CULTURGEST

Fundação da Caixa Geral de Depósitos

Lisboa, 15 de Fevereiro de 2012

"PETRÓLEO, GÁS, a ENERGIA em MUDANÇA: da GEPOLÍTICA às TECNOLOGIAS e MERCADOS"

António Costa Silva

Presidente da Comissão Executiva

PARTEX
OIL AND GAS

2ª Conferência

"A MATRIZ ENERGÉTICA ACTUAL, O CONTEXTO HISTÓRICO, VULNERABILIDADES E SOLUÇÕES"

SUMÁRIO

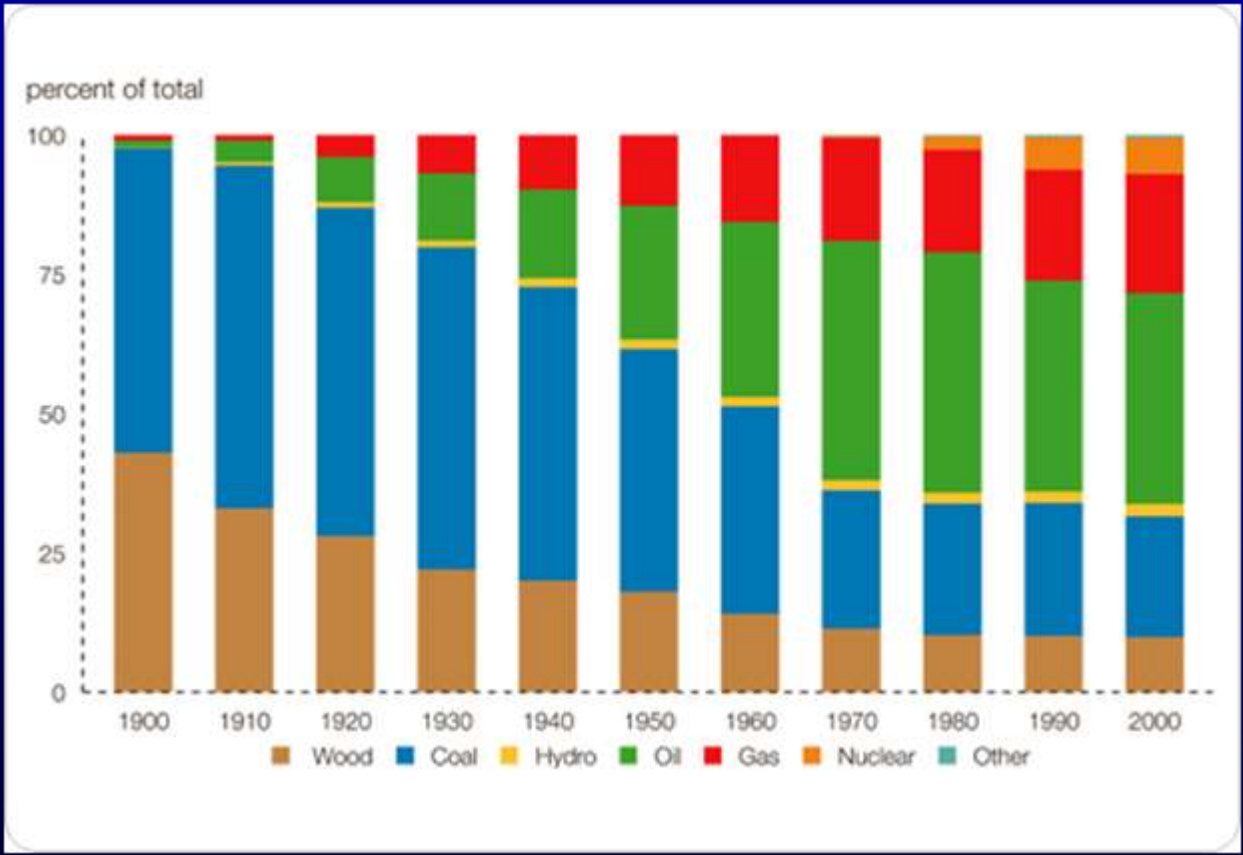
1. **EVOLUÇÃO HISTÓRICA da MATRIZ ENERGÉTICA e DESAFIOS para o FUTURO**

2. **O PAPEL DAS RESERVAS NÃO CONVENCIONAIS incluindo o SHALE GAS**

3. **AS ALTERAÇÕES CLIMÁTICAS, UM MUNDO SEM CO_2 e o IMPACTO na ECONOMIA**

1. EVOLUÇÃO HISTÓRICA da MATRIZ ENERGÉTICA e DESAFIOS para o FUTURO

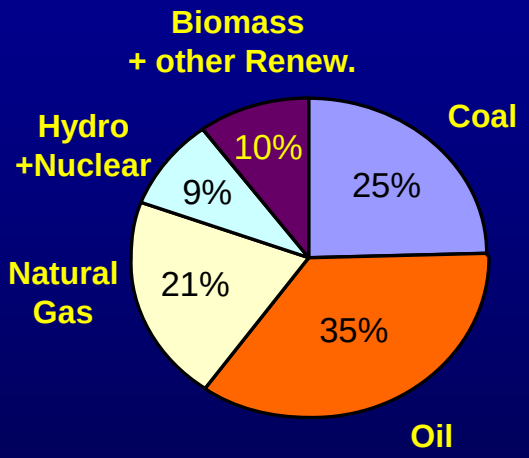
Evolving Energy Sources



Source: Outlook for Energy, 2030 - Exxon

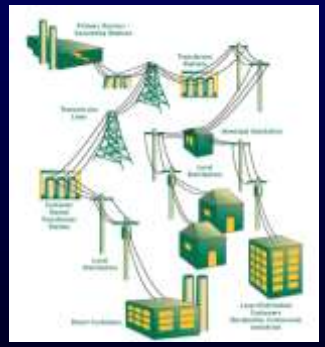
THE DOMINANT OIL MODEL

- Centered in oil and fossil fuels -

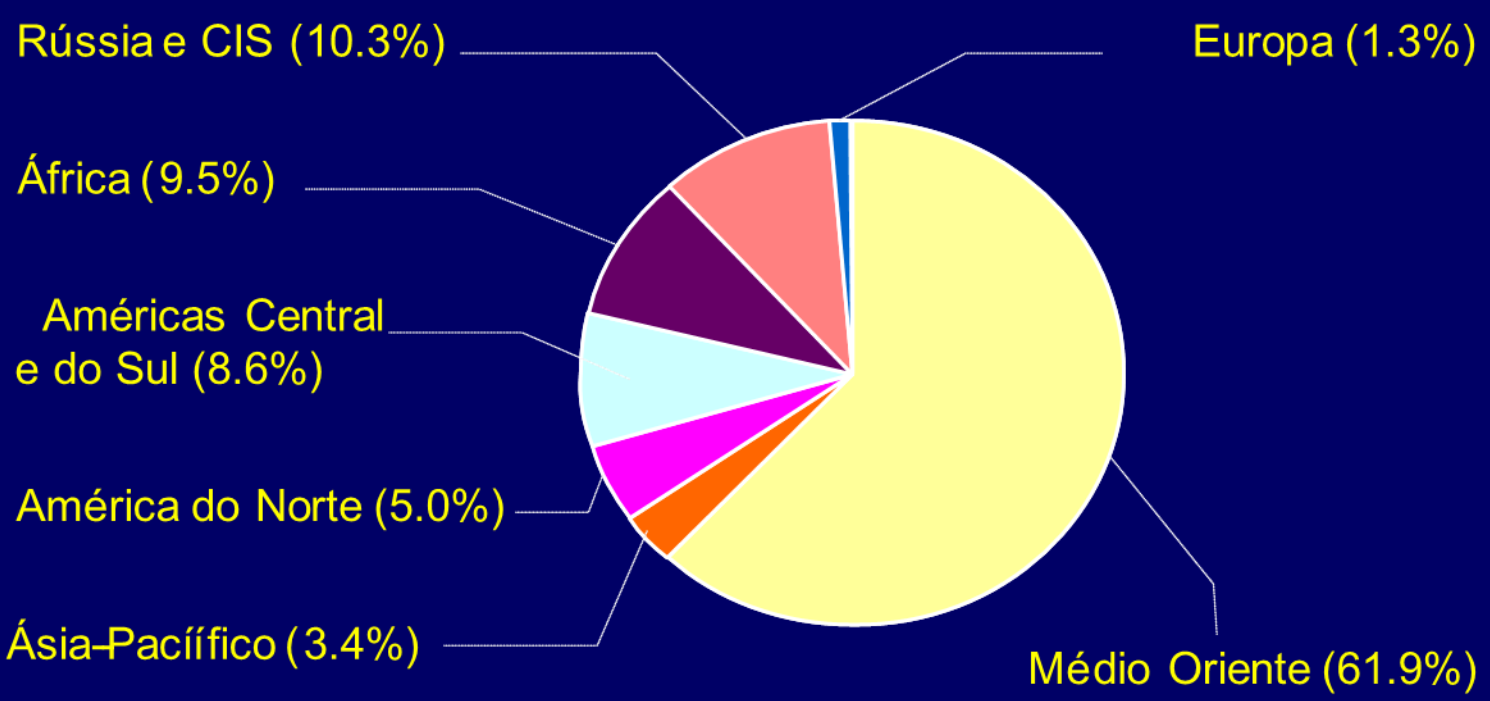


KEY FEATURES

- Centered - oil model
- No diversity
- Flow in one direction
- No good energy mix
- Heavy and costly
- No flexibility

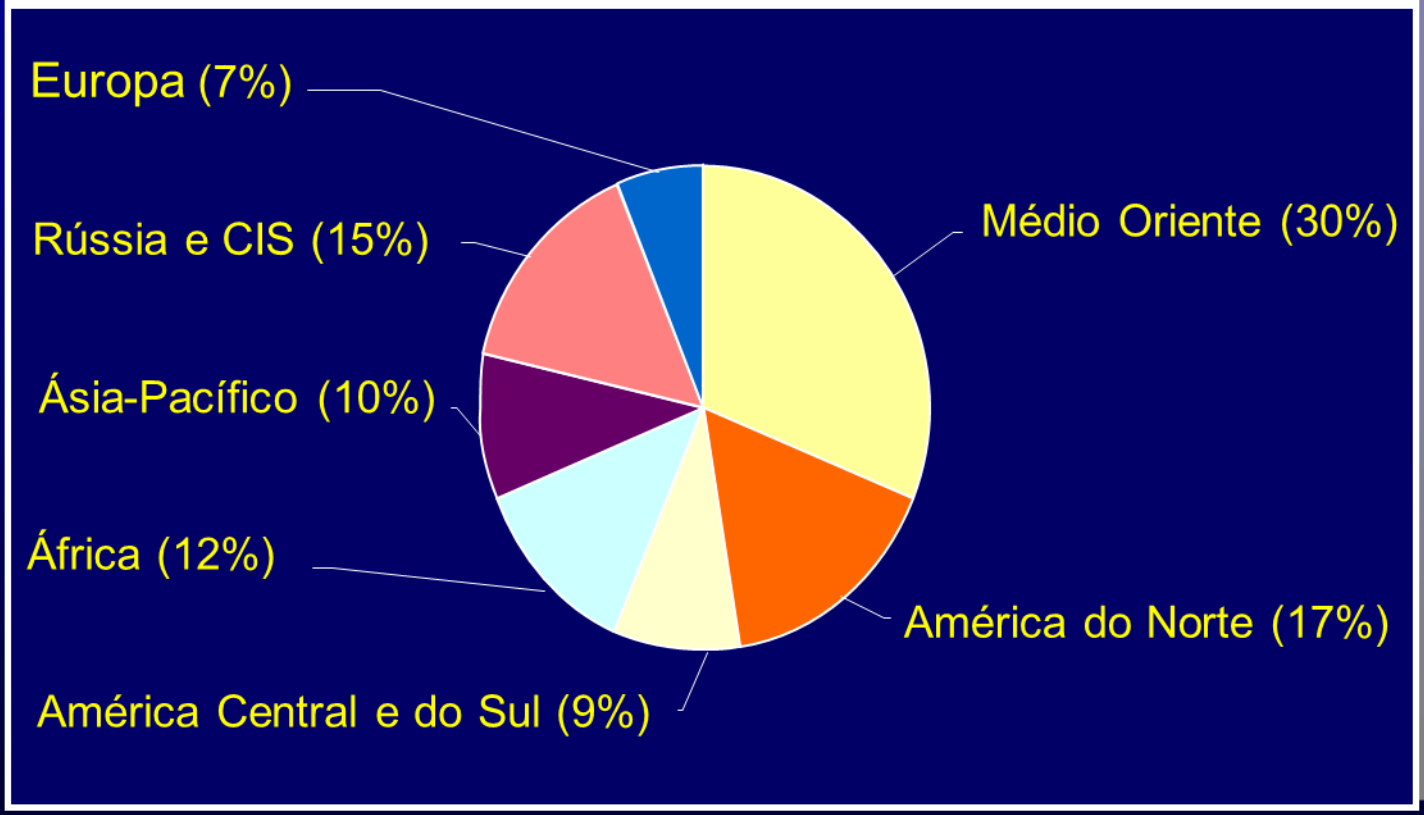


RESERVAS PROVADAS DE PETRÓLEO NO MUNDO
Total: 1200 Mil Milhões de Barris



Fonte : BP Statistical Review

PRODUÇÃO MUNDIAL de PETRÓLEO
Produção Média Mundial: 85 MB/D

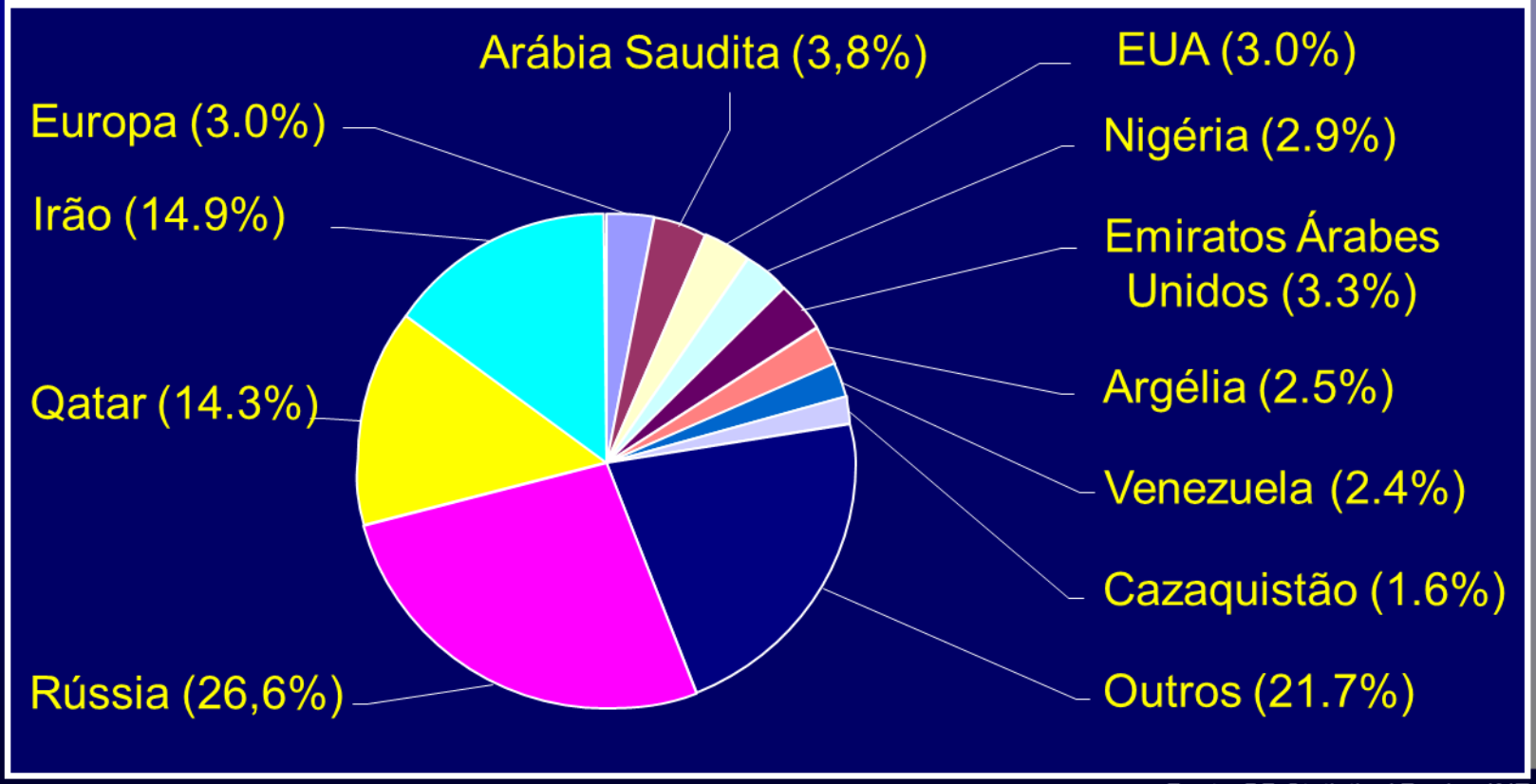


Fonte: BP Statistical Review

TOP 10 Oil Producers		
Country	Share of world's total (%)	Thousand barrels/day
1 Saudi Arabia	12.60	10,413
2 Russian Federation	12.60	9,978
3 USA	8.00	6,879
4 Iran	5.40	4,401
5 China	4.80	3,743
6 Mexico	4.40	3,477
7 Canada	4.10	3,309
8 UAE	3.50	2,915
9 Venezuela	3.40	2,613
10 Kuwait	3.30	2,626

