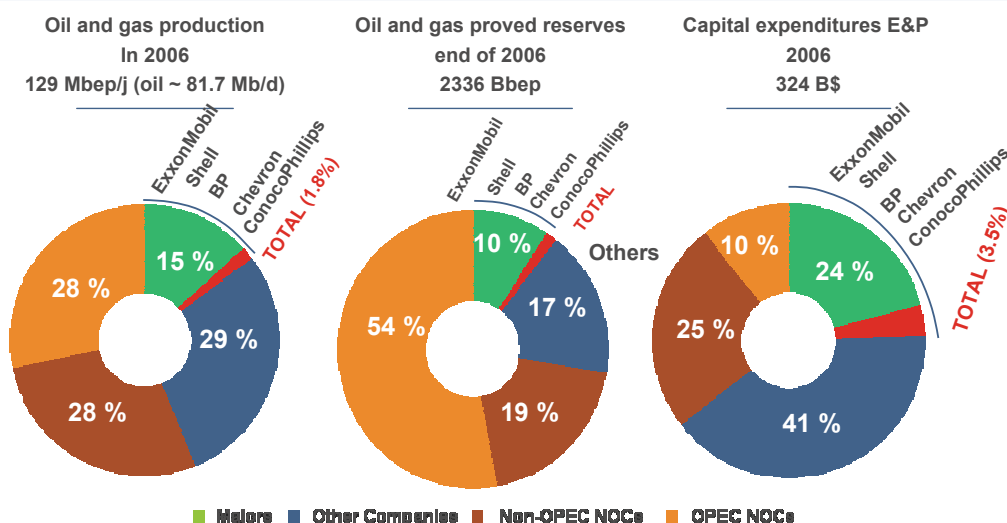
*Majority States-owned Firms



53

What energy future after world oil production peak?

National Oil Companies dominate oil and gas industry



Legend:
 Major: Saudi Aramco, PDVSA, NNPC, Qatar Petroleum, Sonatrach, NIOC, ADNOC, NOC, KPC, Pertamina, Sonangol
 Non-OPEC NOCs: PEMEX, Petrochina, Petrobras, Statoil, Sinopec, Petronas, ONGC, Gazprom, CNOOC, CNPC, Ecopetrol, etc.
 Sources: BP Statistical Review, Wood Mackenzie, Total estimates, IFP, Lehman Brothers & Citigroup surveys



54

What energy future after world oil production peak?

IOC's and NOC's Links

Today

Some upstream cooperations but
Very little integration

IOC's



NOC's

Tomorrow

Growing joint operations and
even cross-ownerships

IOC's



NOC's

Linkages intensity



Weak

Medium

strong

30 - 4789



55



What energy future after world oil production peak?

Oil C^{ies} and services C^{ies} links

Today

Very limited linkages today
but some do exist.

Oil C^{ies} (IOC'S and NOC'S)



Services C^{ies}

Tomorrow

Increased linkages:

- long term contracts,
R and D associations,
- NOC's/Service Cies association,
- "reintegration" by oil Cies?

Oil C^{ies} (IOC'S and NOC'S)



Services C^{ies}

Linkages intensity



Weak

Medium

strong

30 - 4789



56



What energy future after world oil production peak?

Crisis short/medium term impact on the oil industry investment strategy

Business area most impacted

- 1 ▪ exploration drilling
- 2 ▪ seismic
- 3 ▪ onshore drilling (especially US) (*)
- 4 ▪ shallow offshore drilling
- 5 ▪ US Natural gas
- 6 ▪ extra heavy oil/tar sands
- 7 ▪ Cash short NOC's
- 8 ▪ Cash short independants

Business area less impacted

- 1 ▪ deep offshore drilling
- 2 ▪ LNG projects
- 3 ▪ Large oil and gas projects
- 4 ▪ Major IOC's
- 5 ▪ some NOC's (chinese, ...)
- 6 ▪ cash rich independants

(*): number of onshore gas drilling rigs fell from 1600 (September 2008) to 700 (June 2009) according to Baker Hughes.

