IEF-IFP Symposium

Role of Technology in the Petroleum Sector in Enhancing Global Energy Security

Riyadh, 15th December 2008

Energy Technology Developments

- Challenges and opportunities for a global energy security -

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International Energy Agency

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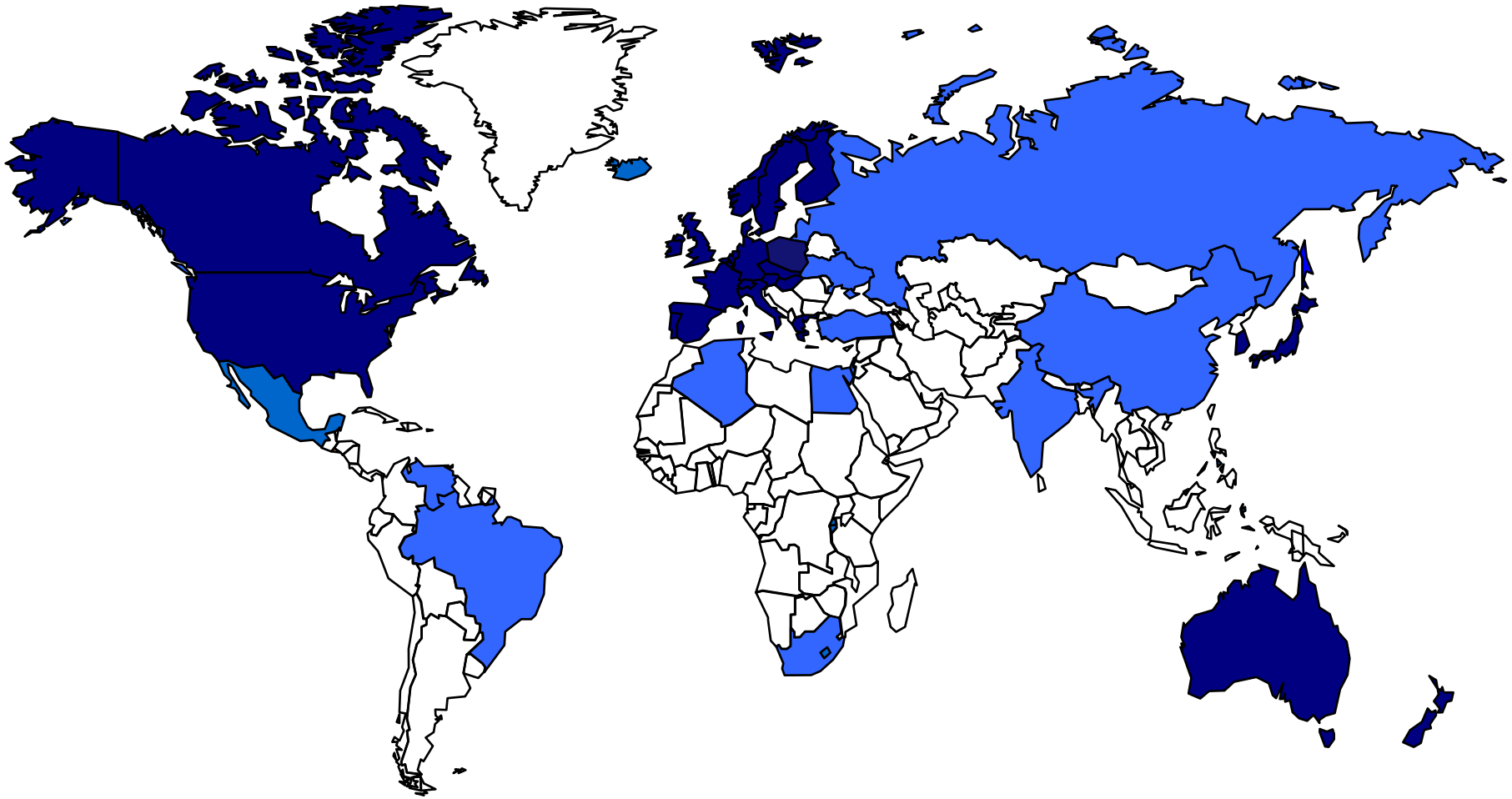
The IEA's role:

- Integral part of members' energy security
- Conducts policy analysis, compiles data
- Convenes expertise
- Publishes findings

IEA's Global Energy Technology Co-operation



More than 5 000 participants from governments, industry and R&D community

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IEA Energy Technology Network

Since 1975, demand driven, 79 IAs have been created, 37 have merged or closed down
42 IAs with more than 5 000 participants

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Situation Today

- Financial crisis
- Can oil and gas deliver?
- Climate change will become a major constraint for energy
- Access to modern forms of energy

- What is the long term perspective?

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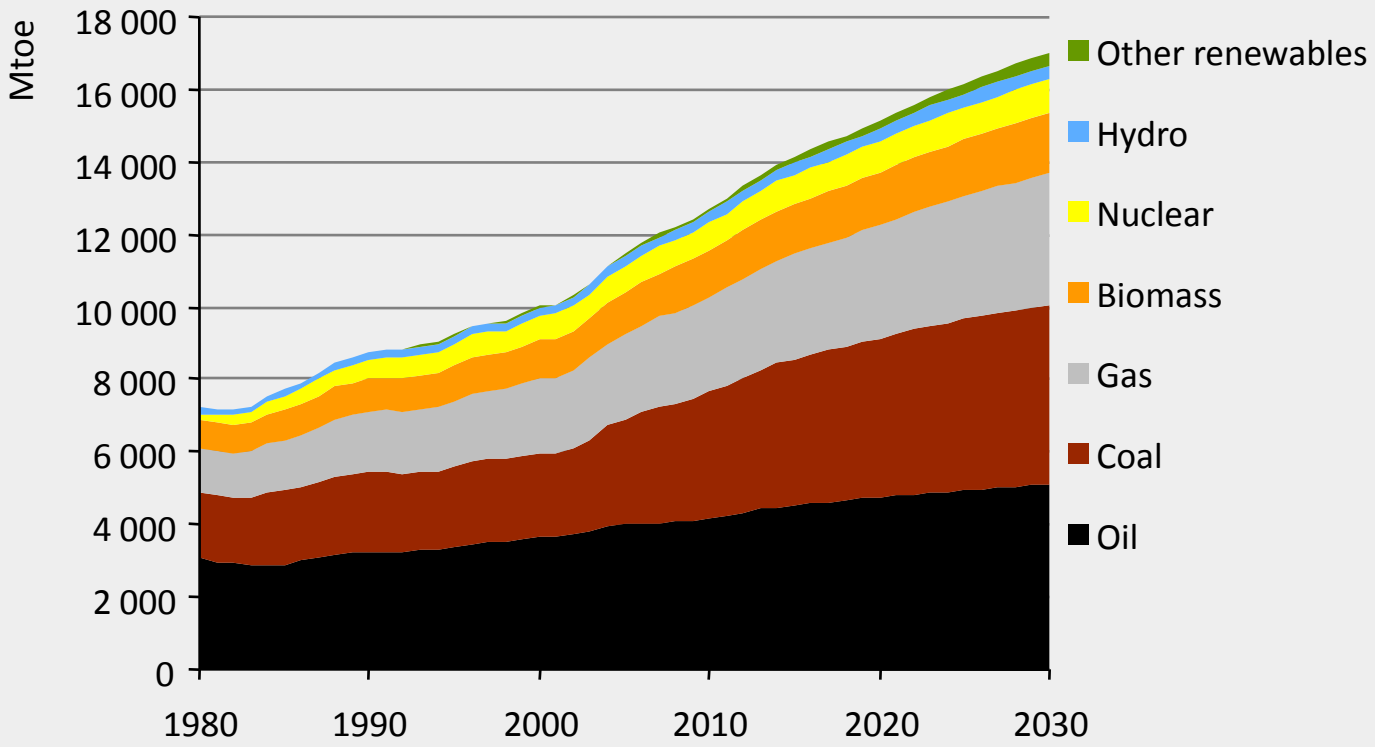
World primary energy demand in the Reference Scenario: this is unsustainable!

World Energy Outlook 2008



World energy demand expands by 45% between now and 2030 – an average rate of increase of 1.6% per year – with coal accounting for more than a third of the overall rise

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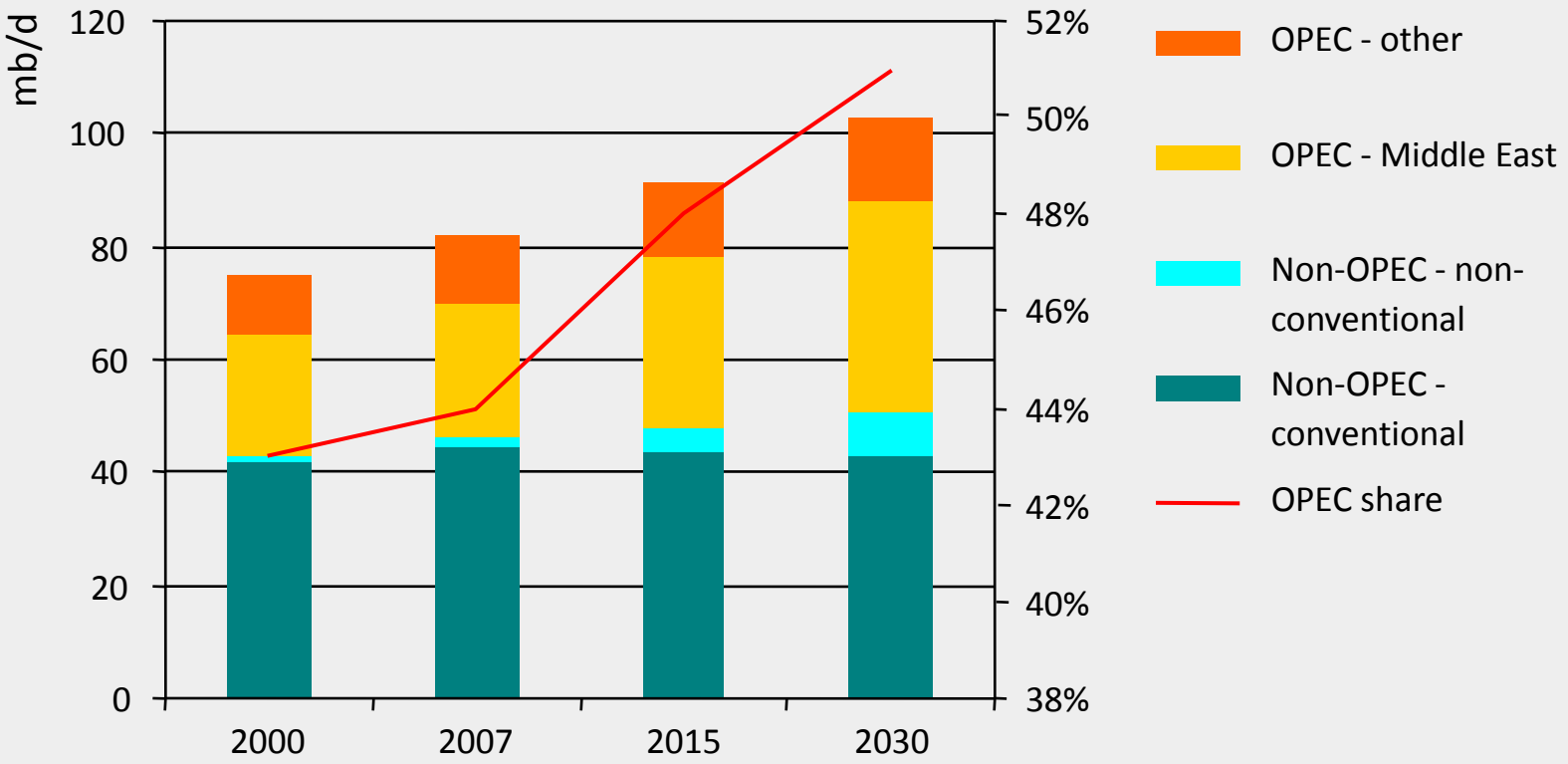
World oil production by OPEC/non-OPEC in the Reference Scenario