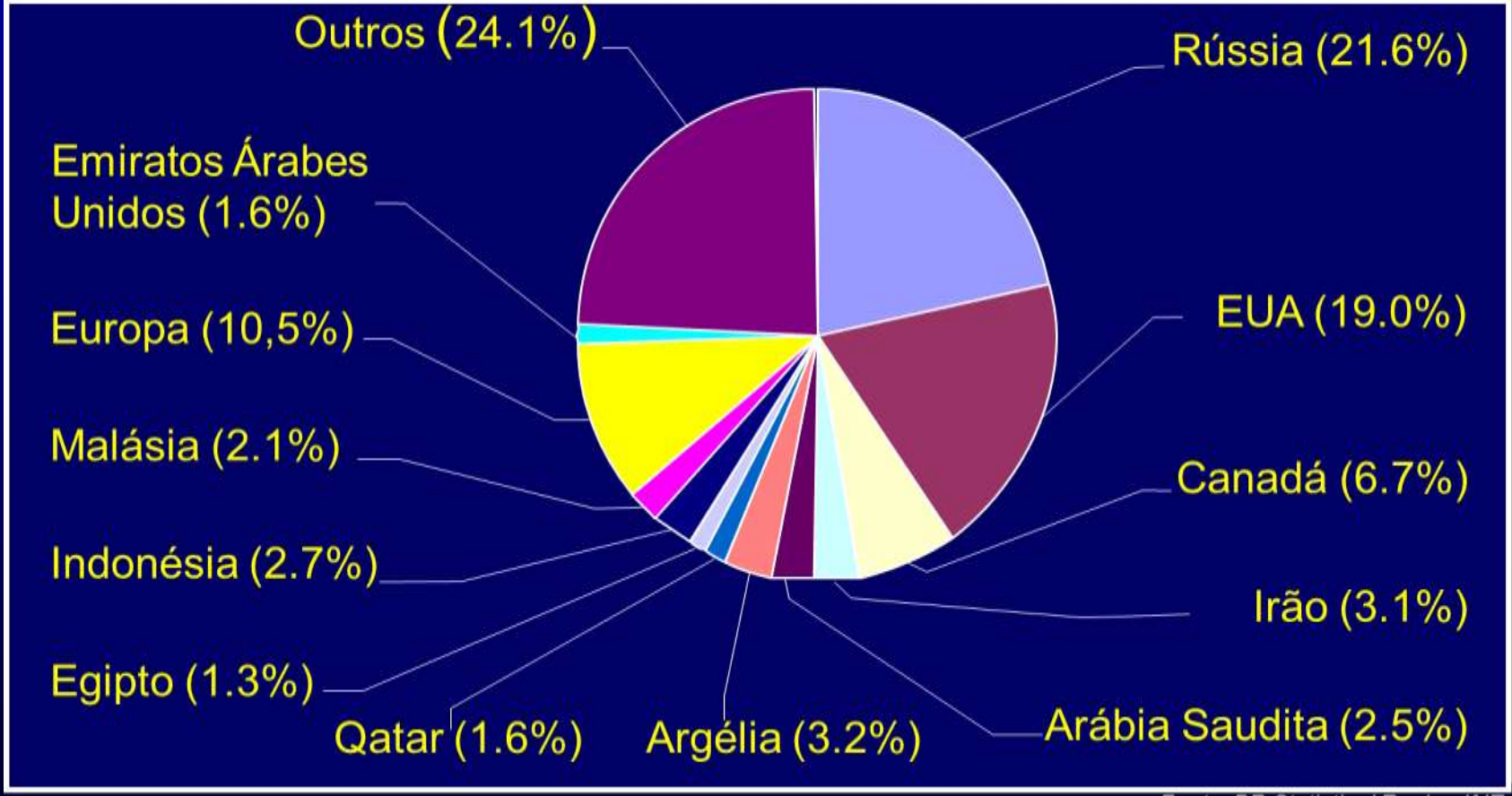
TOP 10 Oil Consumers		
Country	Share of world's total (%)	Thousand barrels/day
1 USA	23.90	20,698
2 China	9.30	7,855
3 Japan	5.80	5,051
4 Indía	3.30	2,748
5 Russian Federation	3.20	2,699
6 Germany	2.80	2,393
7 South Korea	2.70	2,371
8 Canada	2.60	2,303
9 Saudi Arabia	2.50	2,154
10 France	2.30	1,919

RESERVAS PROVADAS de GAS no MUNDO
Total: 179.83 Triliões de metros cúbicos (Tmc)



Fonte: BP Statistical Review/AIE

PRODUÇÃO MUNDIAL de GAS
Total: 2763 mil milhões de metros cúbicos



Fonte: BP Statistical Review/AIE

OLNG

WORLD OIL RESERVES: A BALANCED APPROACH

NEGATIVE TRENDS

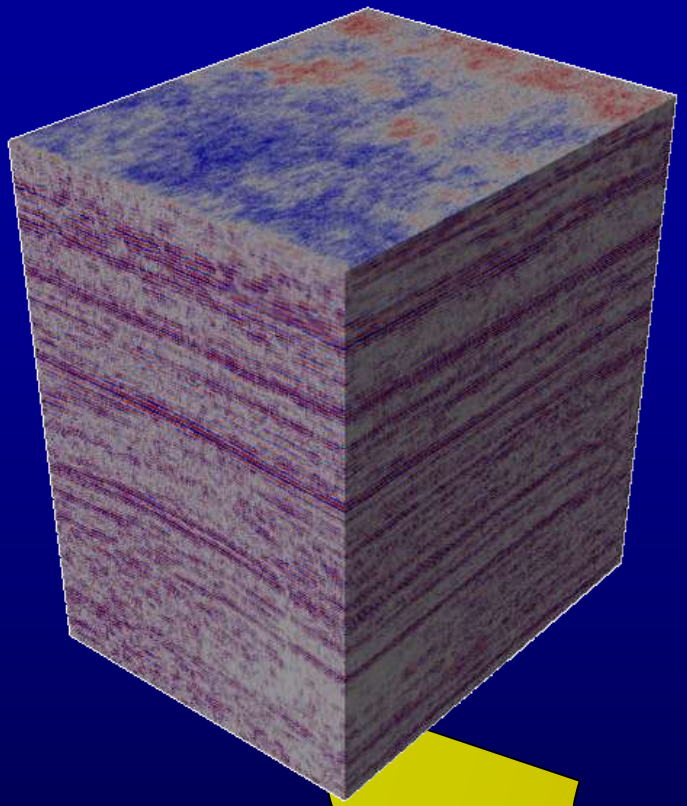
- Few Giant Discoveries since early 90's
- Current Production from increasingly mature fields
- Declining discoveries: 1 bbl is found for every 3 bbls produced
- Production decline in the North Sea, Alaska, USA
- Reliability of Reserves Estimates: Poor reporting
- Majors declining Reserves Replenishment Ratios

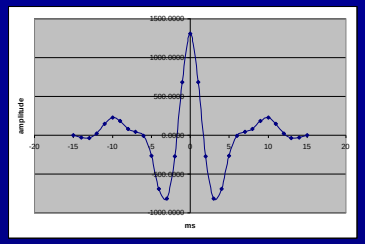
POSITIVE TRENDS

- Untapped reserves in the Middle East (Iraq/Saudi Arabia)
- The "Omani" paradygm
- Deep-offshore, polar and arctic oil potential
- Unconventional oil reserves: Venezuela/Canada
- Technology Role:
  - Seabed Logging
  - Digital Field concept
- Average Ultimate Recovery is low (30/35%); room for enhancement

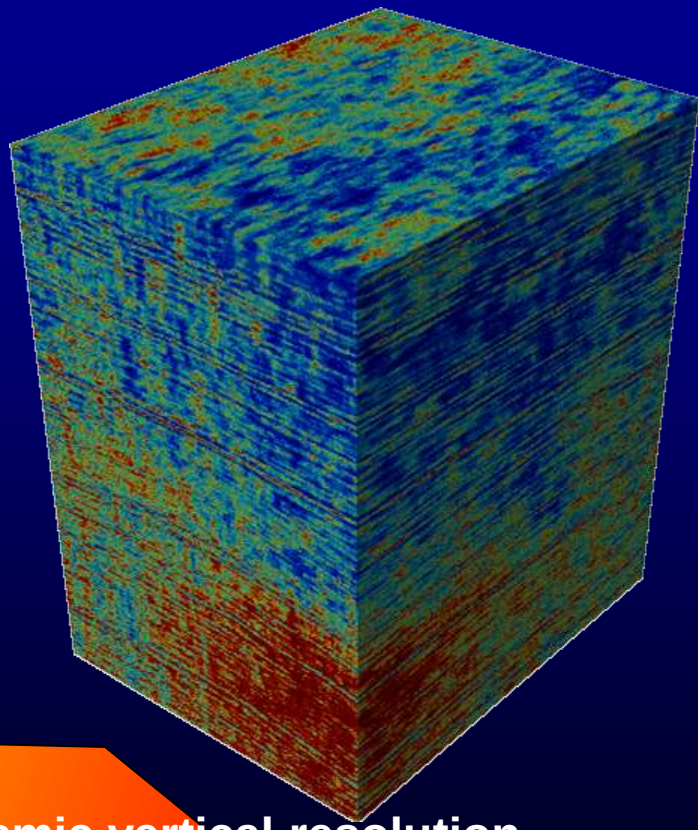
GSI - Global Seismic Inversion

Seismic Amplitudes



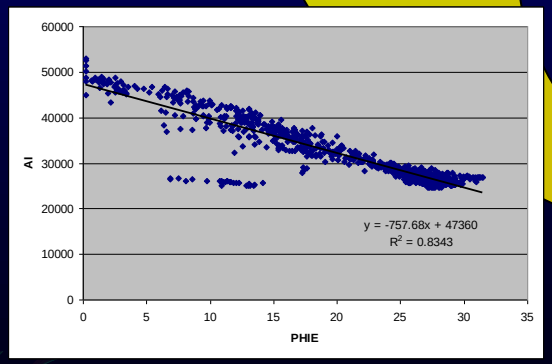


Acoustic Impedances (AI)



AI = Density x Velocity

Related with porosity



Increase seismic vertical resolution
Close to reservoir properties (porosity)

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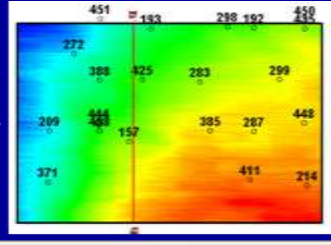
OIL AND GAS