30 - 4789



57



What energy future after world oil production peak?

Crisis medium/long term impact on the oil industry investment strategy

Compagnies with low Debts

- Most NOC's and IOC's
- Some medium size
- Some small independants



- 1 ▪ Limitations on borrowing capabilities and on project financing structuring will delay some major projects.
- 2 ▪ However they will try to purchase stakes of weaker companies in those similar long term projects.
- 3 ▪ Will do limited external growth (acquisitions) but major mergers unlikely.

Compagnies with high Debts

- A few IOC's and NOC's
- Most medium size companies
- Most small independants



- 1 ▪ Some will get bankrupted, some will be acquired and some will merge, especially among US independants.
- 2 ▪ Most will focus their investment on short or medium term projects and delay as possible longer term ones.
- 3 ▪ Some will sell interests in long term projects (UTS: an exception or a missed opportunity?).

30 - 4789

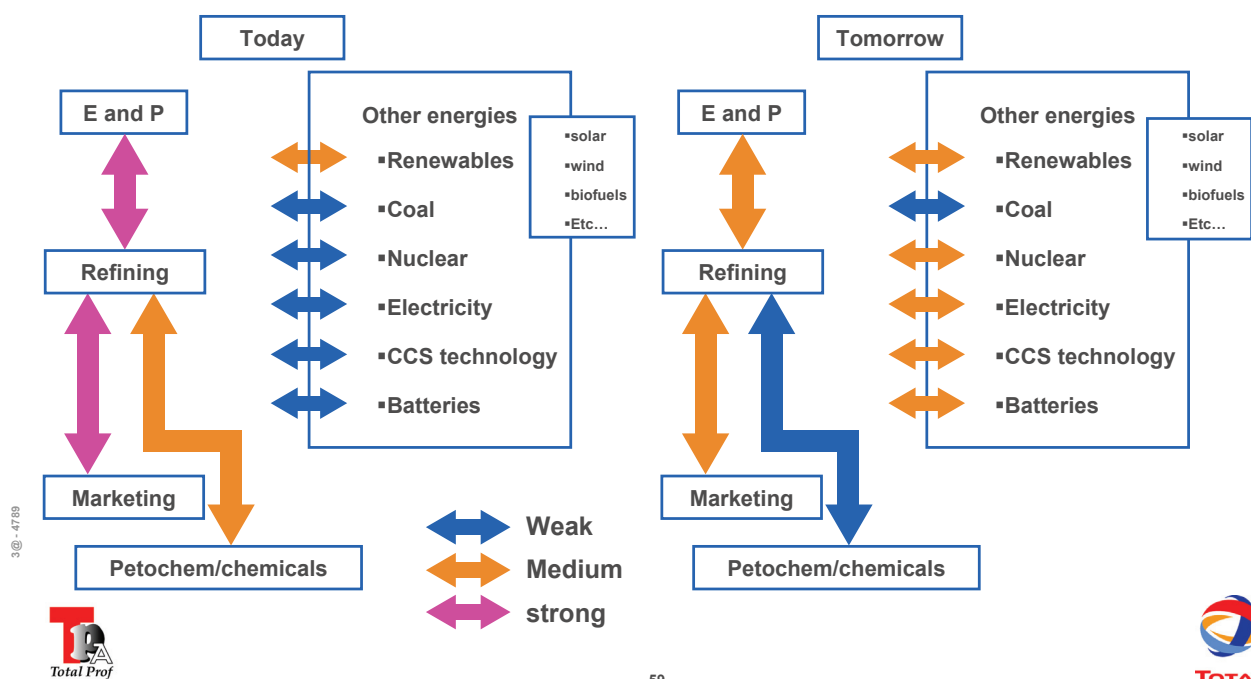


58



What energy future after world oil production peak?