World Energy Outlook 2008



Production rises to 104 mb/d in 2030, with Middle East OPEC taking the lion's share of oil market growth as conventional non-OPEC production declines

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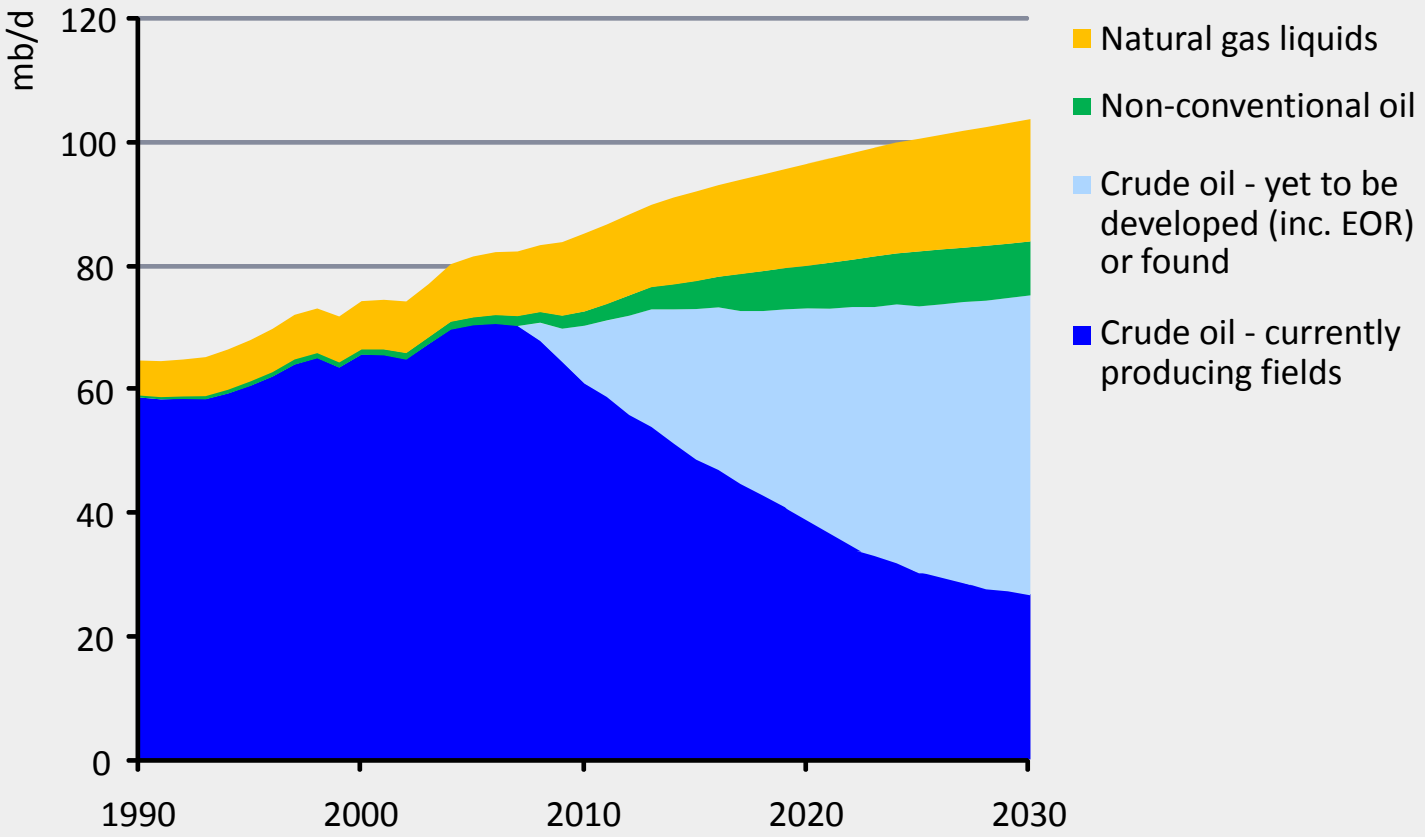
World oil production by source in the Reference Scenario

World Energy Outlook 2008



Even if oil demand was to remain flat to 2030, 45 mb/d of gross capacity – roughly four times the capacity of Saudi Arabia – would be needed just to offset decline from existing oilfields

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Summary & conclusions

World Energy Outlook 2008

- Current energy trends are patently unsustainable — socially, environmentally, economically
- Oil will remain the leading energy source but...
  - *The era of cheap oil is over, although price volatility will remain*
  - *Oilfield decline is the key determinant of investment needs*
  - *The oil market is undergoing major and lasting structural change, with national companies in the ascendancy*
- To avoid "abrupt and irreversible" climate change we need a major decarbonisation of the world's energy system
  - *Copenhagen must deliver a credible post-2012 climate regime*
  - *Limiting temperature rise to 2°C will require significant emission reductions in all regions & technological breakthroughs*
  - *Mitigating climate change will substantially improve energy security*
- The present economic worries do not excuse back-tracking or delays in taking action to address energy challenges

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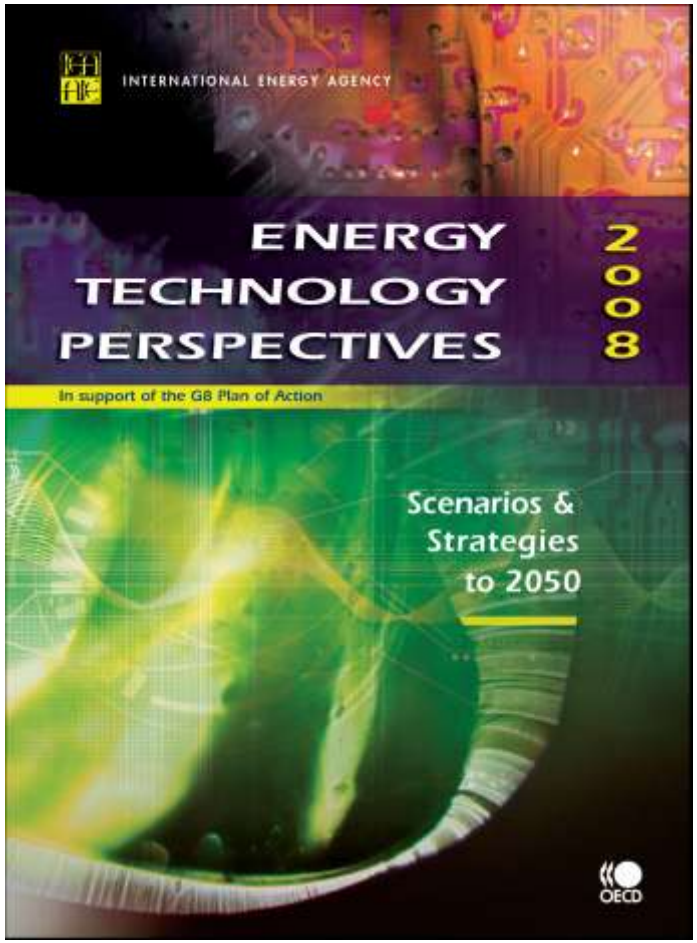
On request of the G8:

IEA has looked into the future role of energy technologies

IEA Energy Technology Perspectives 2008

Scenarios & Strategies to 2050



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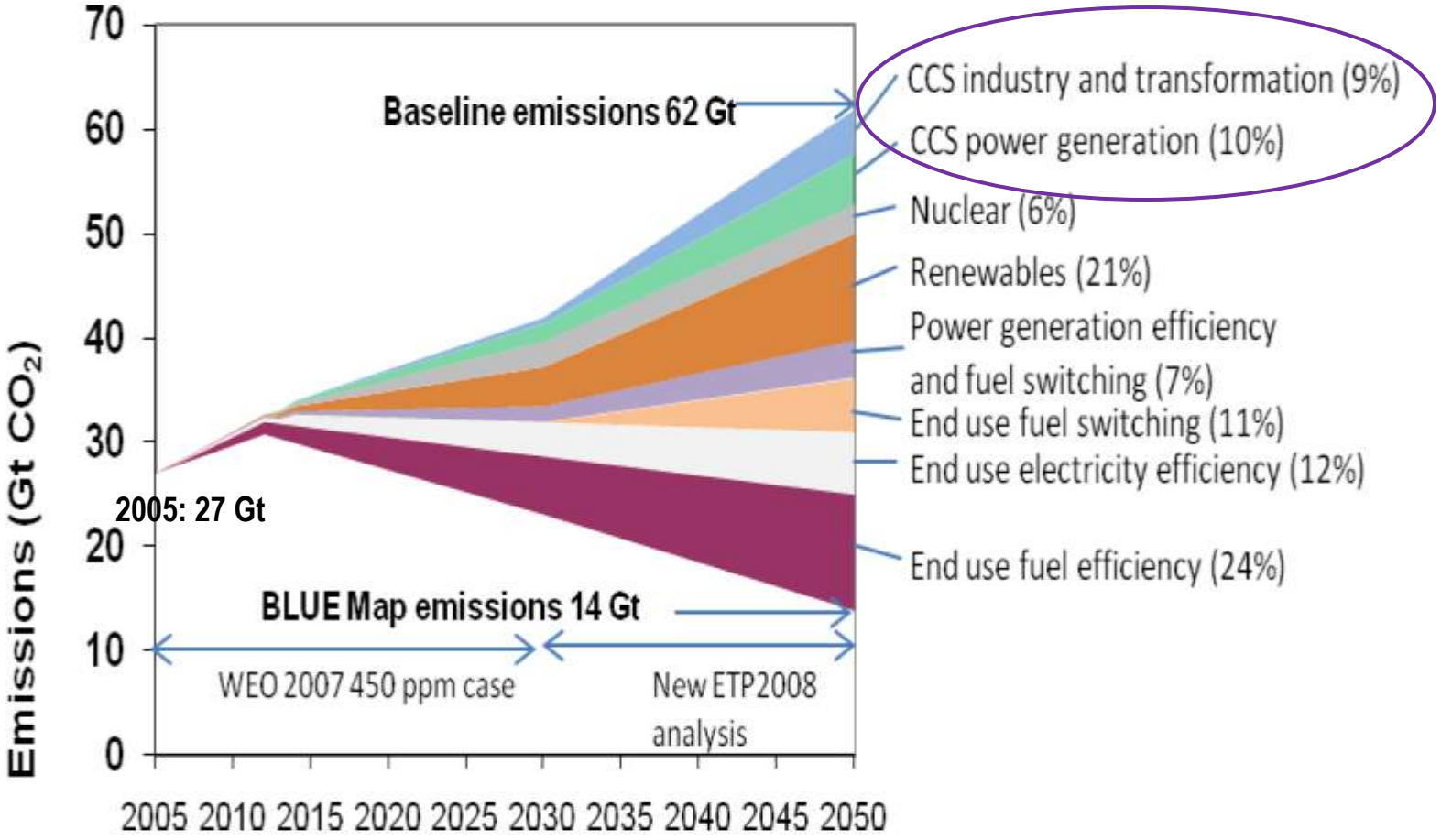
CCS within a carbon abatement portfolio