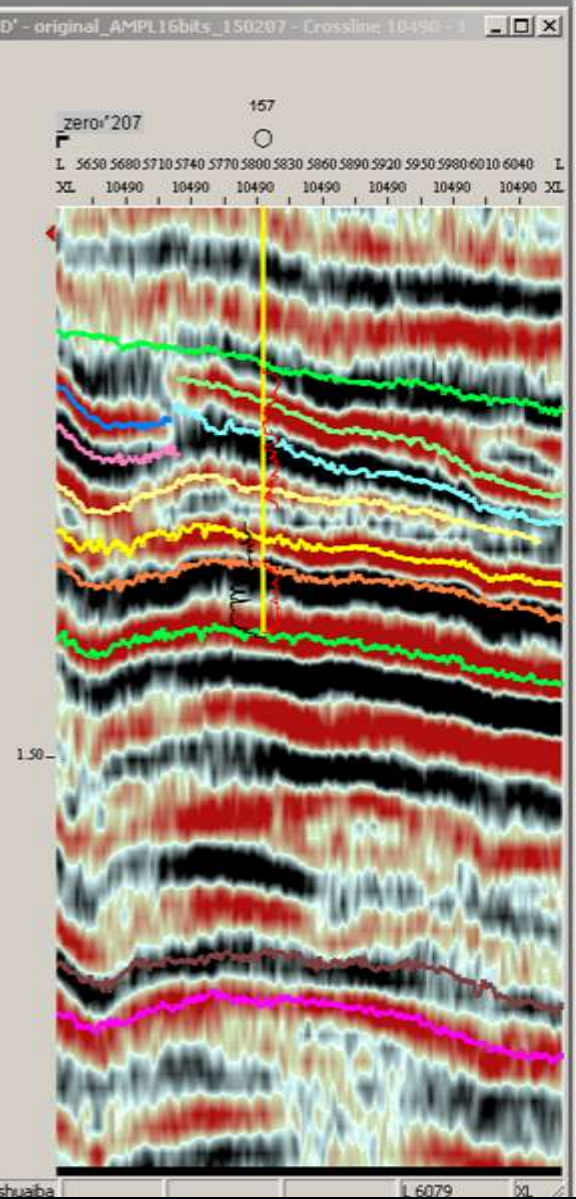
GSI - Global Seismic Inversion

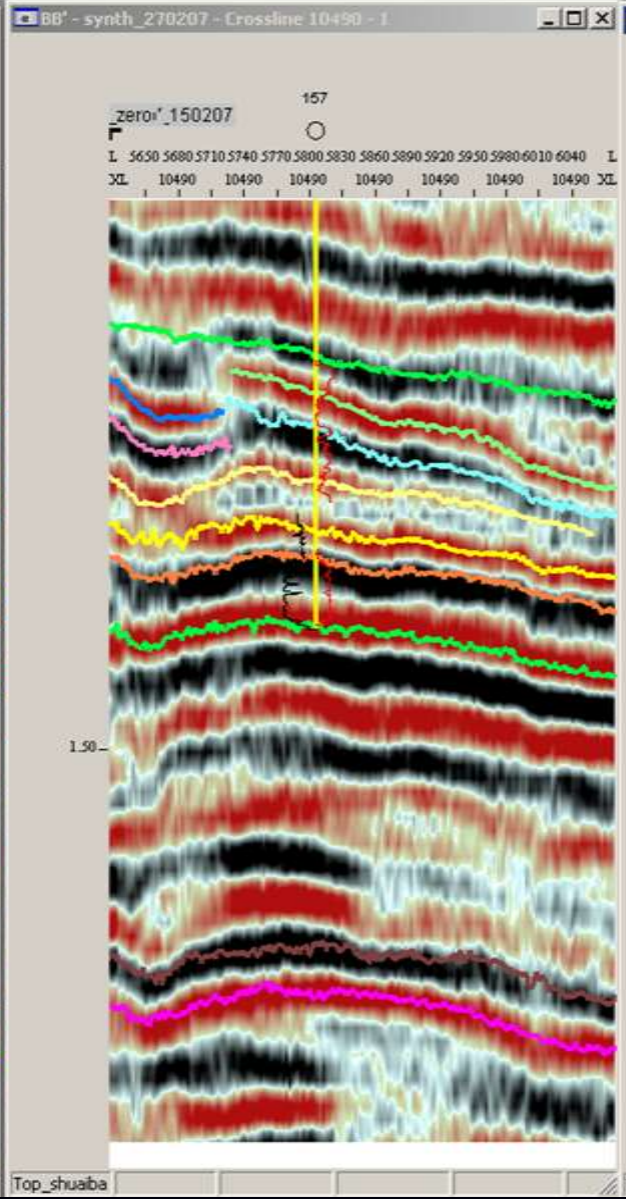


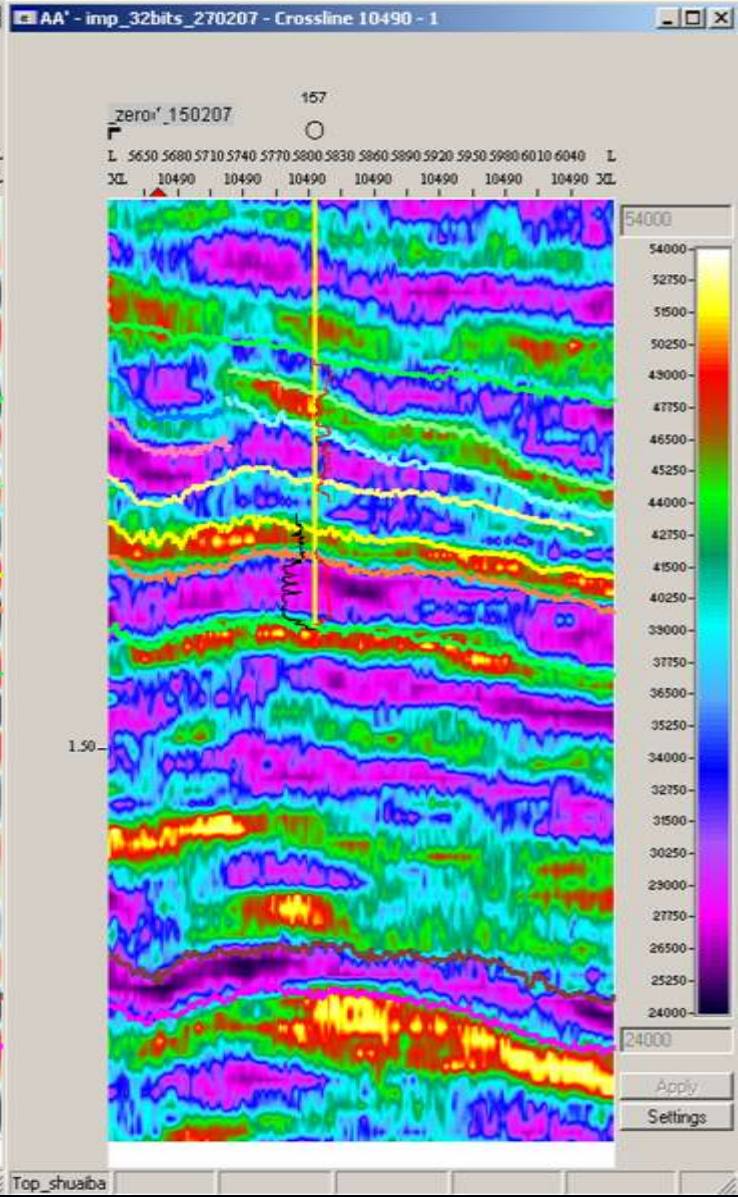
Original Seismic

Synthetic Seismic

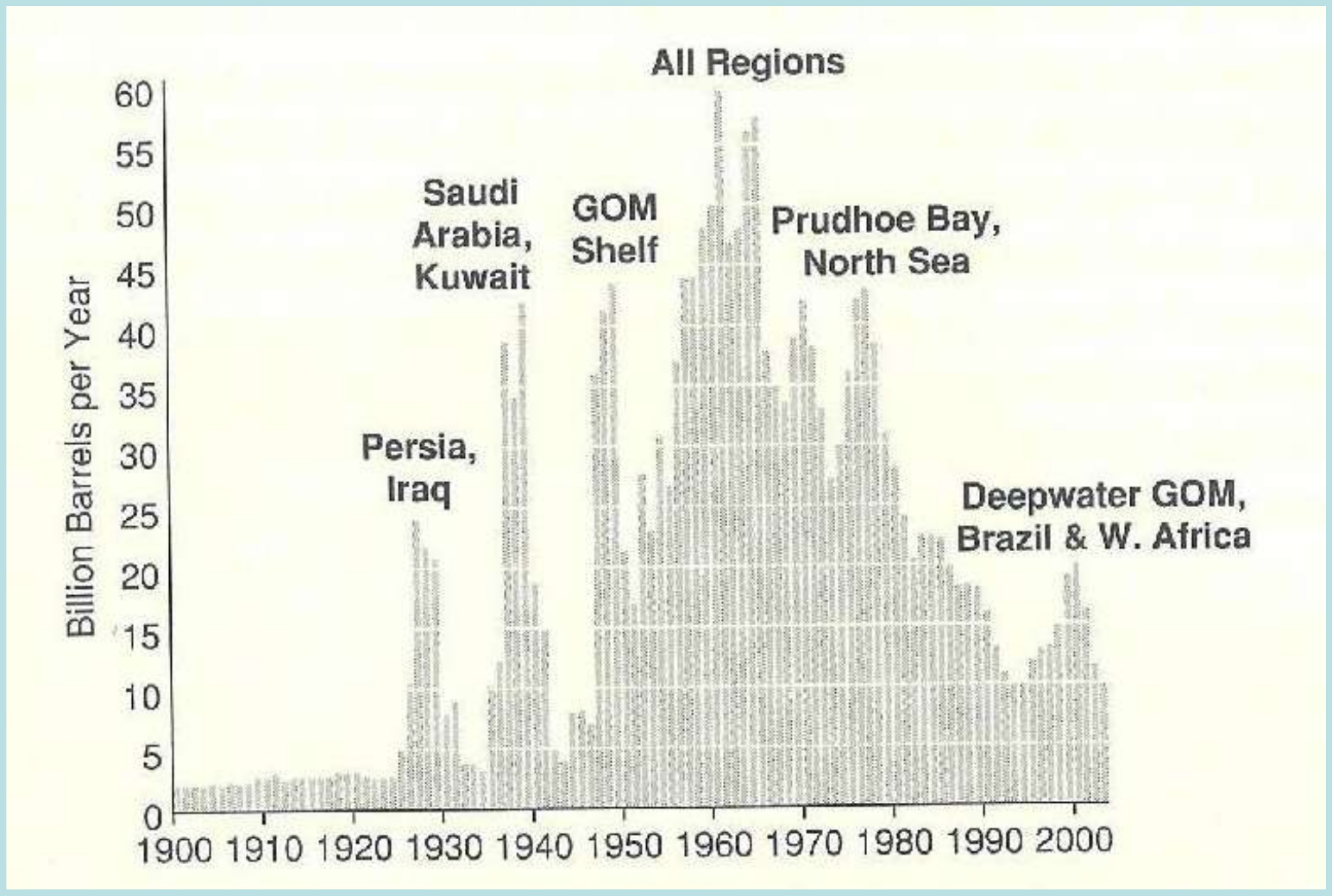
Seismic AI



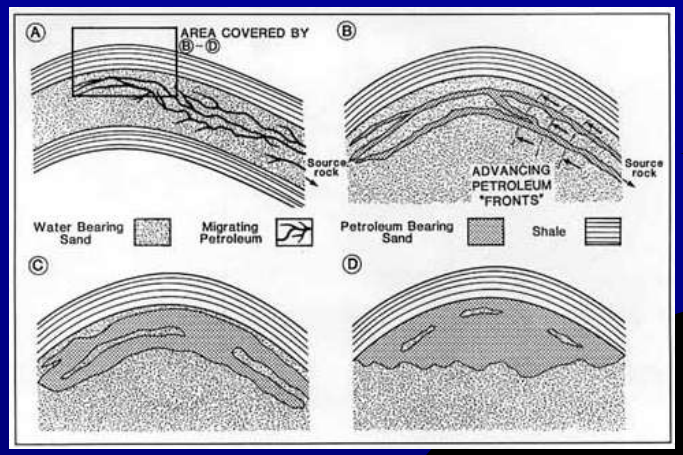




Total Volume of New Discoveries Worlwide: By Year, 1900/2004



"The MAGIC FIVE"



1- SOURCE


Microfractures in organic rich shale. Hunt, 1995.

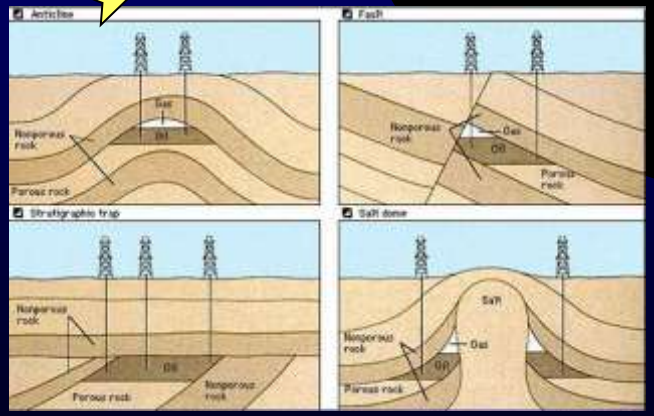
2 - MIGRATION

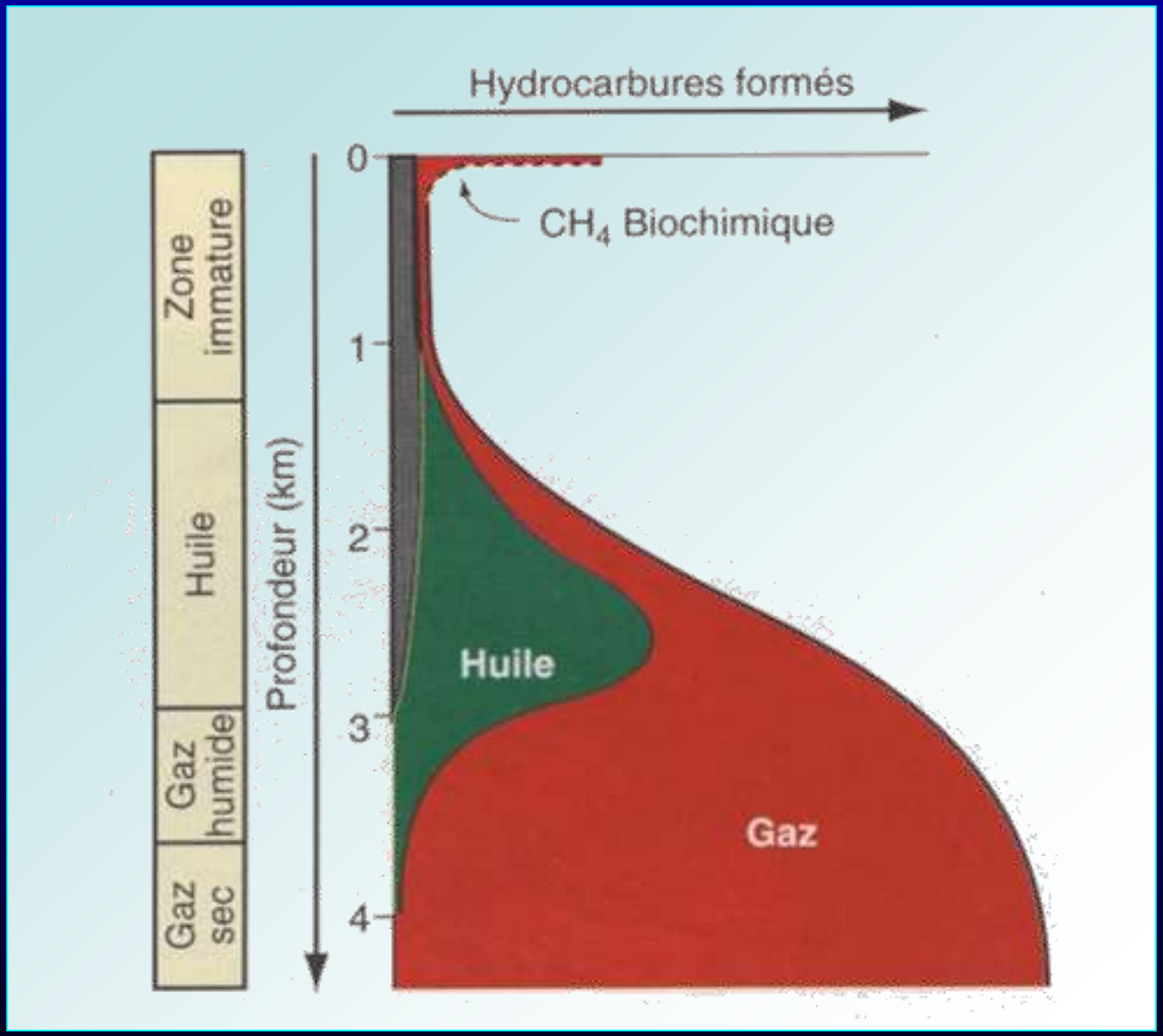
5 - TIMING

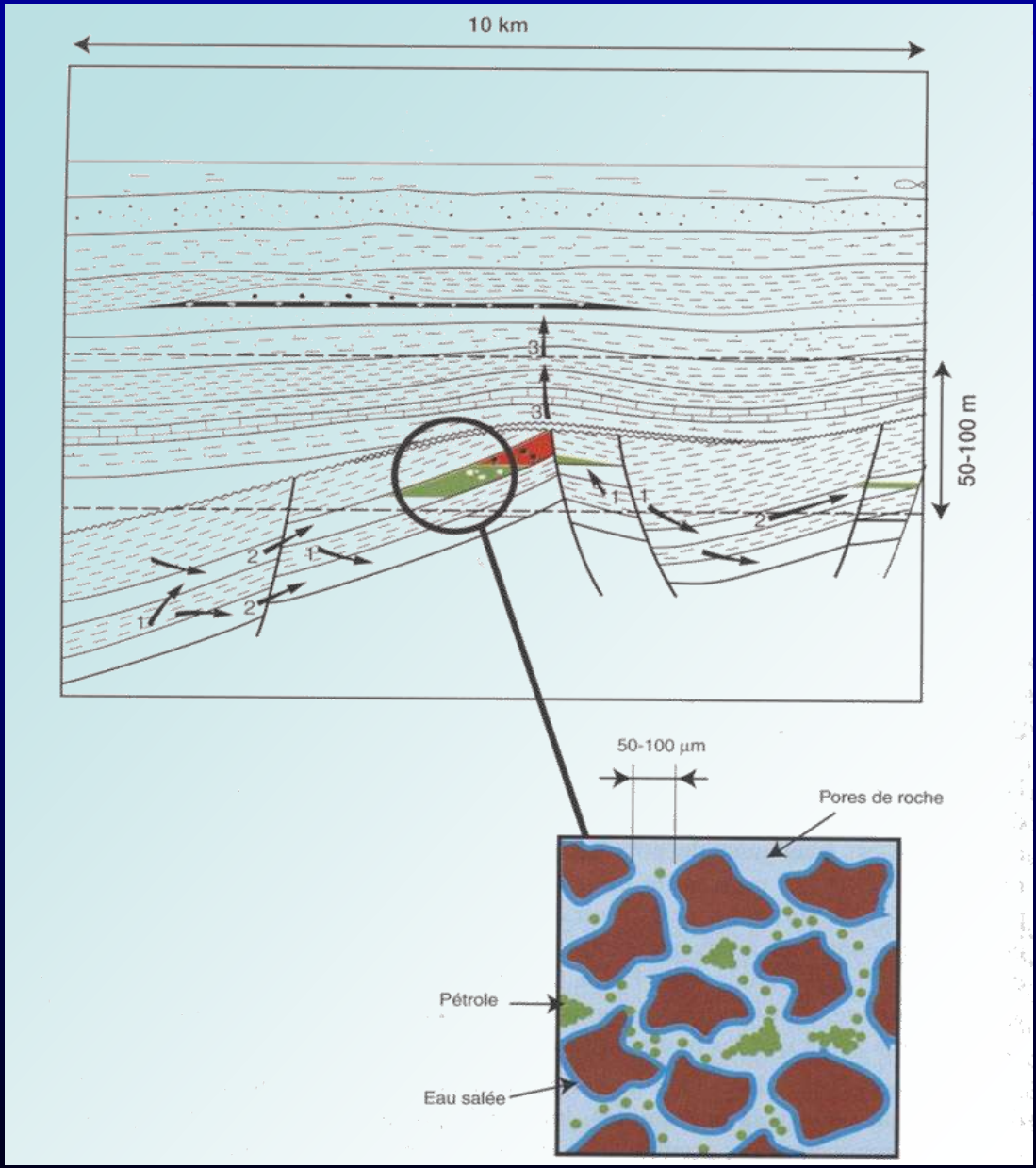
Successfull acumulation!
Is it economic ?