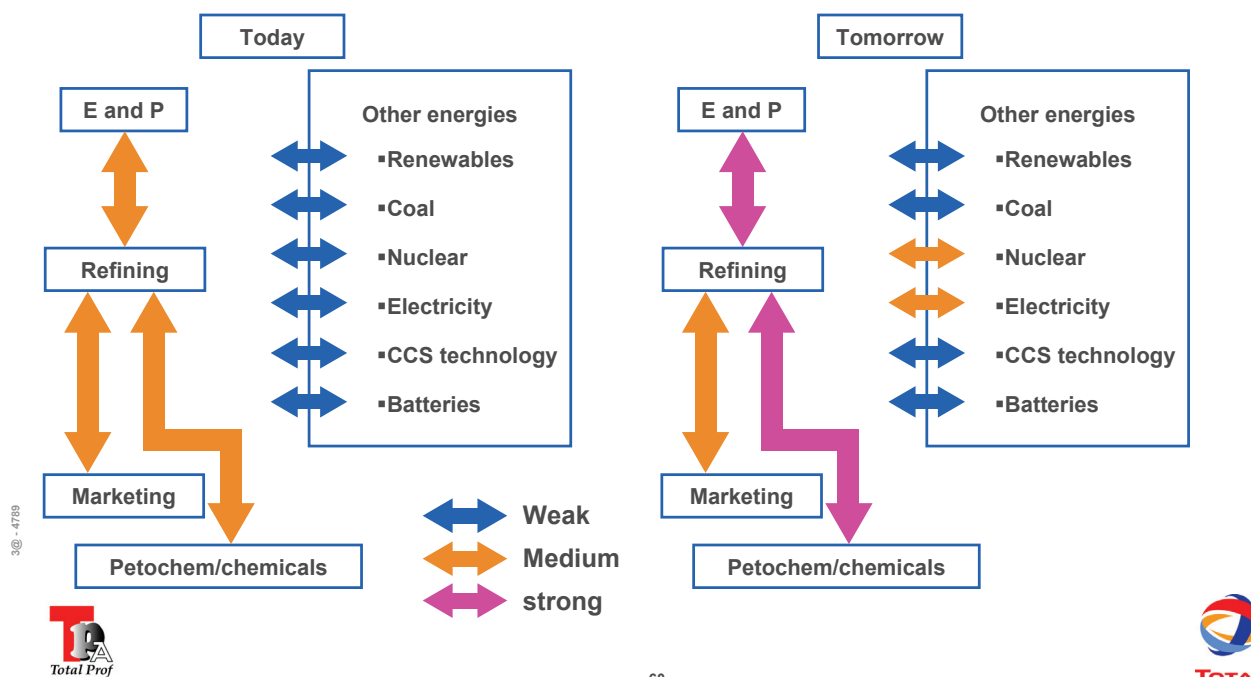
The IOC's business model today and tomorrow



59

What energy future after world oil production peak?

The NOC's business model today and tomorrow



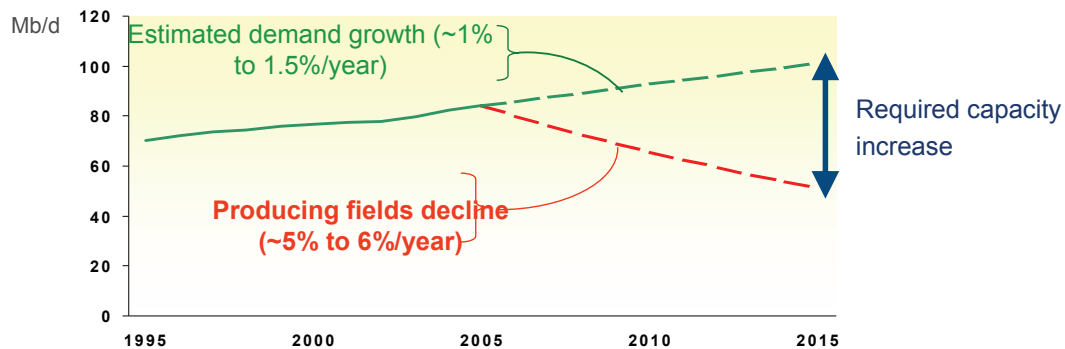
60

What energy future after world oil production peak?