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Summarizing The Case for CCS

- Climate change requires substantive efforts to reduce CO2 emissions
  (28 Gt in 2006 to 14 Gt in 2050)
- To meet IPCC 450ppm target, all electricity production needs to be CO2-free
  (Saudi Arabia: over 100 GW of CO2-free electricity production in 2030 – almost 1 Gt of CO2
  an option for enhanced oil recovery?)
- CCS would contribute 10 Gt reduction compared to the base line scenario
- Without CCS either total CO2 reduction cost would be 70% higher or 2050 emissions would be 70% higher
  (24 Gt instead of 14Gt)

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CCS Demonstration Efforts

- Today: only 4 full-scale CCS demo plants operating worldwide; none with a coal-fired power plant
- The number of major CCS efforts is expanding…
  - Alberta, Canada: $2B funding
  - Australia AUD$3-400 million, Gorgon
  - Norway's Gassnova, UK CCS competition
  - EU ZEP
  - US FutureGen
  - OPEC countries
- …but many of these efforts lack sufficient funding or have slowed down
- It is important to demonstrate CCS retrofits

The next 10 years are critical

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Capture Projects/Prospects

Source: Bluewave Resources

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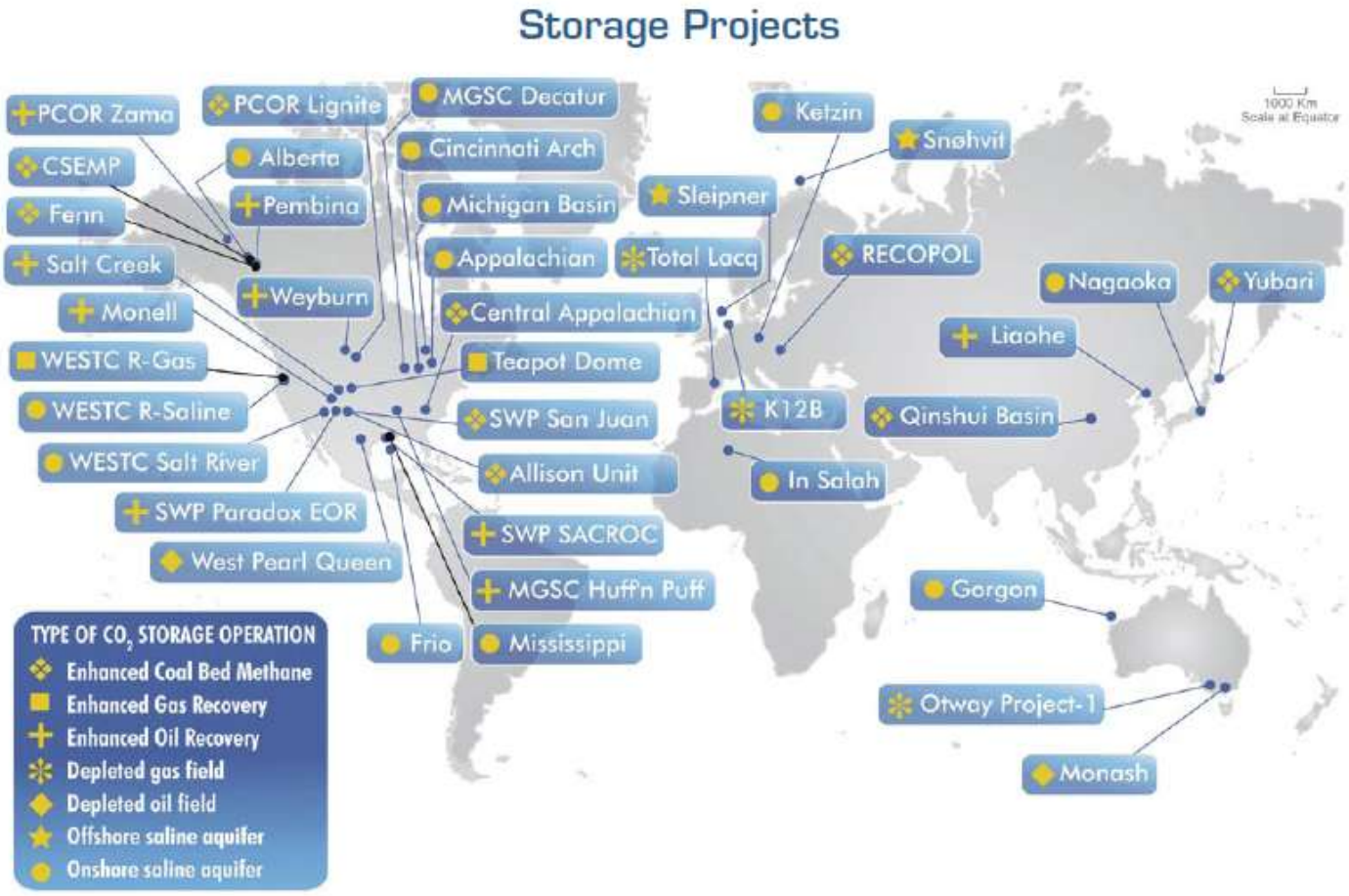
Storage Projects/Prospects



Source: Bluewave Resources

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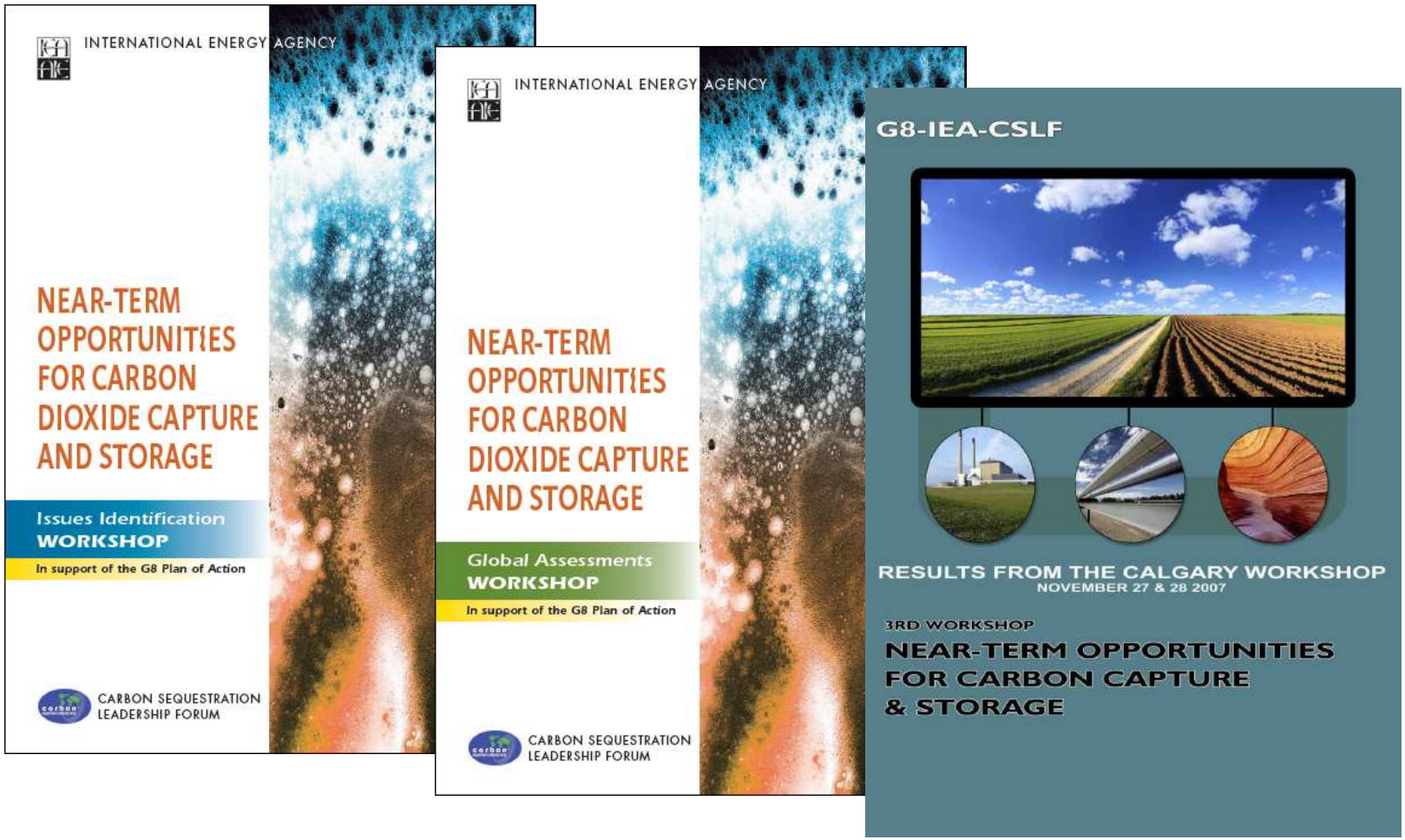
3 IEA/CSLF Workshops on Near-Term Opportunities for CCS



Recommendations reported to the G8

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IEA's G8 Recommendations in Brief

Priorities for Advancing Deployment of CO_2 Capture and Storage

- Demonstrating CO_2 capture and storage and bridging the financial gap
- Taking concerted international action
- Creating a value for CO_2 for commercialisation of CCS
- Establishing legal and regulatory frameworks
- Communicating with the public
- Infrastructure
- Considering requirements for retrofit with CO_2 capture