4 - RESERVOIR

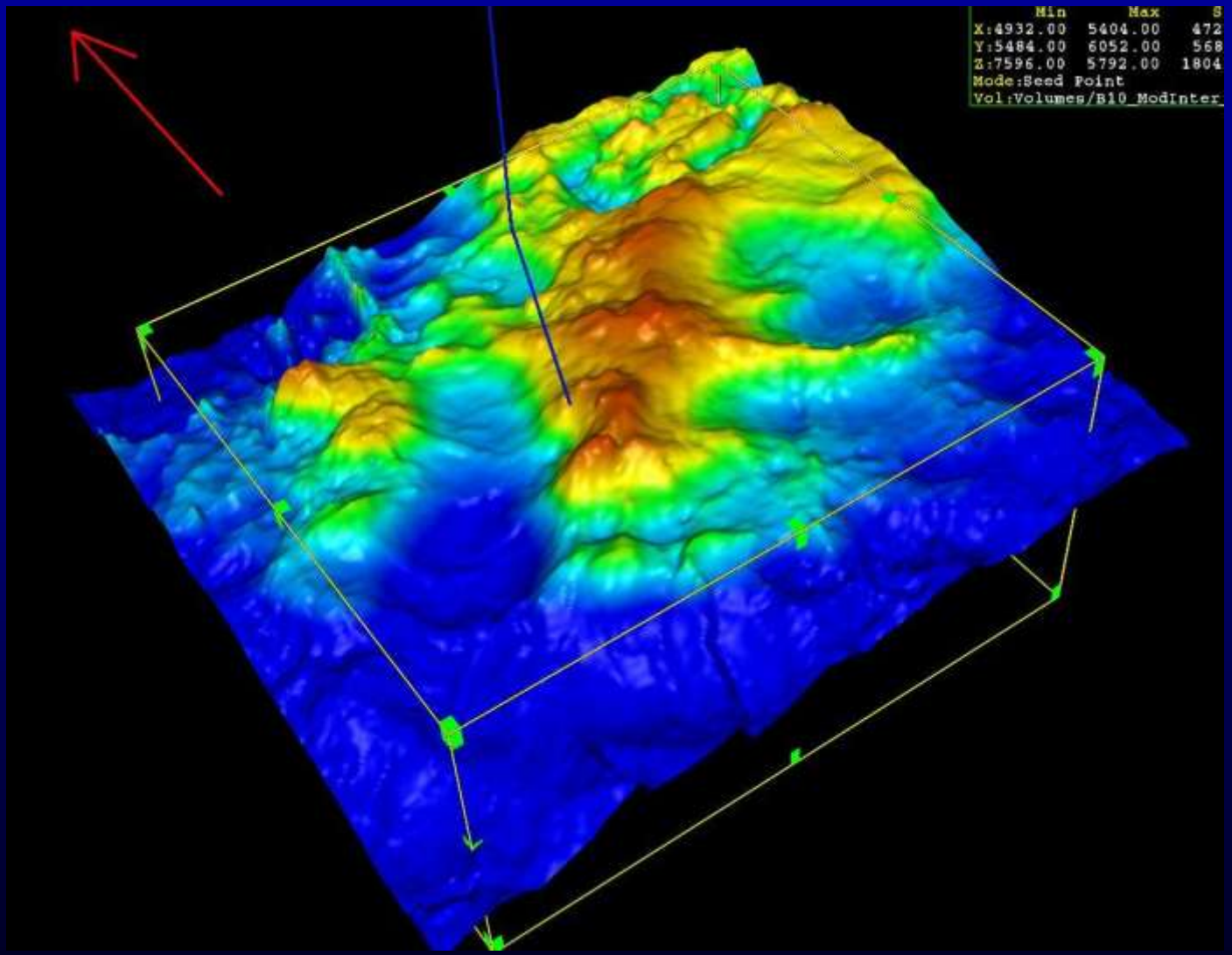
3 - TRAP



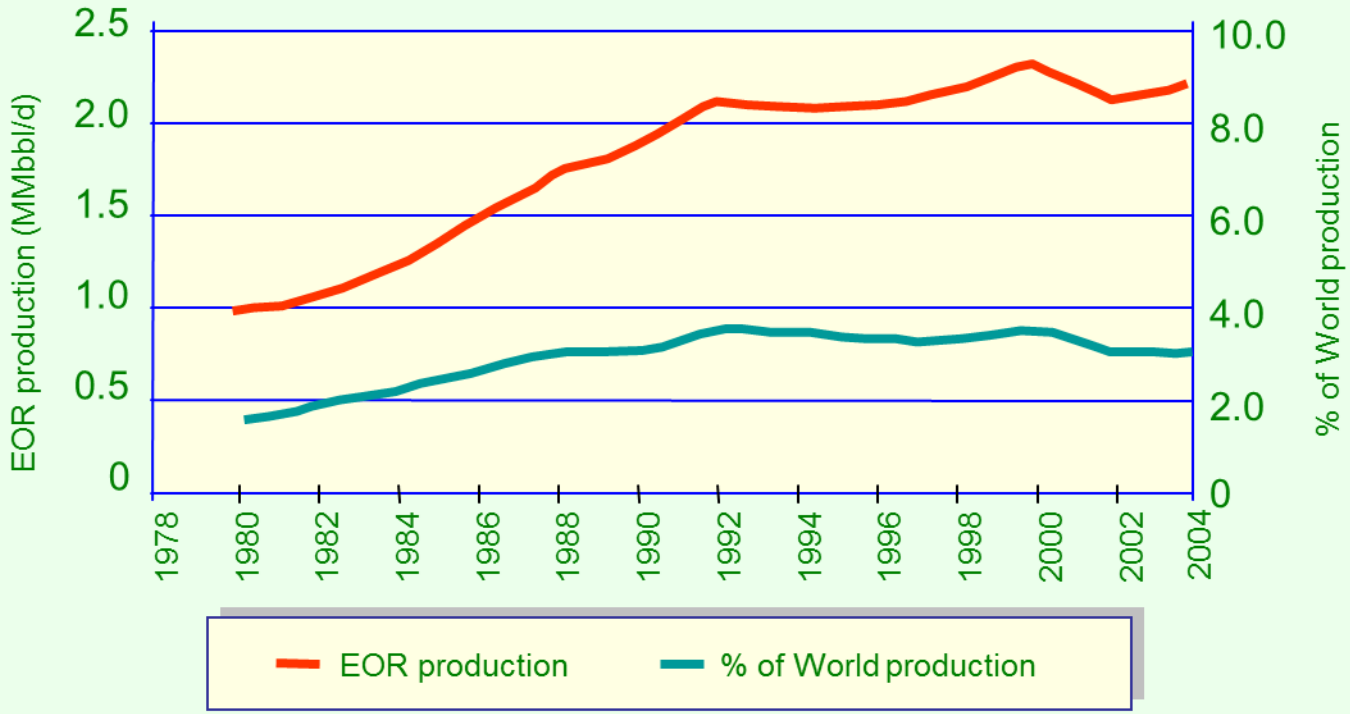

Hydrocarbures formés
Zone immature
Huile
Gaz humide
Gaz sec
Profondeur (km)
0
1
2
3
4
CH_4 Biochimique
Huile
Gaz


10 km
50-100 m
50-100 µm
Pores de roche
Pétrole
Eau salée

Structural Map - Top of Rift



EOR Vs. World Production



Source: OGJ (Oil and Gas Journal)

The role of technology

AREAS	TOOLS	OBJECTIVES
Exploration	Seabed Logging (SBL)	• Based on electro-magnetic methods • Integration with 3D Seismic • Better Resolution
Development/Production (new approaches in gathering and processing data)	Digital Field Concept I.Remote Sensing: combination of seismic and sensors II.Visualization: 3D imaging and modelling III.Intelligent Drilling and Completions: control of production from each reservoir zone IV.Automation V.Data Integration: various sources	• Detects what is happening in the reservoir • Better placement of wells • Steer and complete wells through different zones of the reservoir • Remote gathering of well and field data • Optimised decision process

Sea Bed Logging (CSEM)

- After completion of the sequence stratigraphy work, a model of the expected resistivity profile will be generated
- EMS will model the expected electromagnetic response to demonstrate whether oil and gas prospects could be detected directly with Sea Bed Logging techniques
- Contingent Cost: £10K

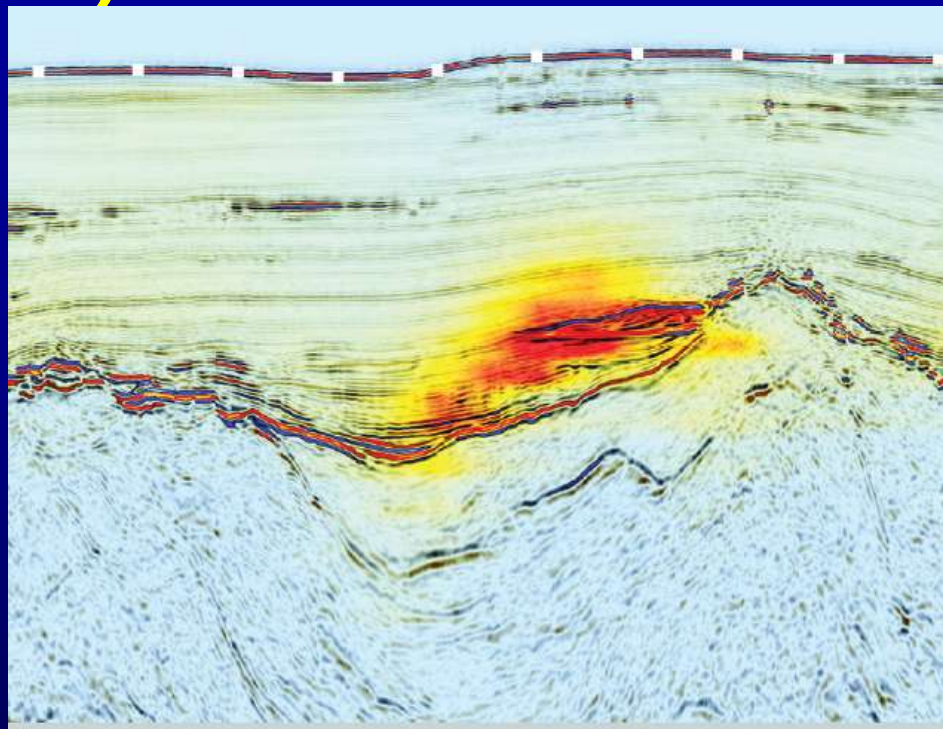


Figure 2: EM-imaging data integrated with seismic data shows which of the structures identified on a seismic image is likely to contain hydrocarbons and which can be discounted from further geophysical or drilling investigations. EM surveys measure resistivity; hydrocarbon-charged reservoirs typically have a much higher resistivity than the surrounding rock, as indicated by the red colour in the image above. (Data courtesy of Murphy Oil Corporation.)

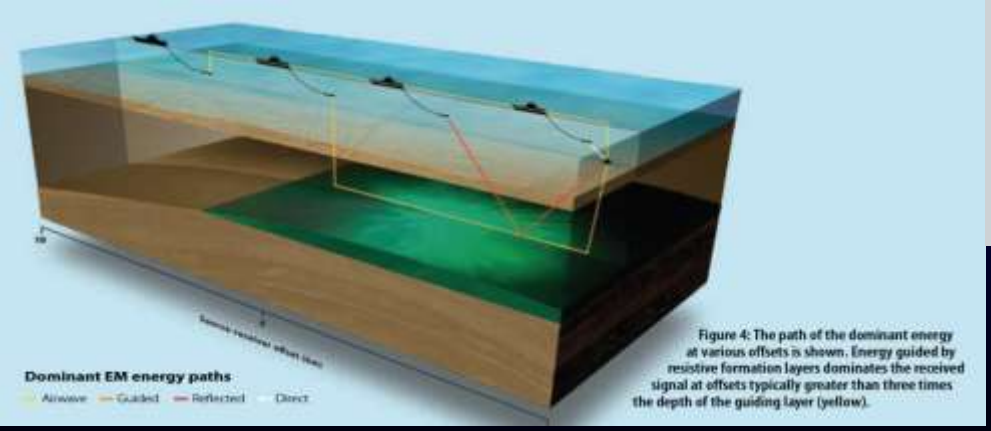


Figure 4: The path of the dominant energy at various offsets is shown. Energy guided by resistive formation layers dominates the received signal at offsets typically greater than three times the depth of the guiding layer (yellow).