The production growth challenge

Mb/d = Million barrels per day

World oil production



Increasing demand and natural decline of producing fields require
~ 50 Mb/d of new production between 2005 and 2015

- Geopolitical constraints or local troubles in producing countries
- New developments are complex, expensive and time-consuming

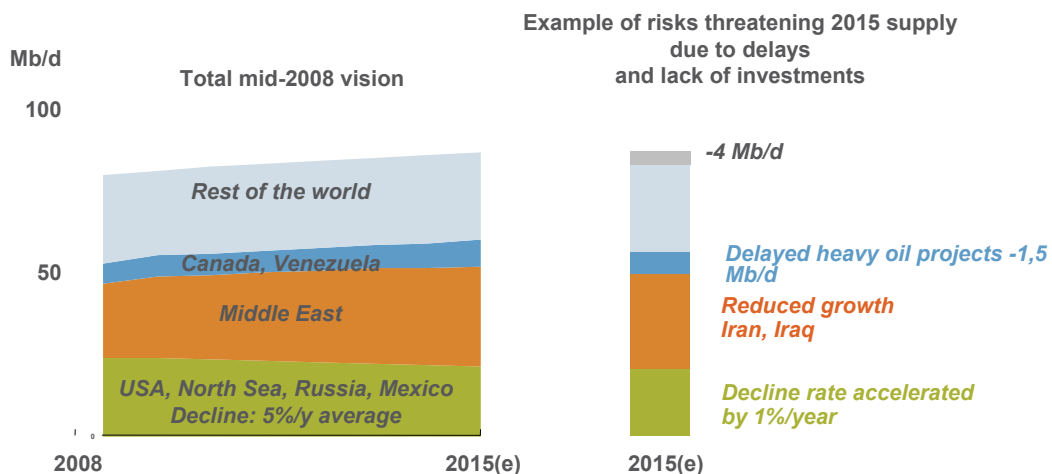


61

What energy future after world oil production peak?

Greater risk to sustainable long-term oil production capacity

World oil production



Example of risks threatening 2015 supply
due to delays
and lack of investments

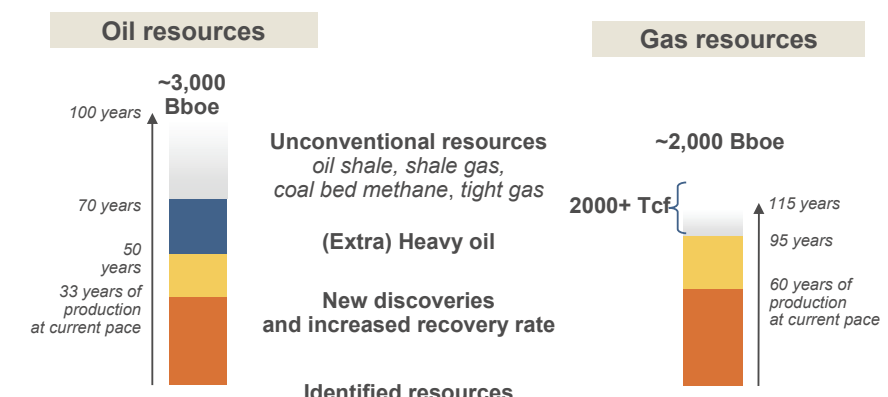
No change in Total's long term strategy



62

What energy future after world oil production peak?

Significant (unconventional) resources yet to be produced



Oil and gas resources require increasing technological proficiency and higher capital expenditures in order to be brought onstream

30 - 4789



63



What energy future after world oil production peak?

Conclusion: future of oil industry

- It should be bright for all players: IOC's, NOC's, independants, but also contractors, major Service Cies, specialized Service Cies... not forgetting R and D Institutes and Training Specialists!
- Twenty years down the road this industry will have been deeply « redesigned » both because of the ressources/production constraints and the climate change issues
- Like always the most adaptable and the best will not only survive: they will do fascinating jobs and make money!!

30 - 4789



64



EAGE

EUROPEAN
ASSOCIATION OF
GEOSCIENTISTS &
ENGINEERS



TOTAL

EAGE
STUDENT FUND



CGGVERITAS