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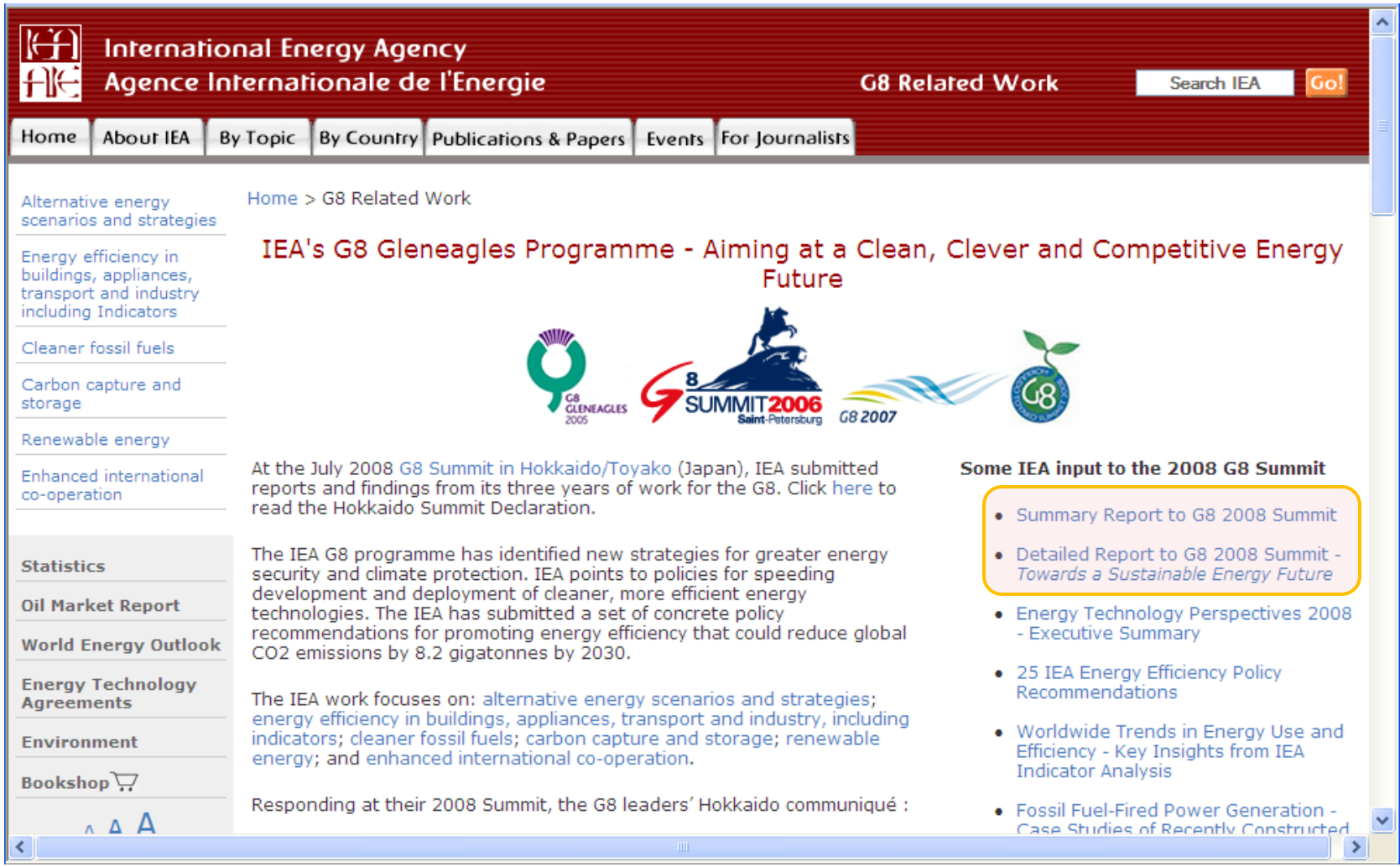
IEA and G8

www.iea.org/G8



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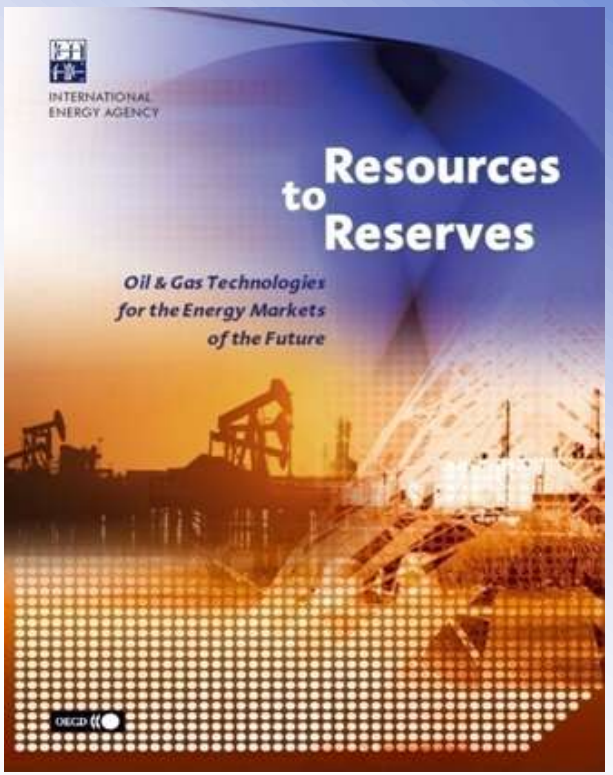
First *Resources to Reserves* Publication Released September 2005

- First IEA study of this kind – now downloadable for free at www.iea.org
- Review of upcoming oil and gas technologies (relating to the upstream sector)
- 2005 conclusions
  - Earth is not running out of oil – principle, but at what cost?
  - $30 – $40 per barrel long term expectations can make some 4 trillion barrels of oil reserves for the future
  - Technology/higher prices can mobilize even more resources
  - Investment and trained personnel is crucial to maintain stable markets
- Audience: Experts and informed laymen
- Goal: Provide common basis for discussion
- Needs update!

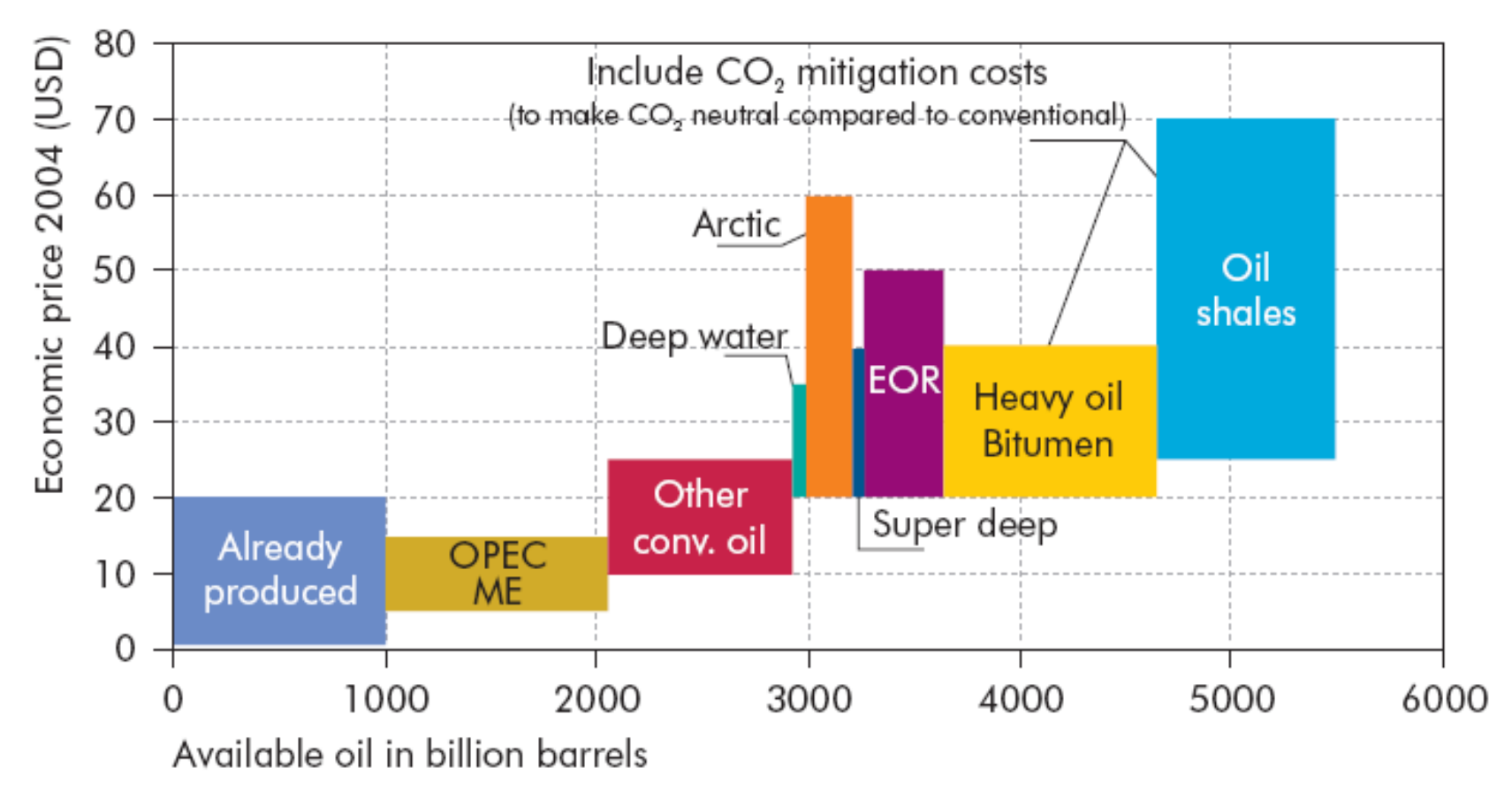
1st Edition …

- Used by
  - IEA
  - National authorities
  - Organisations (BGR, USGS, SPE …)
  - Industry (oil and gas, services)
  - Stern Review
- Related new IEA work
  - Mid Term Oil Market Report
  - World Energy Outlook 2008 analysis of 800 oilfields



Key Graph 2005:

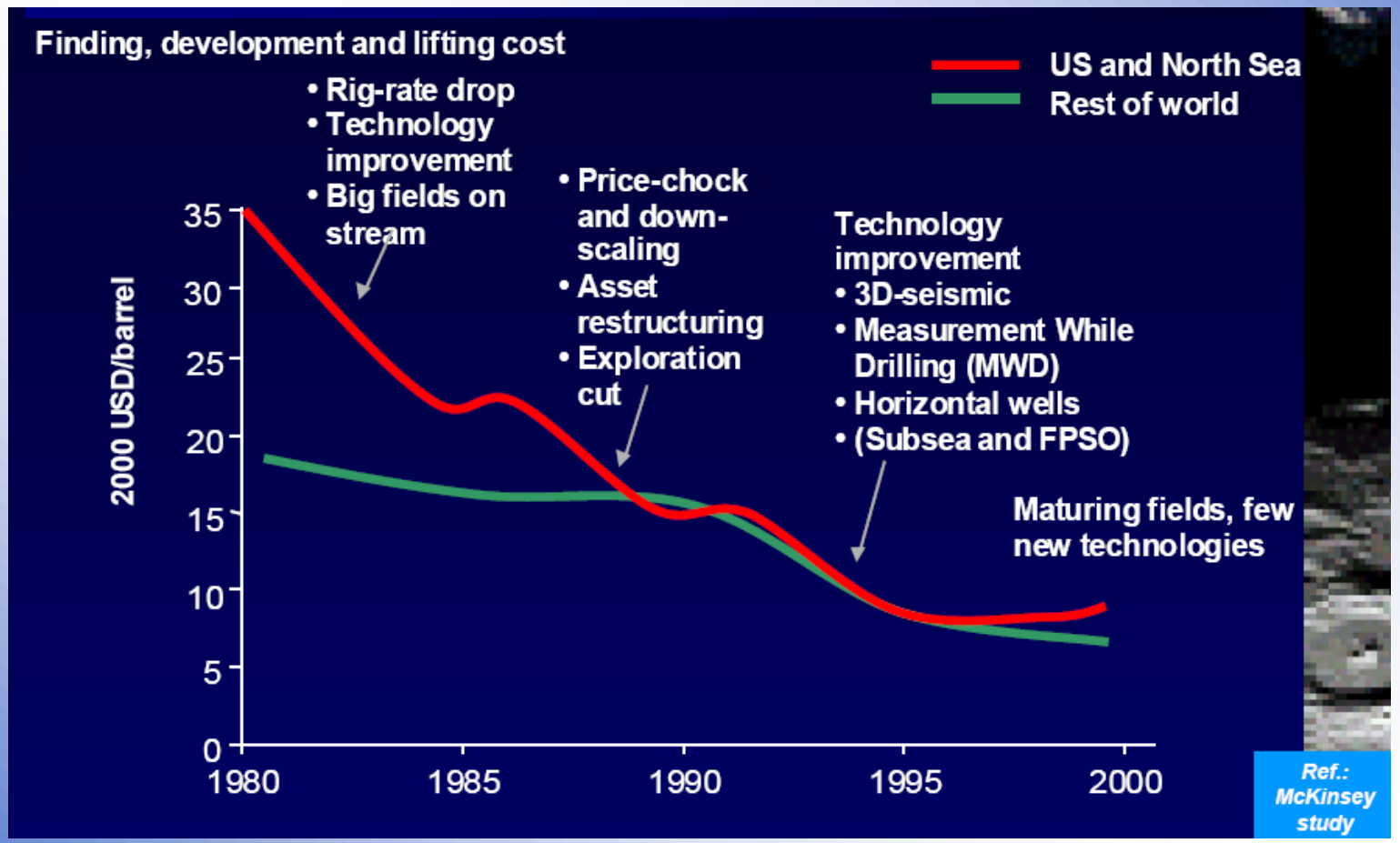
Most recoverable resources should become economical at oil prices significantly below current level



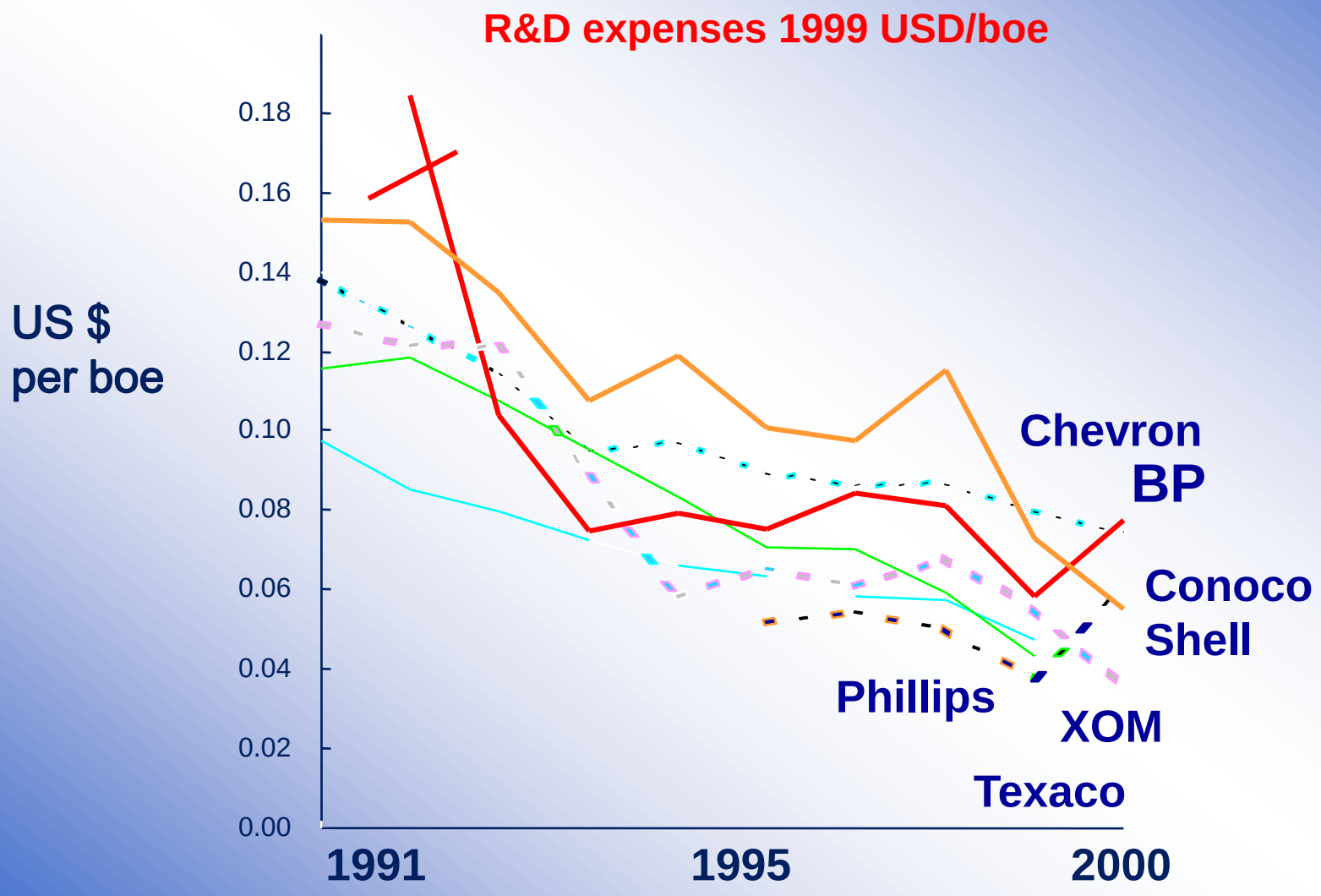
Source: IEA 2005, Resources to Reserves – Oil & Gas Technologies for the Energy Markets of the Future

… specific cost have come down

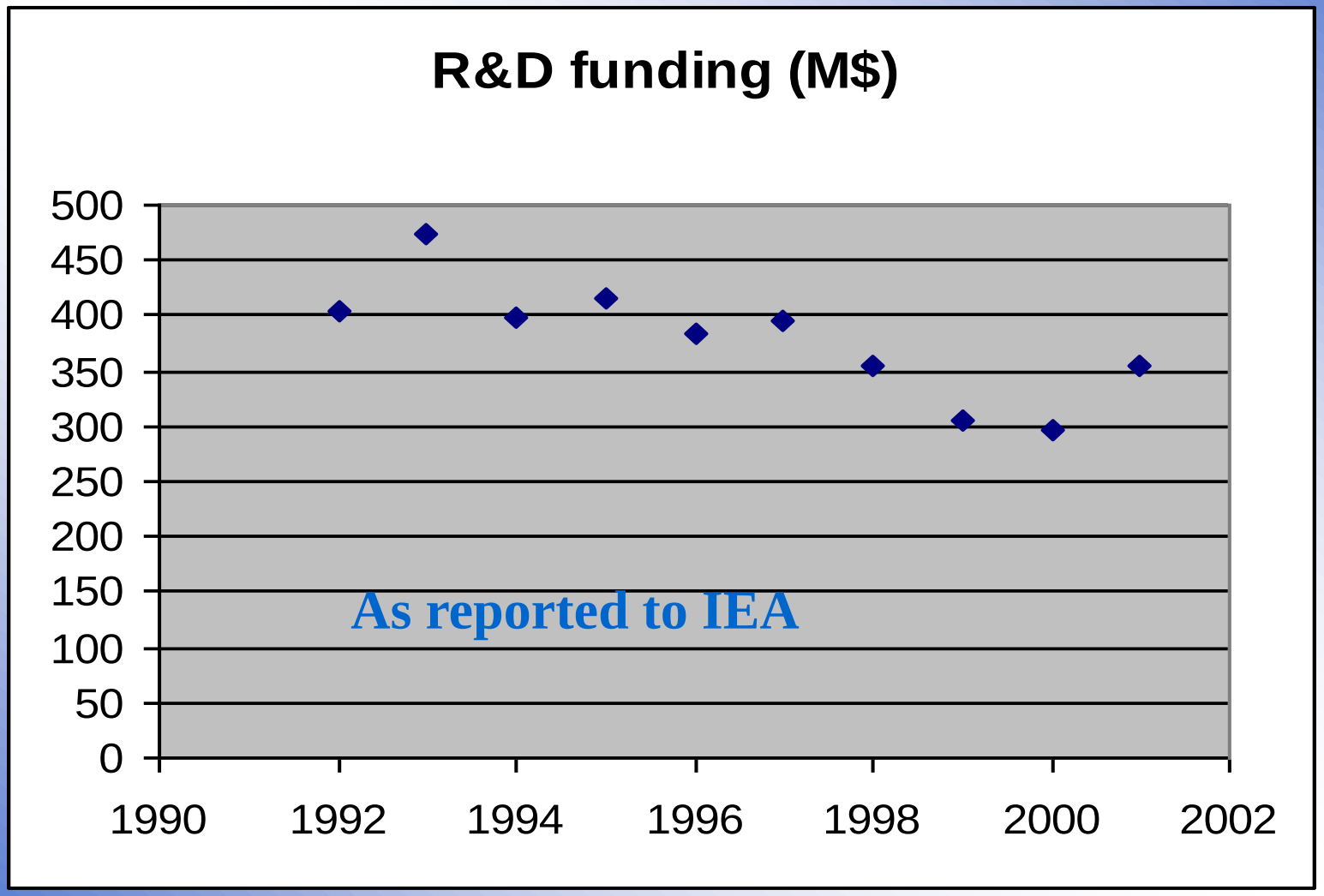
3D seismics, Horizontal drilling, Offshore technology …