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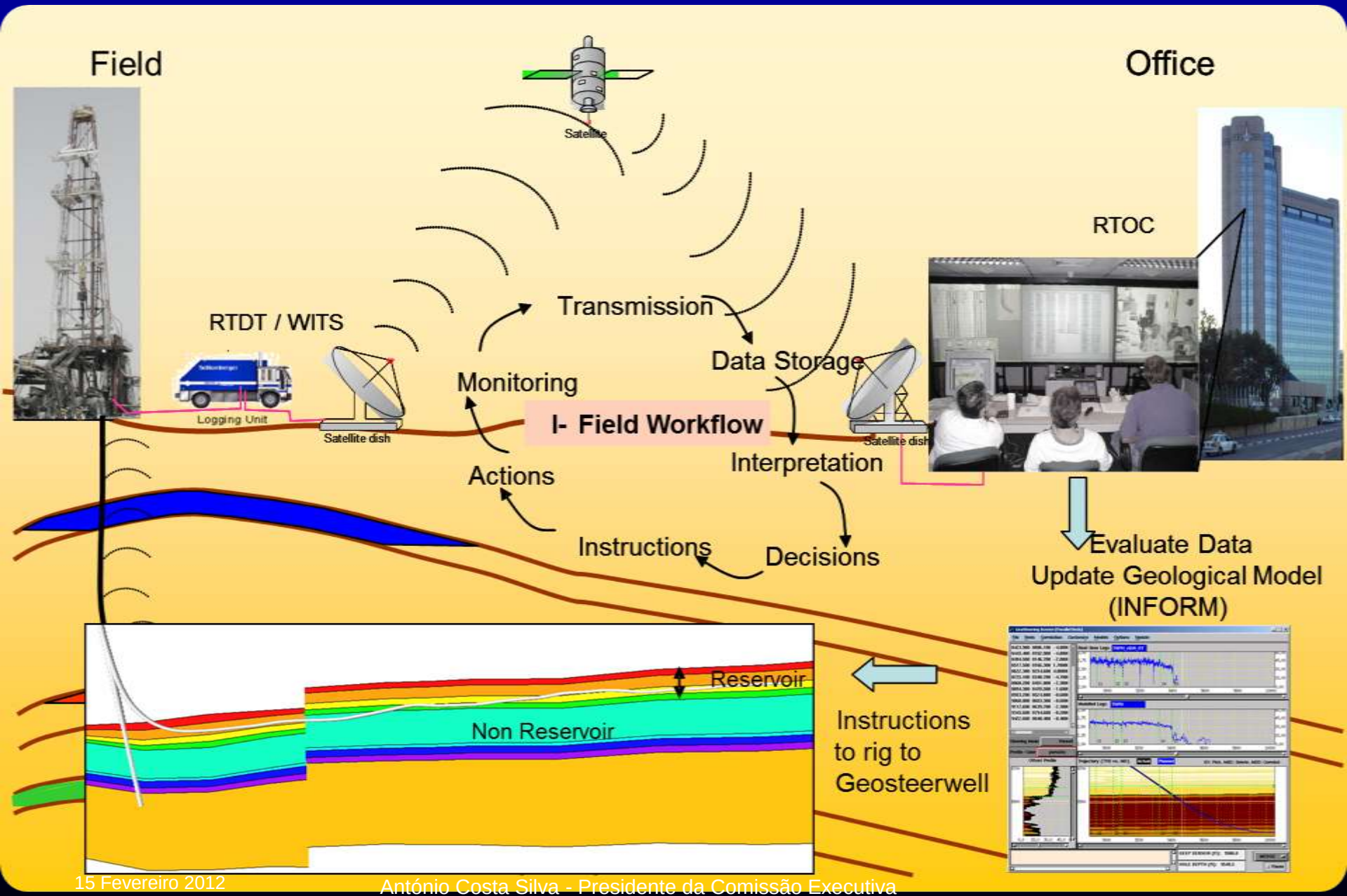
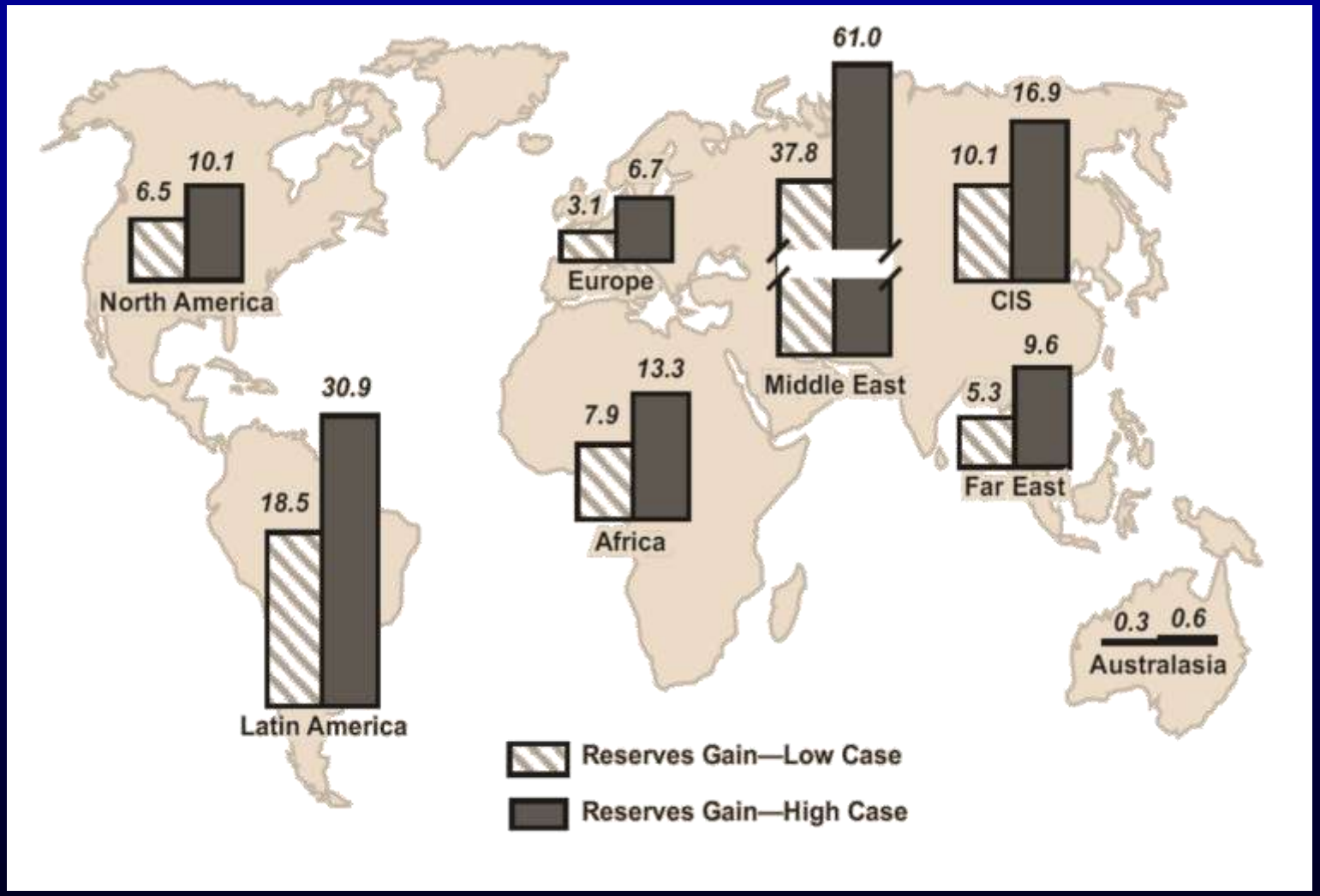
OIL AND GAS

2010+
Automation / i-Field



Estimate of Reserves Gain from the Digital Oil Field of the Future billion barrels)



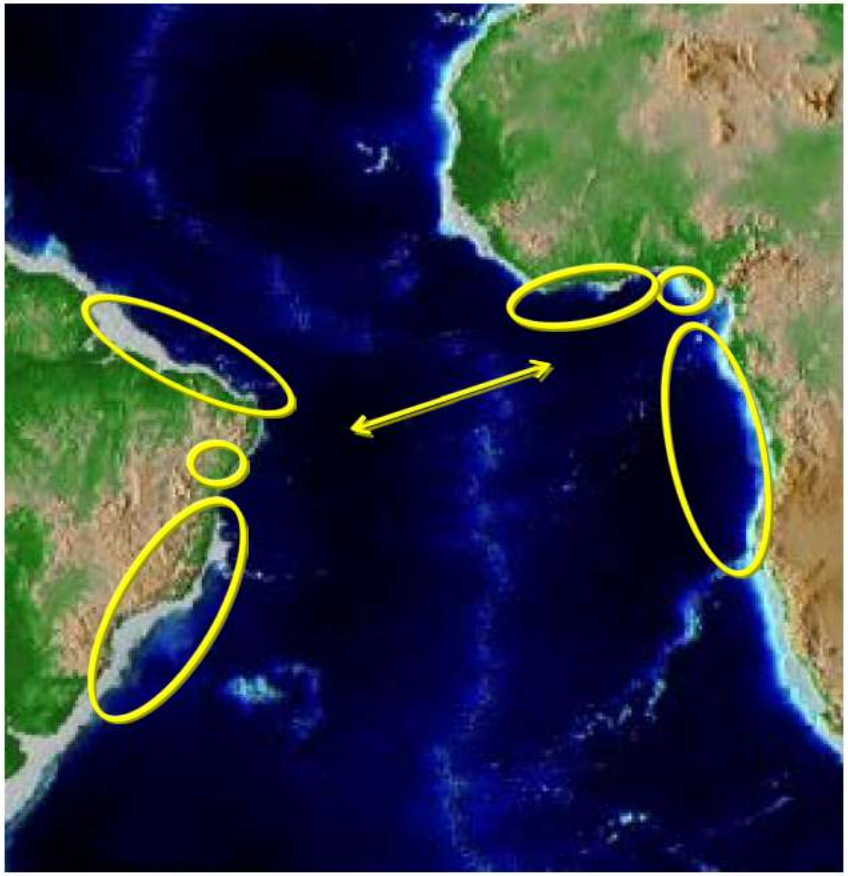
PETROBRAS

West Africa: Pre Salt

Brazilian Equatorial Basins

Reconcavo Basin

Brazilian Pre-Salt

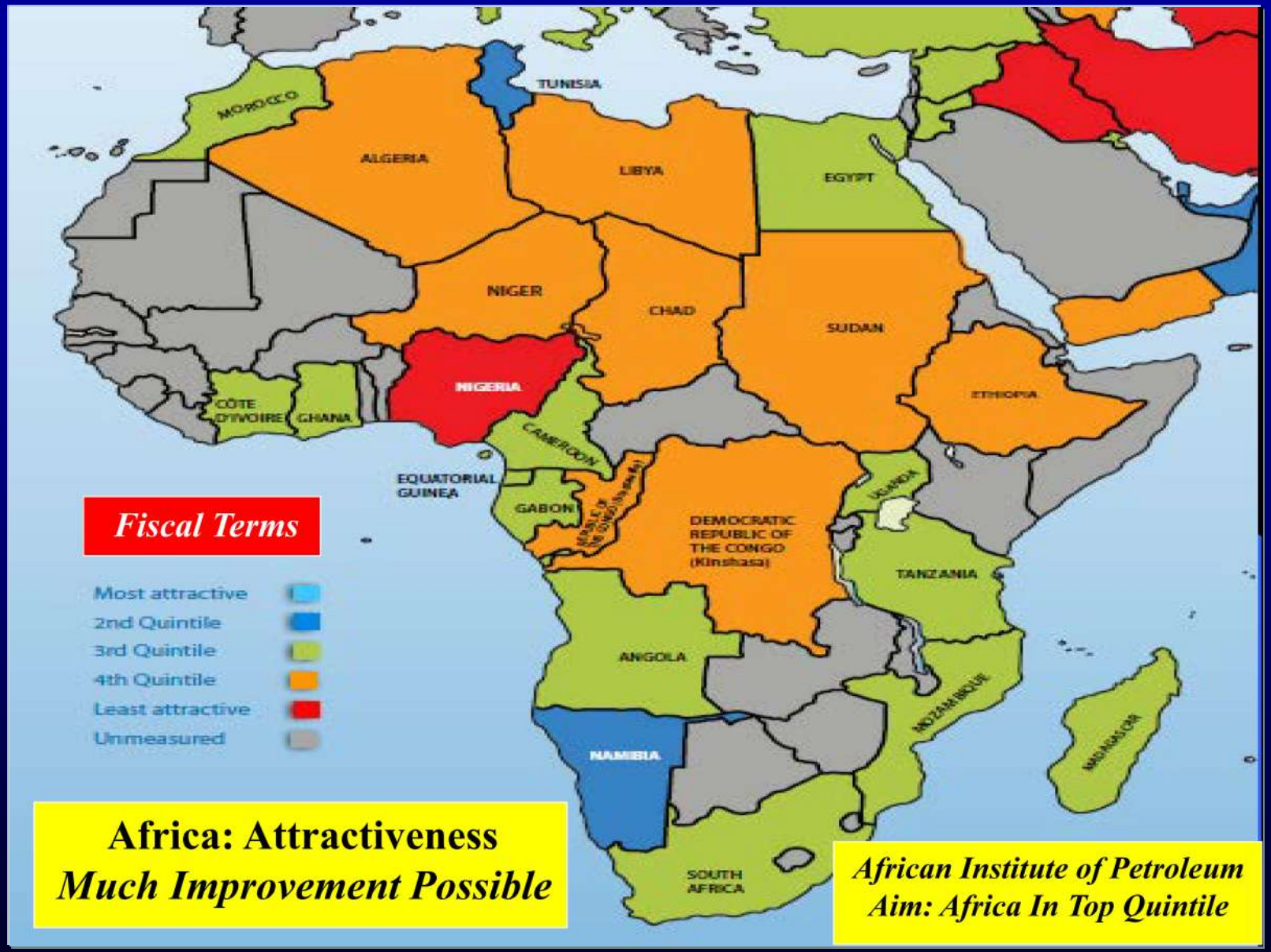


Ghana Jubilee

Niger Delta

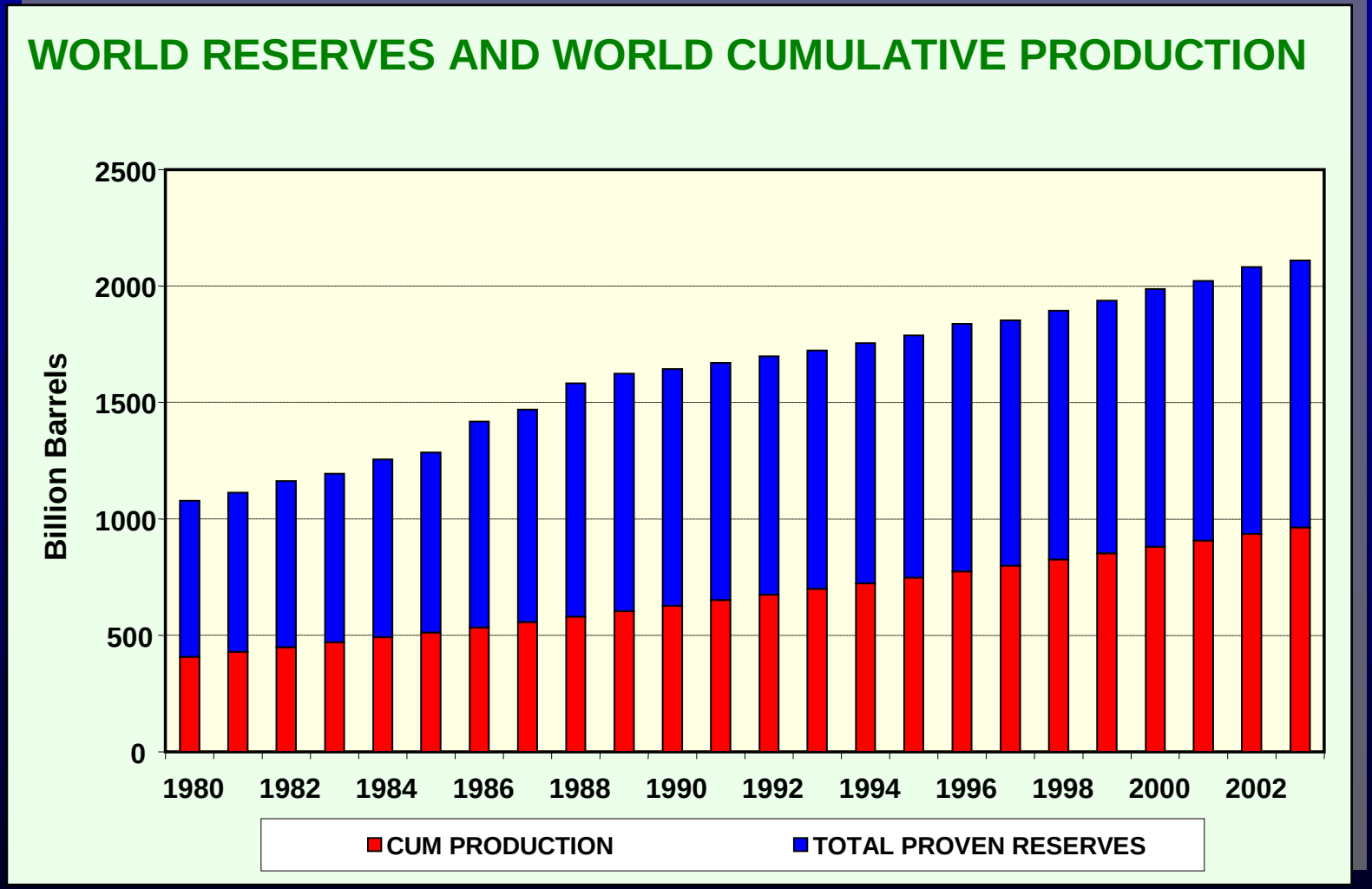
African Pre-Salt

Source: 21st World Upstream Conference Global Pacific & Partners

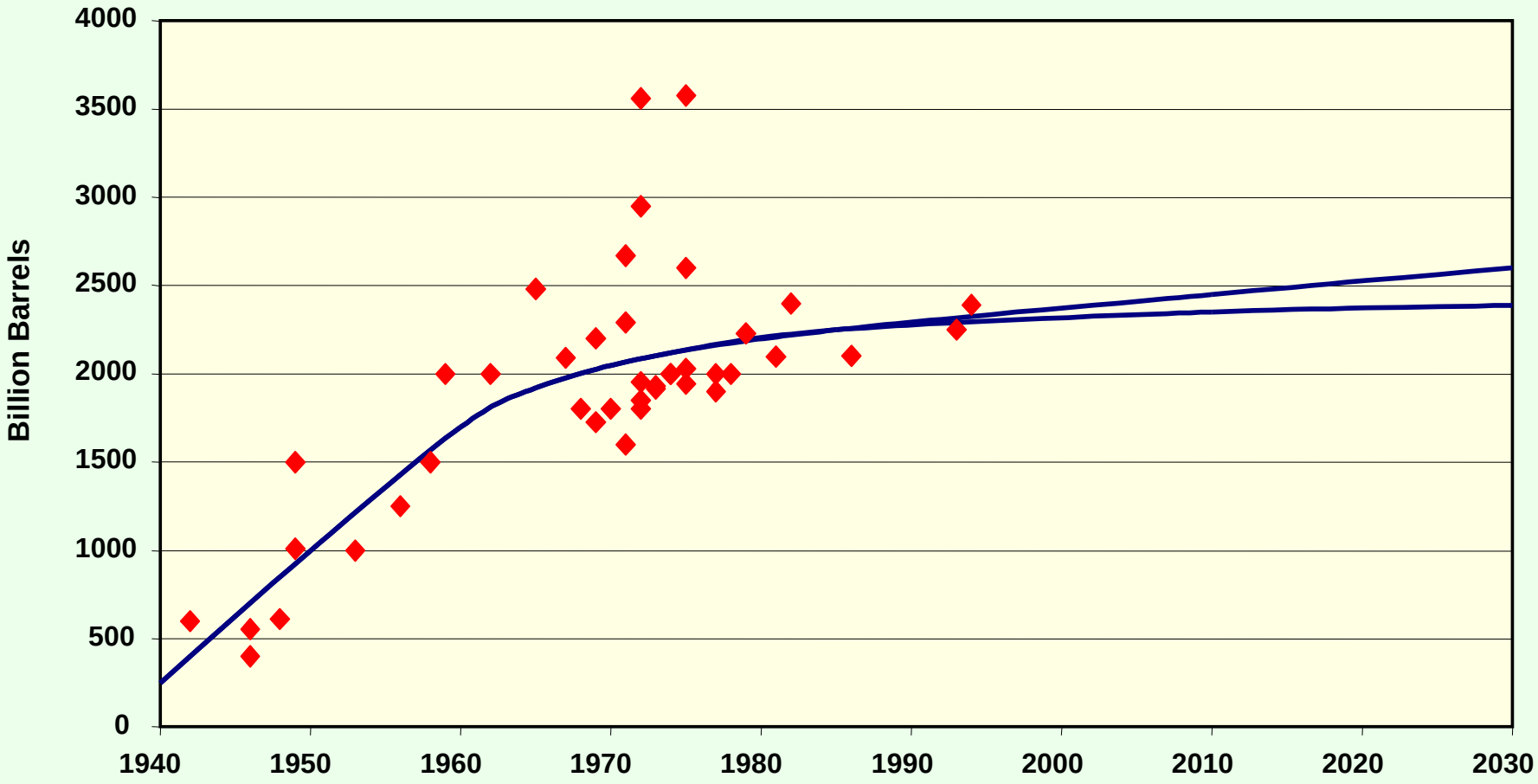


Source: 21st World Upstream Conference Global Pacific & Partners

World Reserves and World Cumulative Production



WORLD OIL RESERVES
ESTIMATES of the ORIGINAL VOLUMES



We have run out of oil many times already…

1885
"The amazing exhibition of oil [is] a temporary and vanishing phenomenon - one which young men will see to come to its natural end."
State Geologist of Pennsylvania

1943
Ultimate global recovery 600 billion bbl
Wallace Pratt, Standard Oil
(Total produced to 2010 ~1200 billion)

1977
"We could use up all of the proven reserves of oil in the entire world by the end of the next decade"
Jimmy Carter

1989
Global production has peaked
Colin Campbell

1919
World oil production to peak by 1928
David White, USGS

1956
Global production to peak 1995-2000 at 33 million bbl/day
M. King Hubbert, Shell

1980
"…world production of oil probably will begin to decline in the mid 1980's"
US Government

2005
Peak will be December 16th, 2005
Kenneth Deffeyes,

Source: 21st World Upstream Conference Global Pacific & Partners

When will supply start declining?

The production peak

- **Estimate future production profiles, the growth rate, the time for peak production and the start of decline**

- **Factors involved:**

  - Reserves

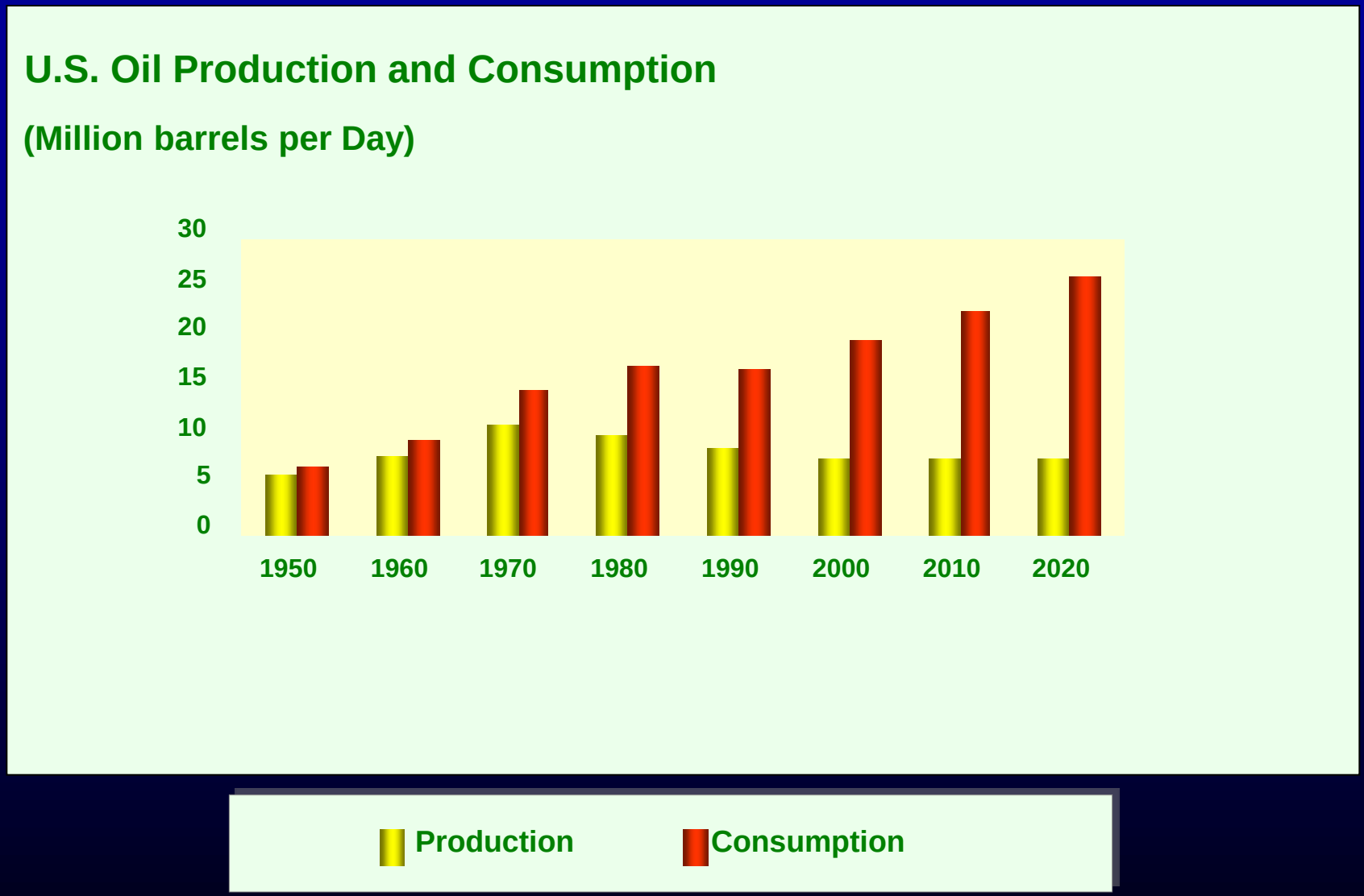
  - Costs

  - Technology

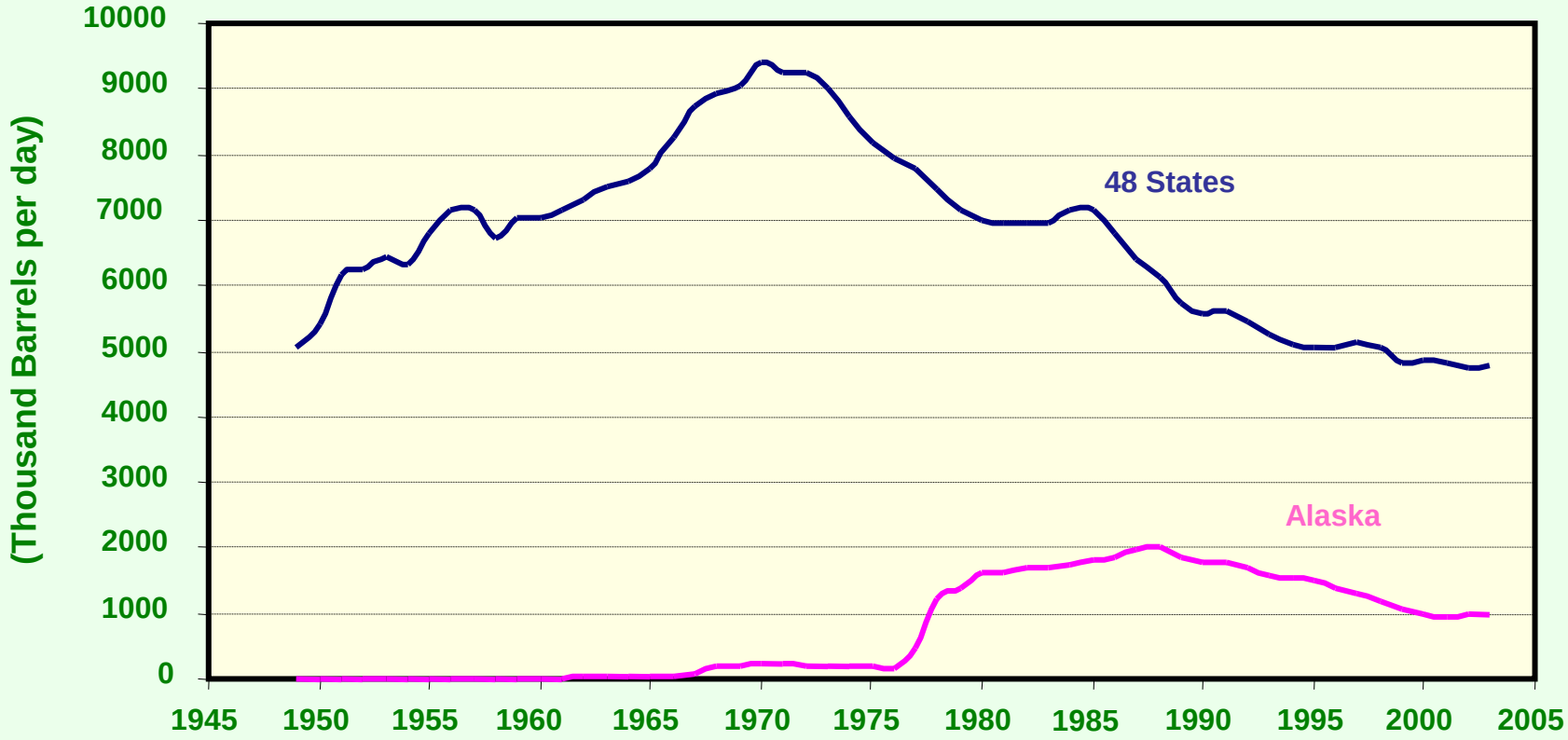
  - Strategies

Technology and expertise will definitively play a fundamental role in turning uneconomical reserves into real barrels