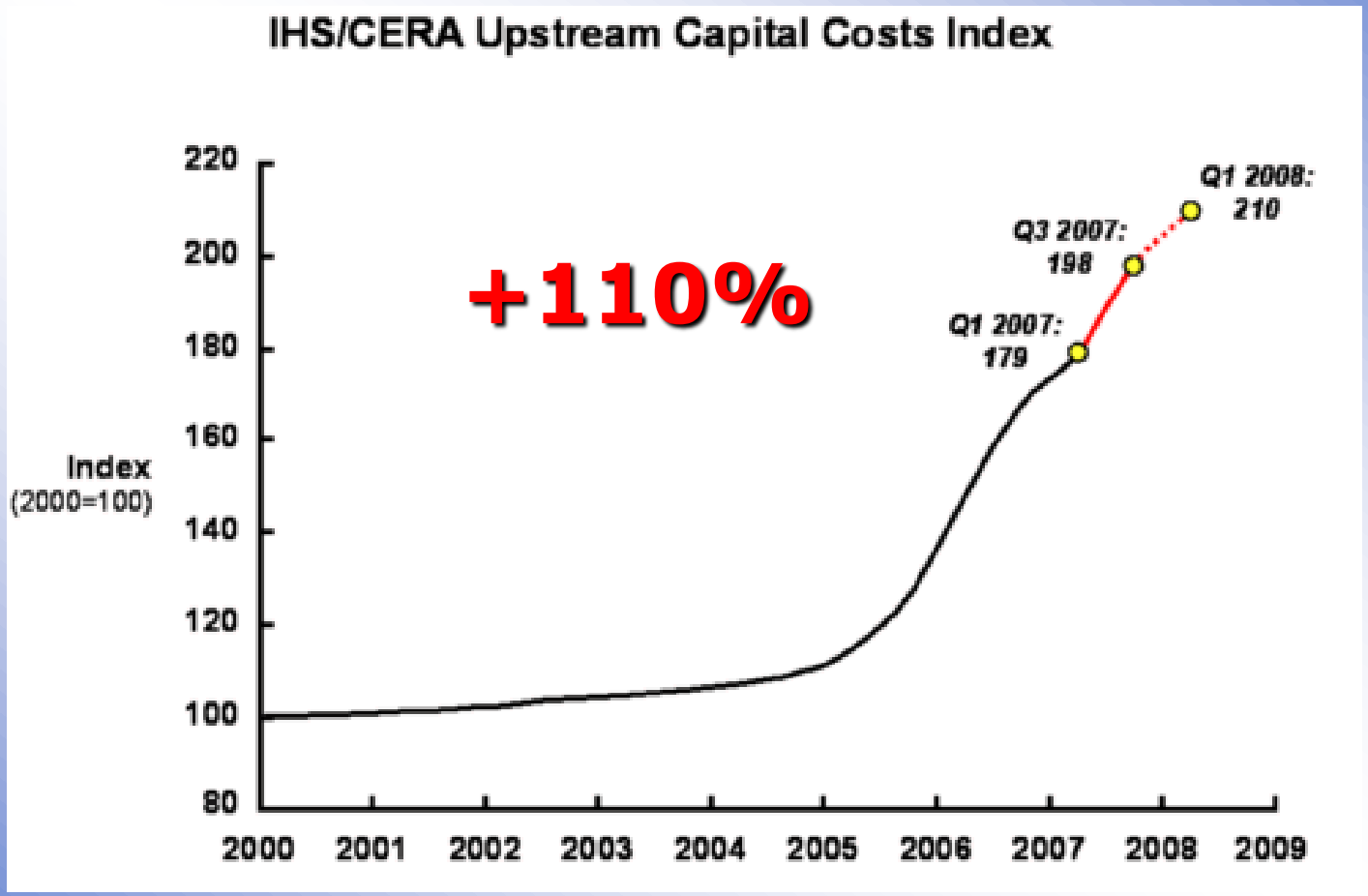
… but R&D investments in oil and gas too



… public R&D spendings too but not so fast as in total

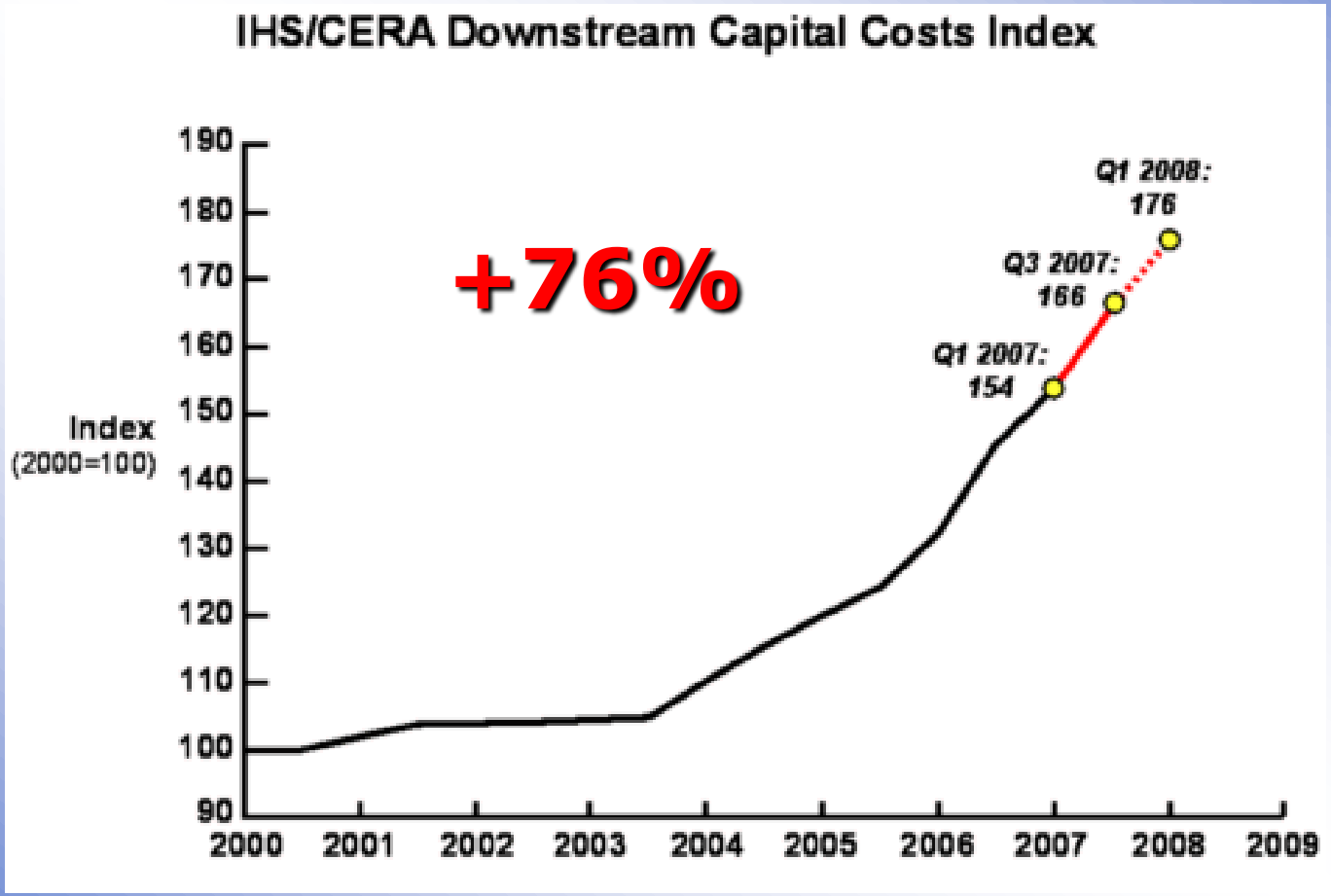


Cost Inflation in Upstream Investment (since 2000)



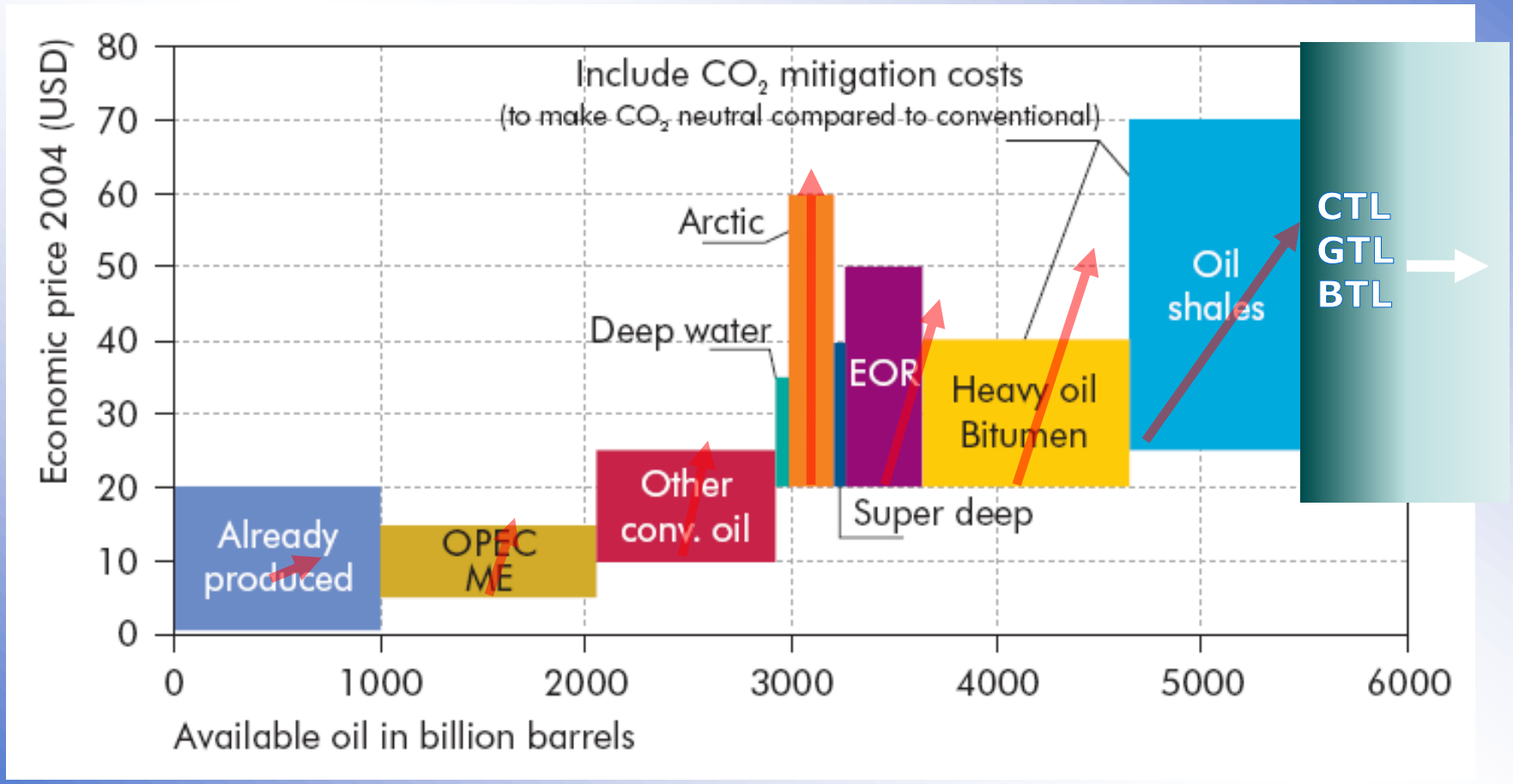
Source: IHS-CERA, May 2008

Cost Inflation in Downstream Investment (since 2000)



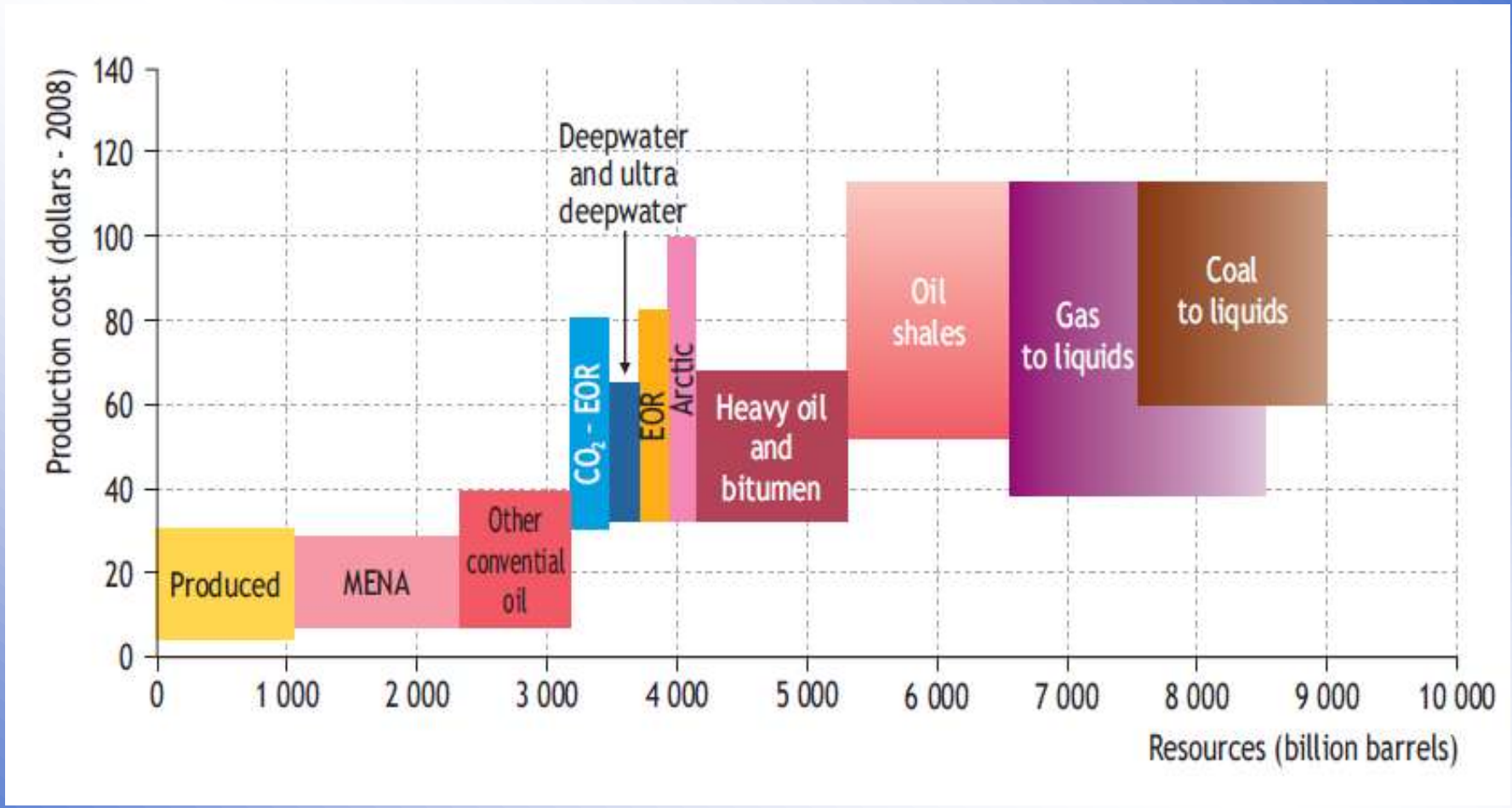
Source: IHS-CERA, May 2008

Update needed!



Source: IEA 2005, Resources to Reserves – Oil & Gas Technologies for the Energy Markets of the Future

Oil and Gas will be increasingly unconventional and from harsh environments



Source: WEO 2008

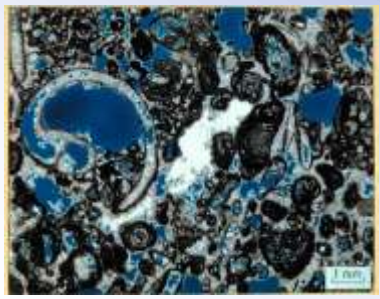
Supply

- *The world is not running out of energy resources,*
- *But supply may struggle to keep pace.*

Key challenges needs and opportunities

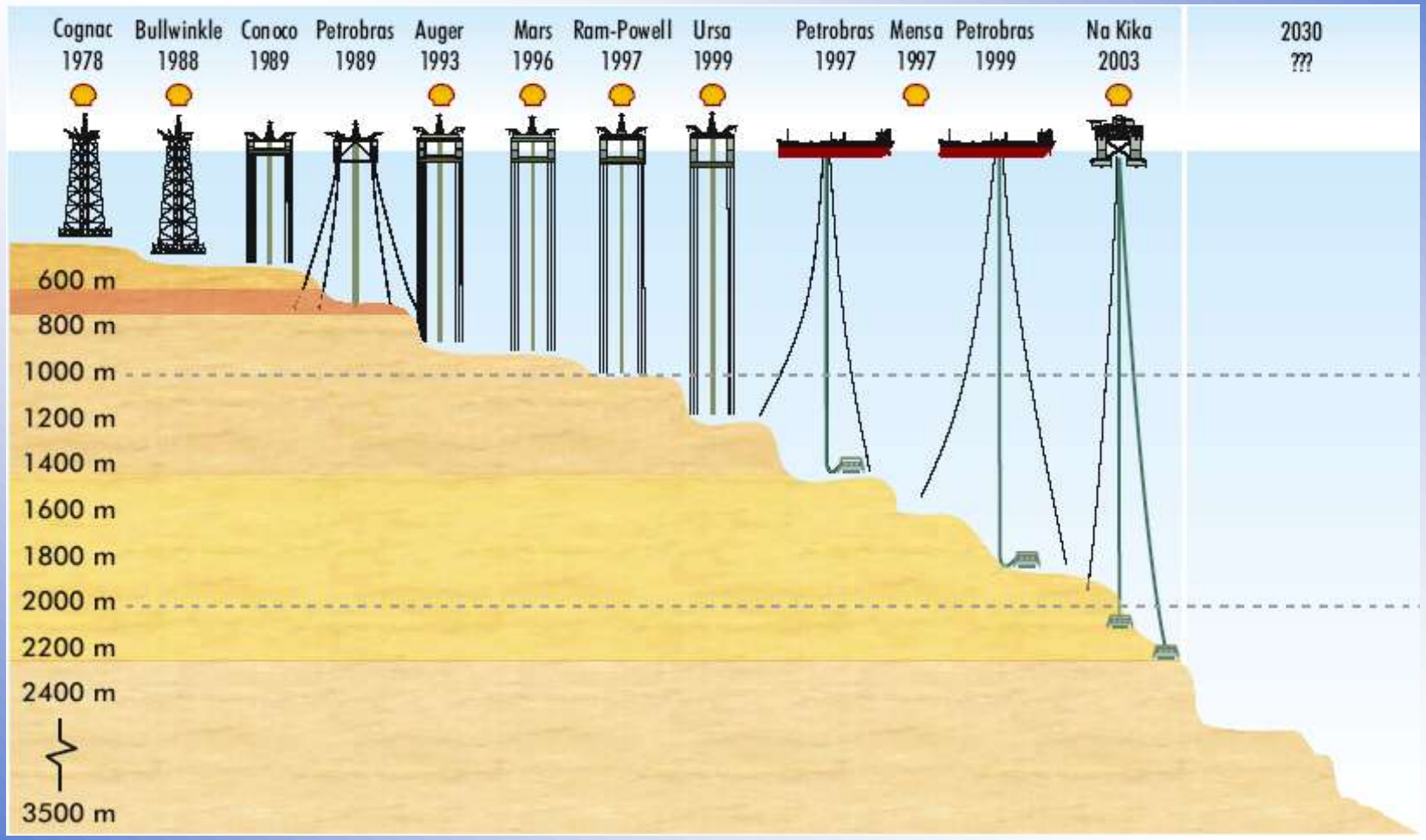
- **Reservoir Characterization**
  - Large scale heterogeneities: Faults, fractures, stylolites, tar mats, etc.
  - Wettability distribution (Oil-wet zones, water-wet zones, mixed)
  - Mineralogy determination: dolomitization and diagenesis
  - Saturation determination in carbonates and its impact on reserves

- **Reservoir management**
  - Tracking fluid movement in the reservoir and displacement efficiency
  - Water management in carbonates