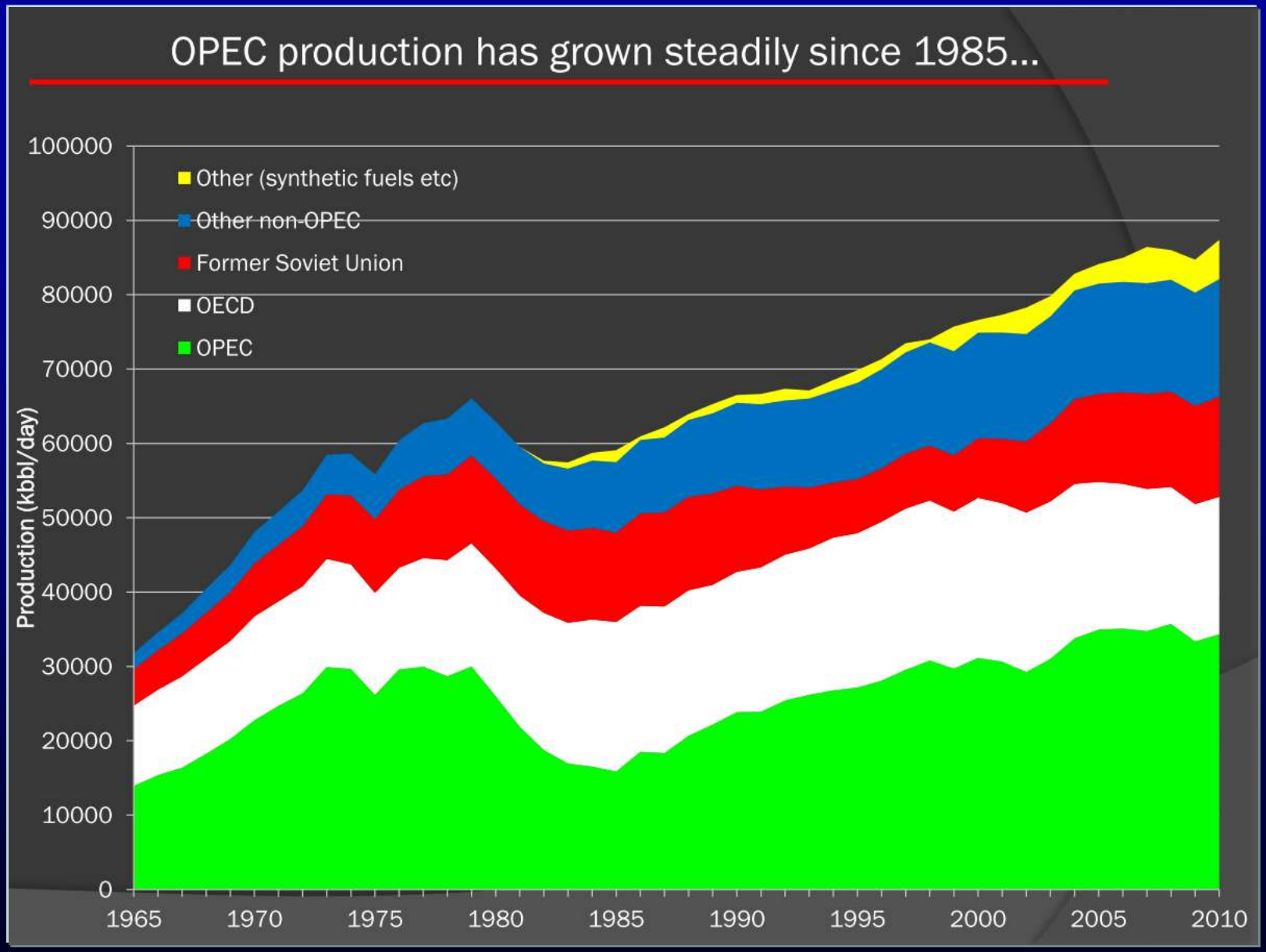
U.S. Oil Production and Consumption



EVOLUTION OF USA AND ALASKA OIL PRODUCTION

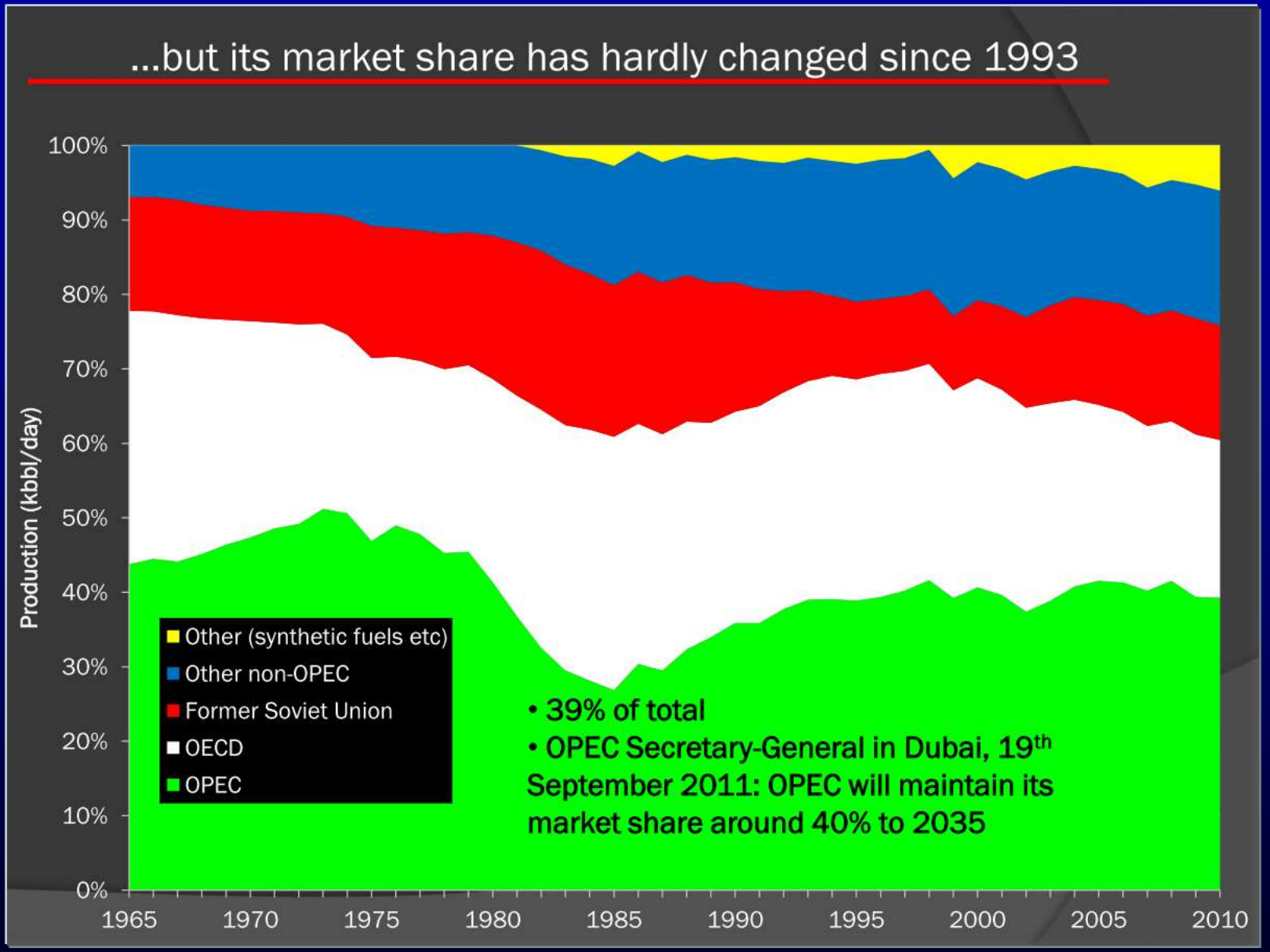


Source: EIA



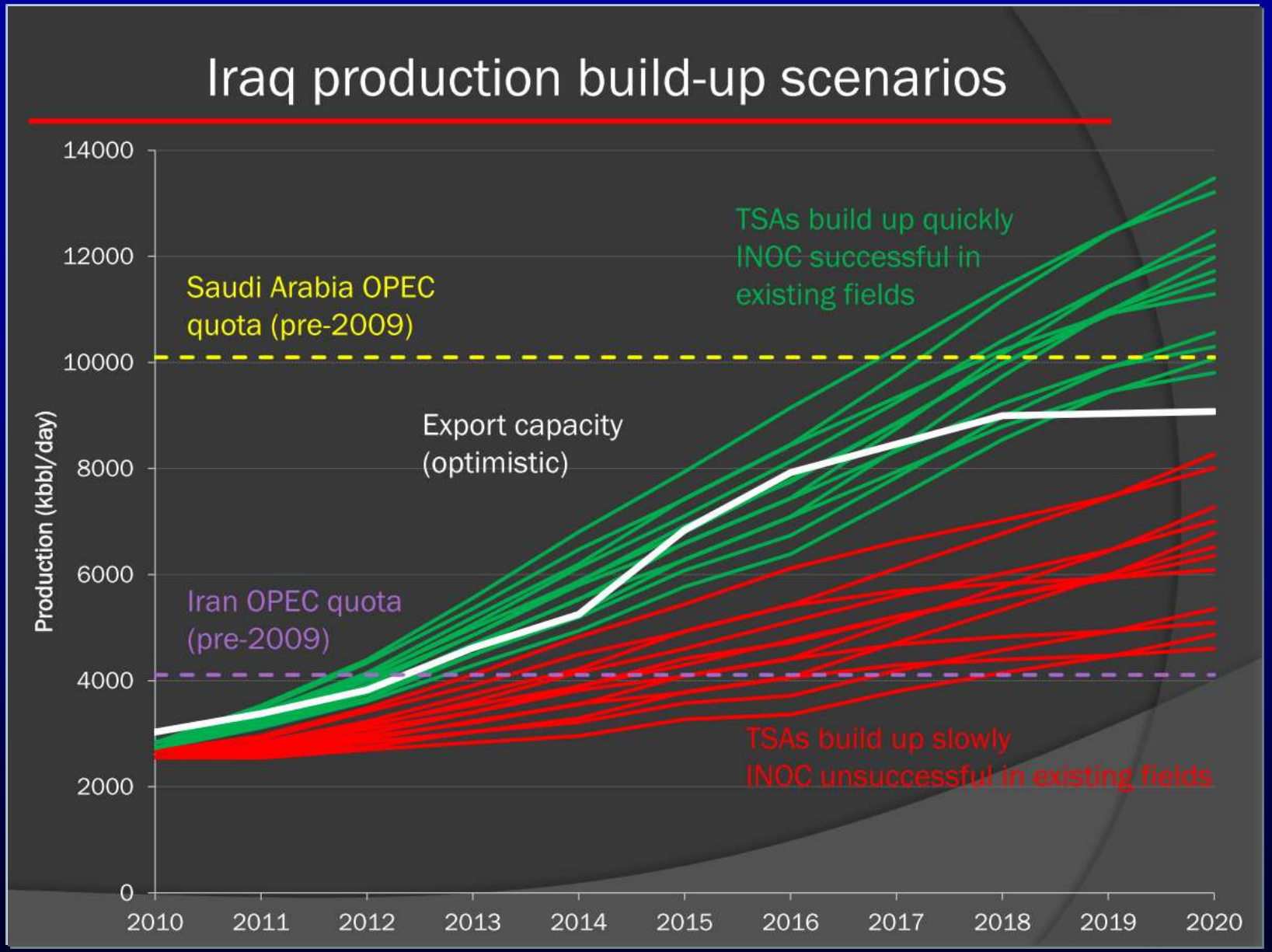
Source: 21st World Upstream Conference Global Pacific & Partners

...but its market share has hardly changed since 1993



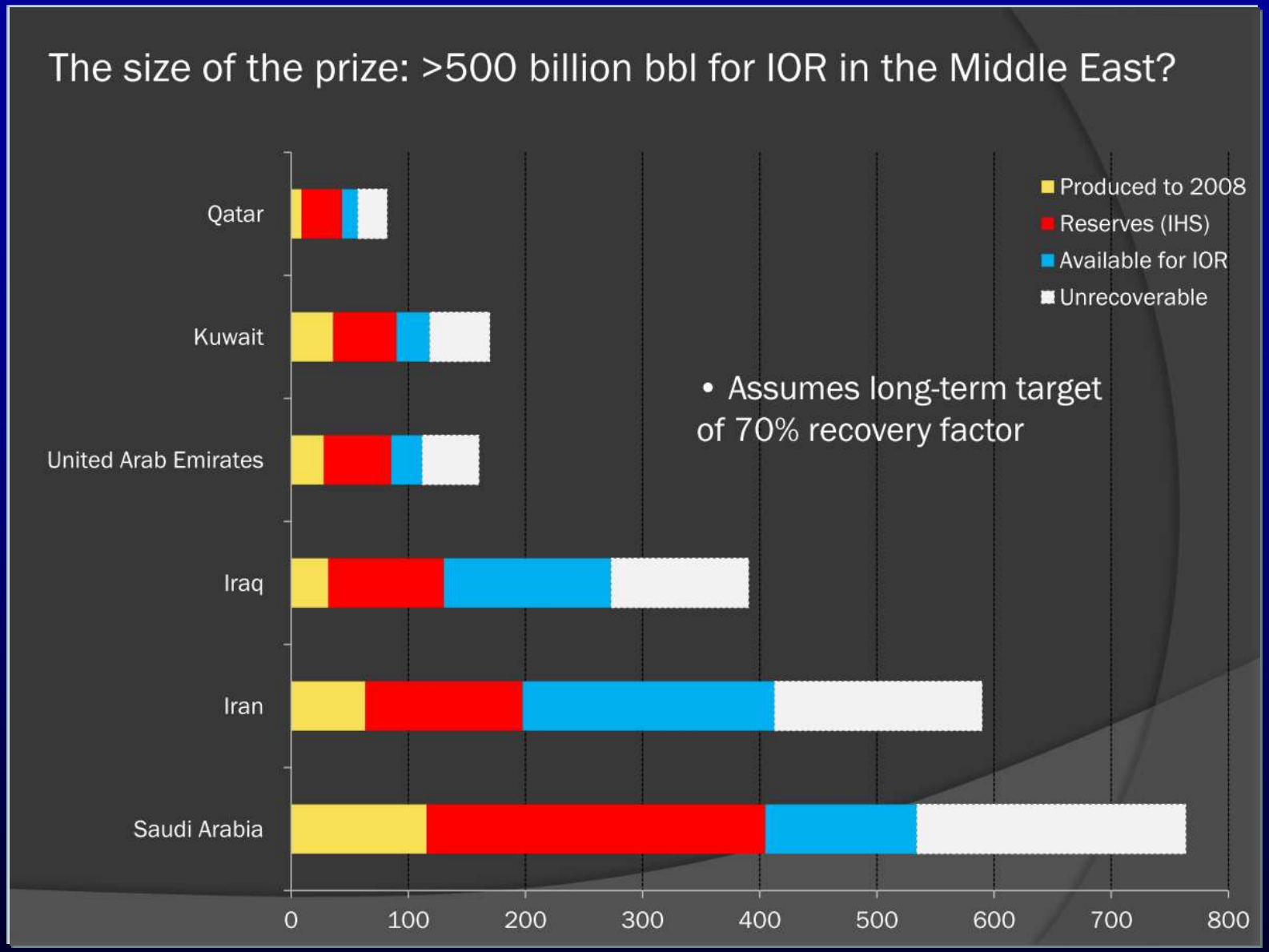
Source: 21st World Upstream Conference Global Pacific & Partners

Iraq production build-up scenarios



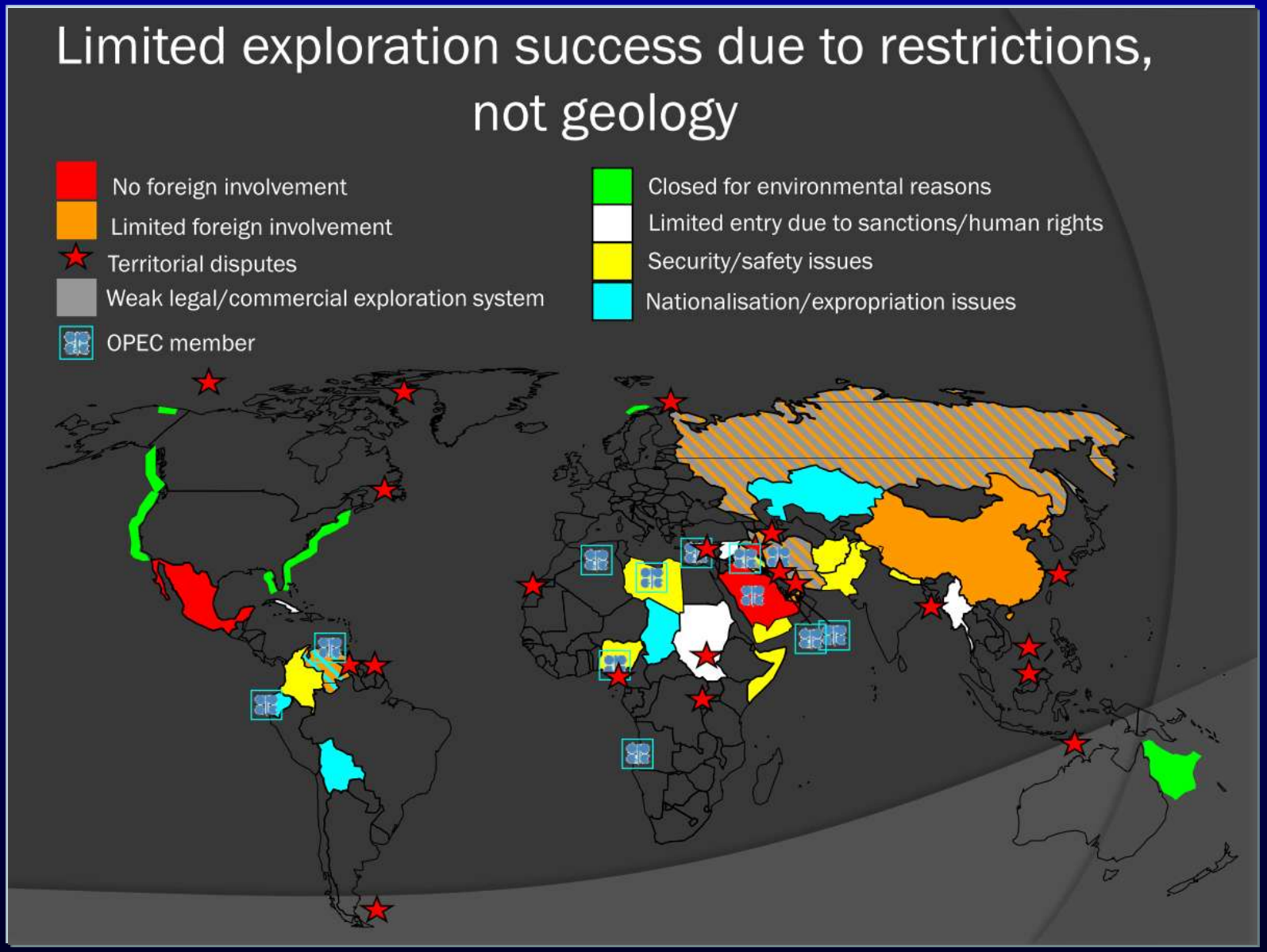
Source: 21st World Upstream Conference Global Pacific & Partners

The size of the prize: >500 billion bbl for IOR in the Middle East?