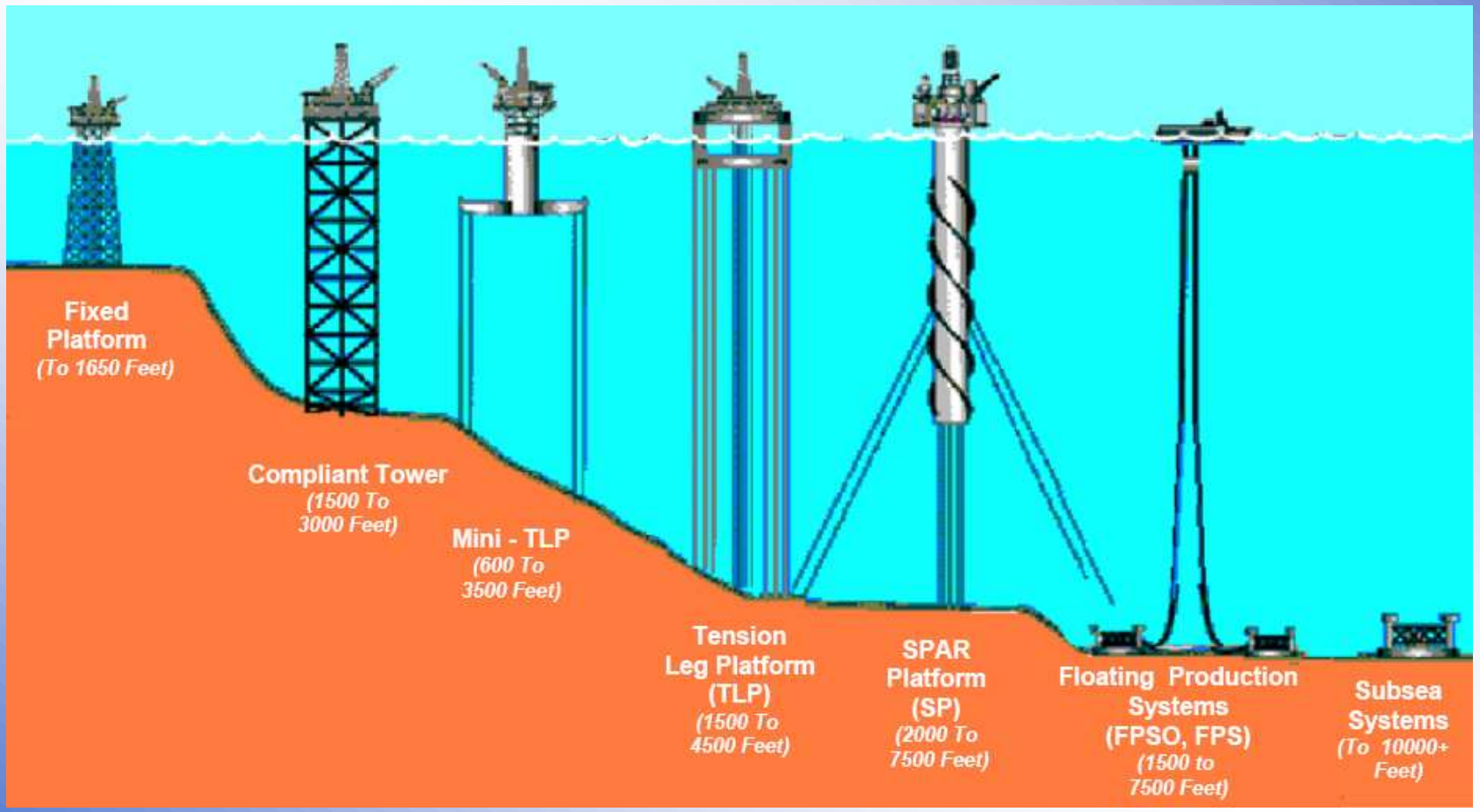
- **Oil Recovery**
  - Modeling and simulation of fluid exchanges between oil-wet matrix blocks and surrounding fractures – Modeling of drainage networks
  - Technologies to optimize sweep efficiency in heterogeneous reservoirs (Well placement, intelligent completions, smart fluids, etc.) – EOR

Evolution of Deepwater Technology

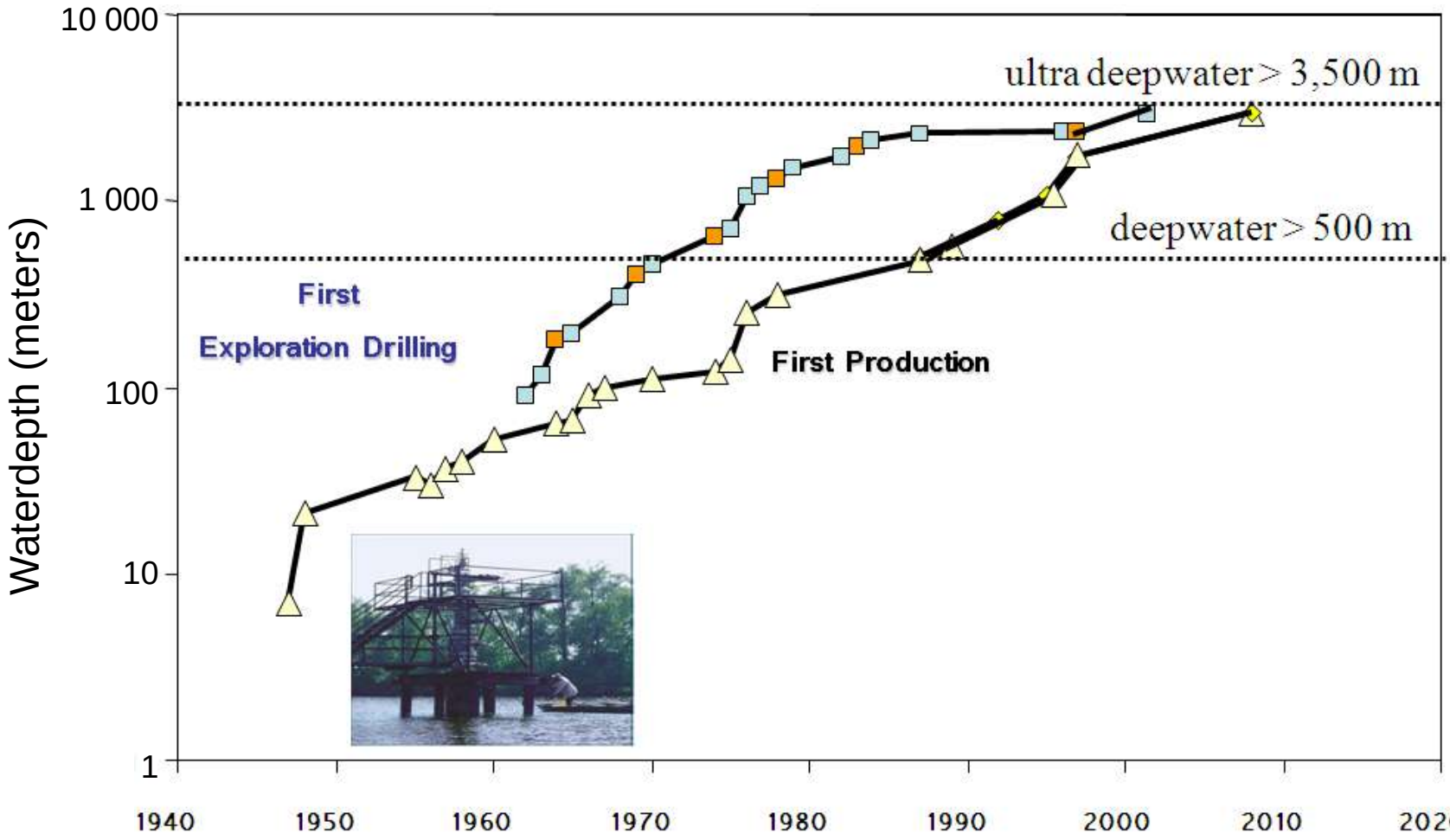


Reproduced in *Resources to Reserves* courtesy of Shell

Stepping into deep water - Norway

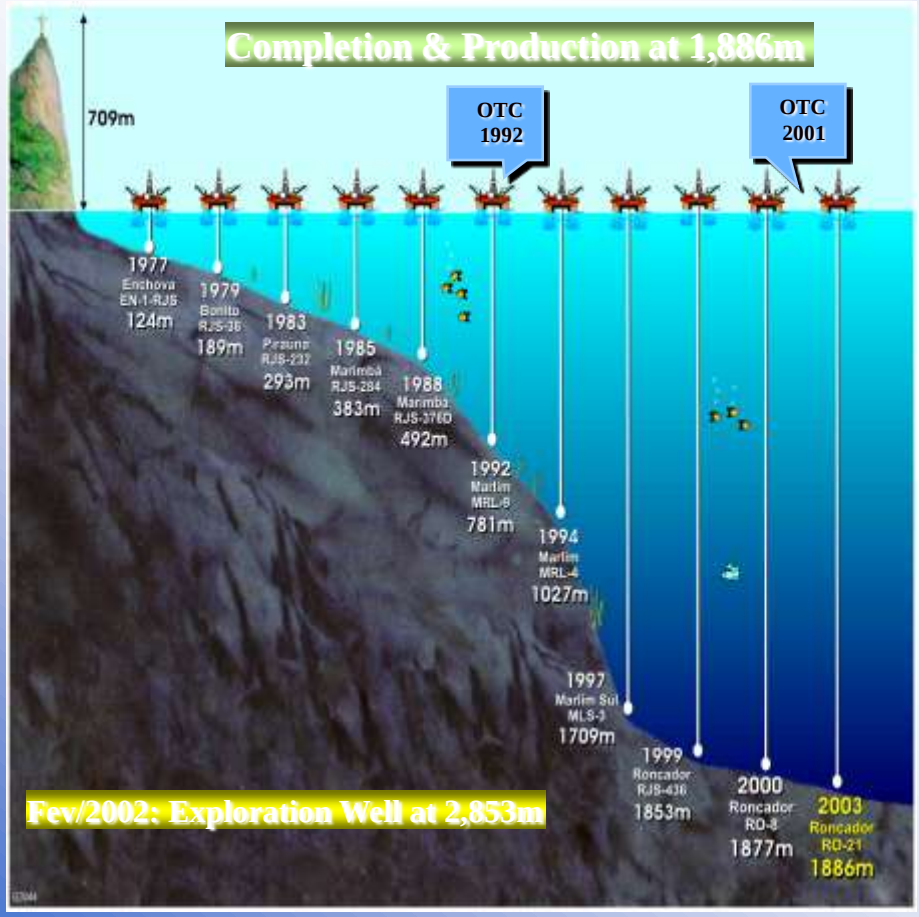


Stepping into deep water



Offshore Records and Facilities - Brazil

Petrobras Records



Offshore Facilities

Equipment	Installed Dec/2006	Planned (2007)
Subsea Trees	608	40
Subsea Manifolds	60	-
Subsea Flexible Flowlines (km)	3 200	400
Umbilicals (km)	1 900	200
Rigid Pipelines (km)	1 857	275
Floating Production Units	28	4
Monobuoys	3	-

Including Espirito Santo & Santos Basins, Piranema field NE Brazil

Resources to Reserves – 2nd Edition

- **Updating (oil update in IEA WEO 2008)**
  - Quantities of resources
  - Exploration costs/economic prices
- **New foci**
  - New case stories
  - Additional information on gas, coal, uranium
  - Non-conventional oil & gas
  - Competing fuels (CTL, GTL and BTL)
  - CO_2 chains, sources, possible sinks, incl. EOR
- **Project schedule**
  - 3 workshops, started September 2007
  - Review workshop May 2009, Florence
  - Launch in summer 2009

Conclusions

- There are opportunities for the IEA to intensify technology collaboration beyond today's level
  - Create better understanding of resources and reserves (studies and publications)
  - Collaboration in technology/policy relevant areas in IEA Implementing Agreements with typically 5 to 30 partners (EOR IA has 9 participants)
  - Address climate change: CO2 abatement strategies and technologies (CCS)