Source: 21st World Upstream Conference Global Pacific & Partners

Limited exploration success due to restrictions, not geology



Source: 21st World Upstream Conference Global Pacific & Partners

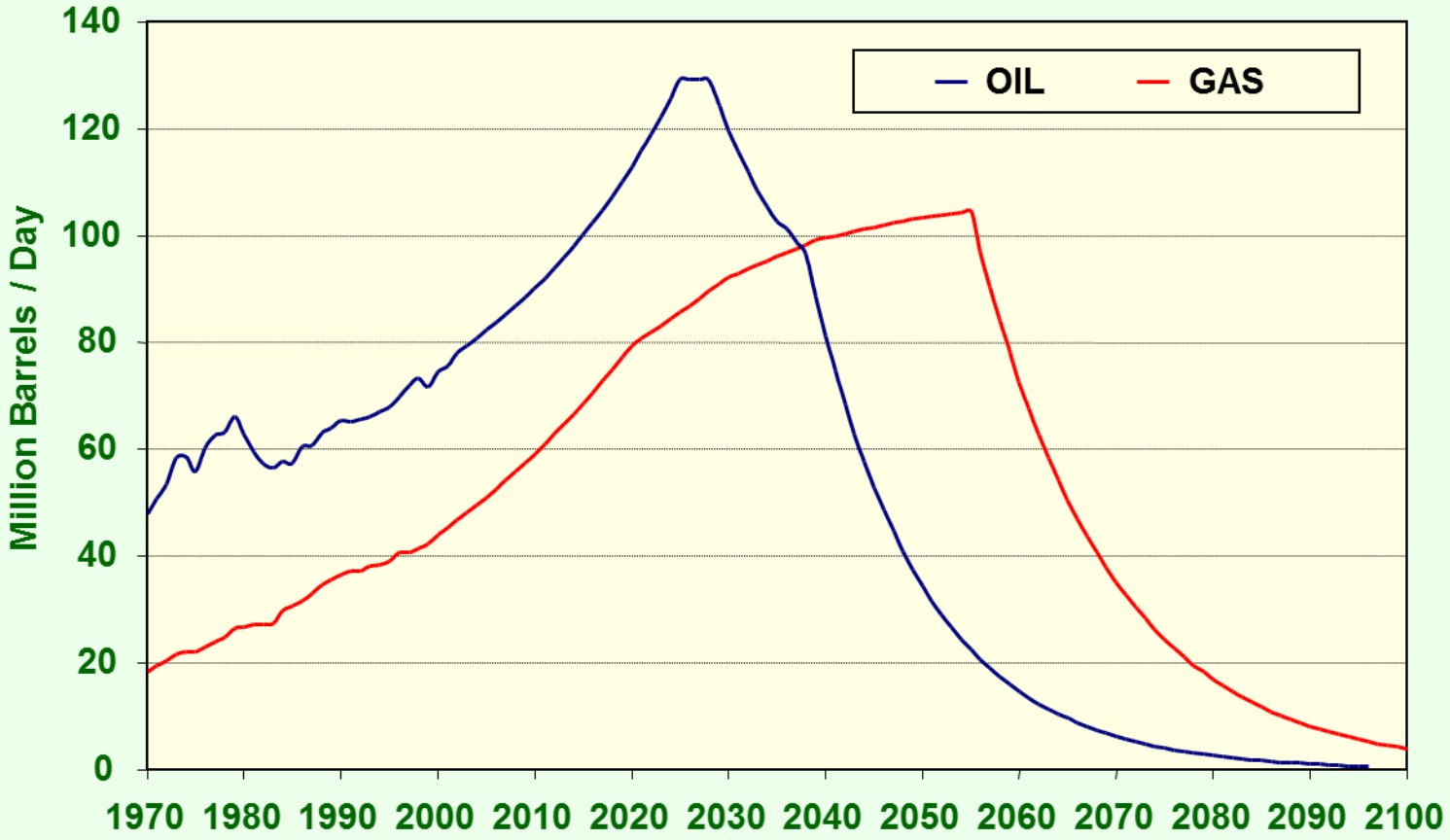
New exploration frontiers

Some new oil plays of the 'Noughties' (2000-09)

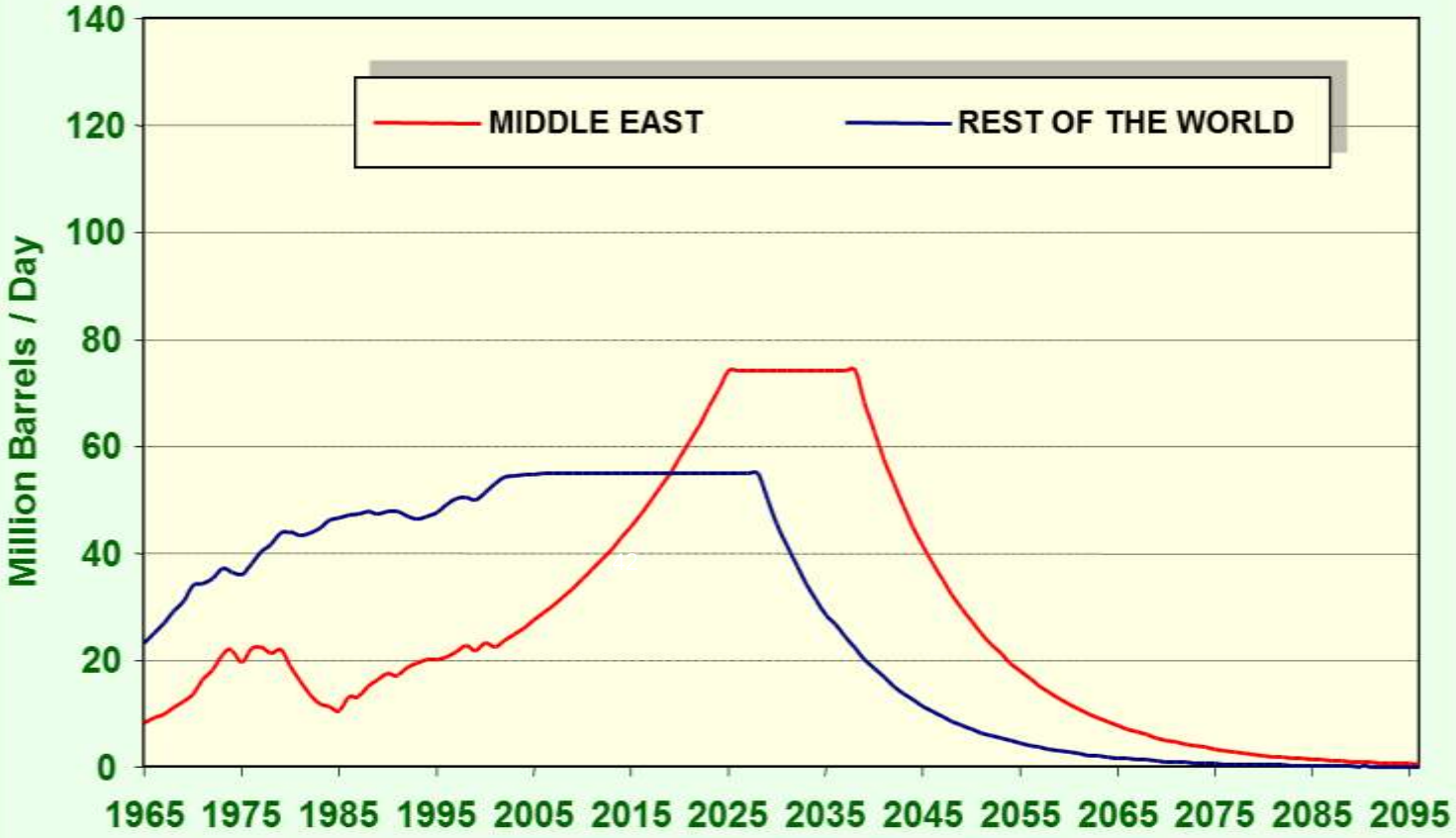
Possible new basins of the 'Tweens' (2010-19)

Source: 21st World Upstream Conference Global Pacific & Partners

FORECAST OF WORLD OIL AND GAS PRODUCTION
HIGHER GROWTH SCENARIO

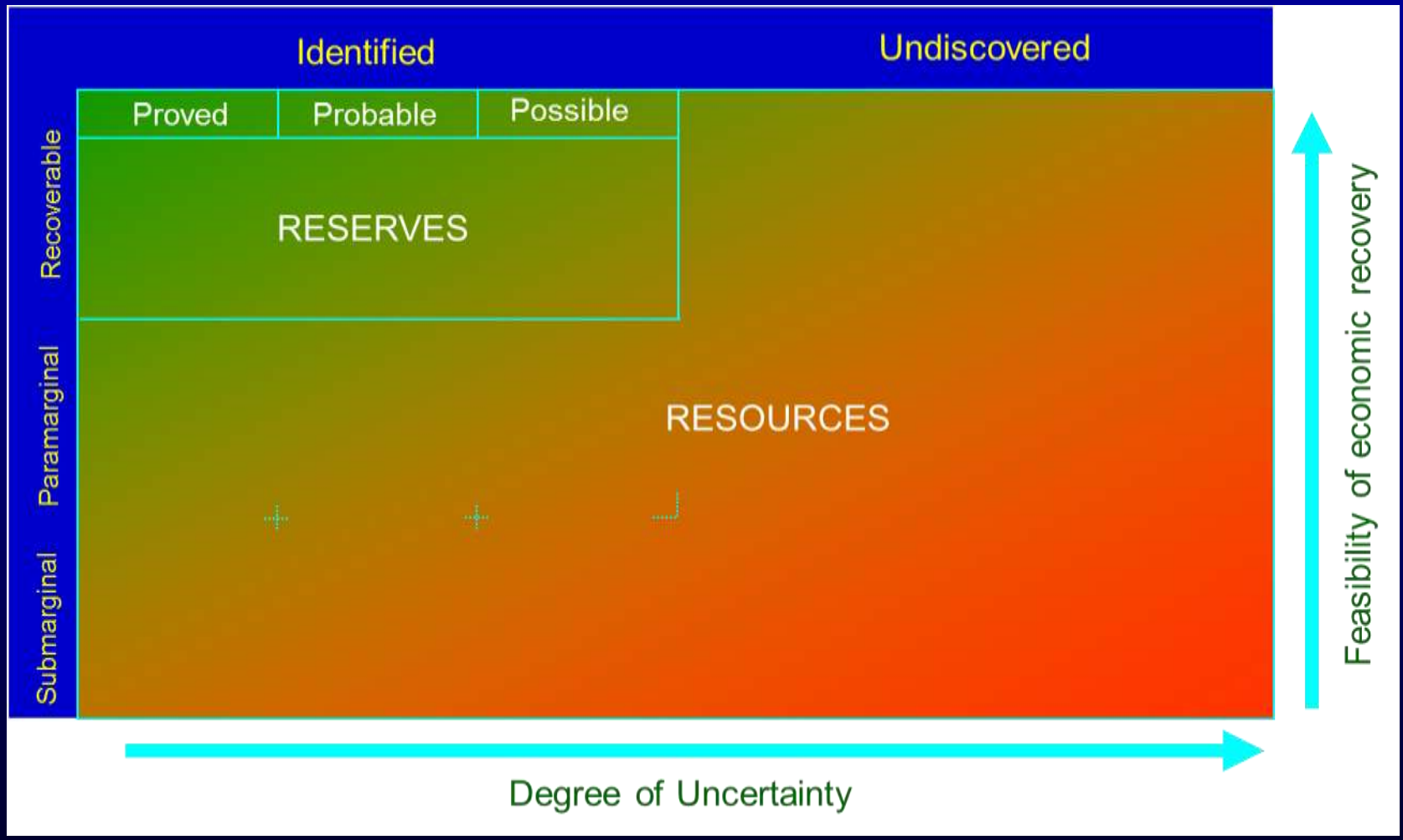


FORECAST OF OIL PRODUCTION
HIGHER GROWTH SCENARIO
MIDDLE EAST AND REST OF THE WORLD

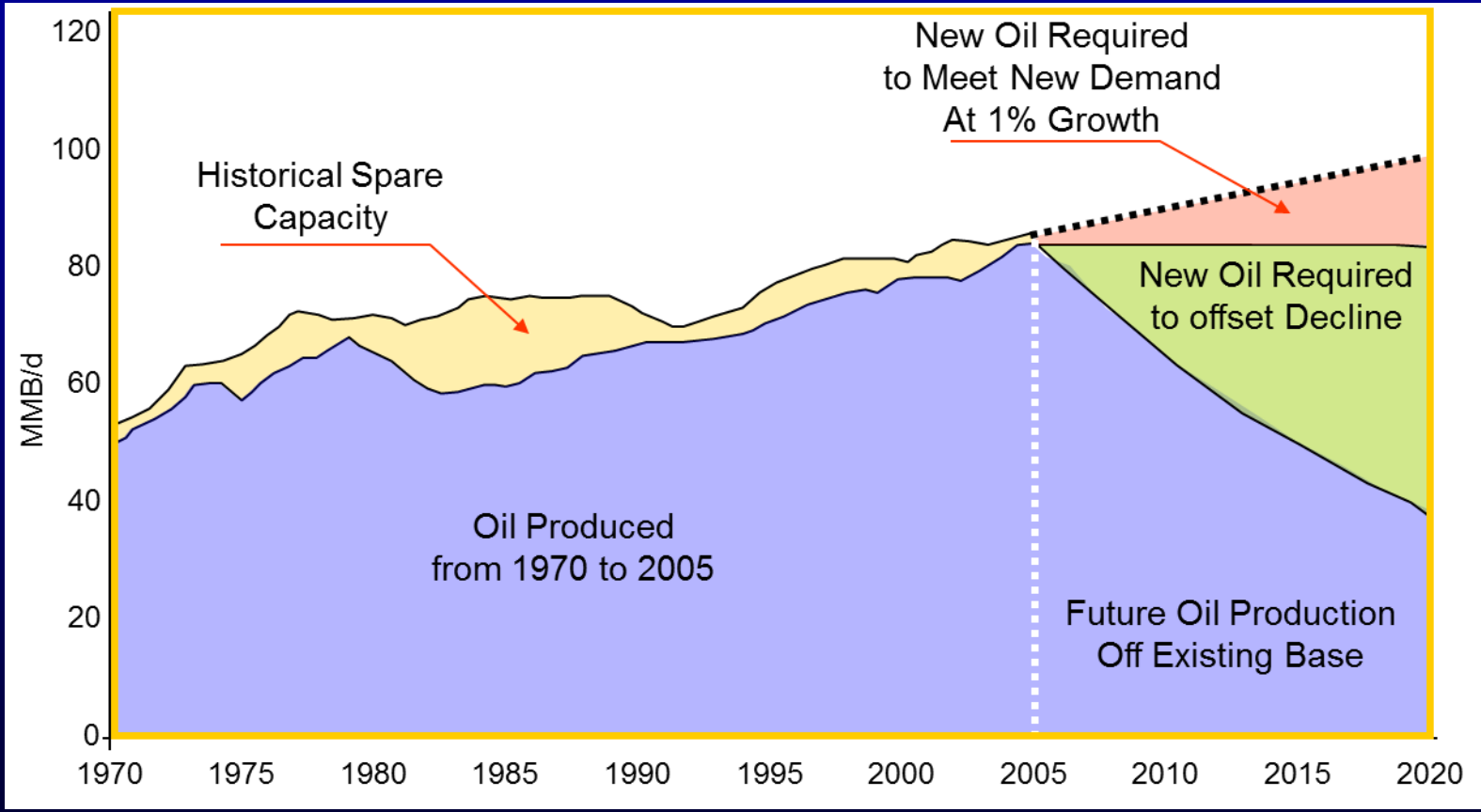


2. O PAPEL DAS RESERVAS NÃO CONVENCIONAIS incluindo o “SHALE GAS”

McKelvey Box

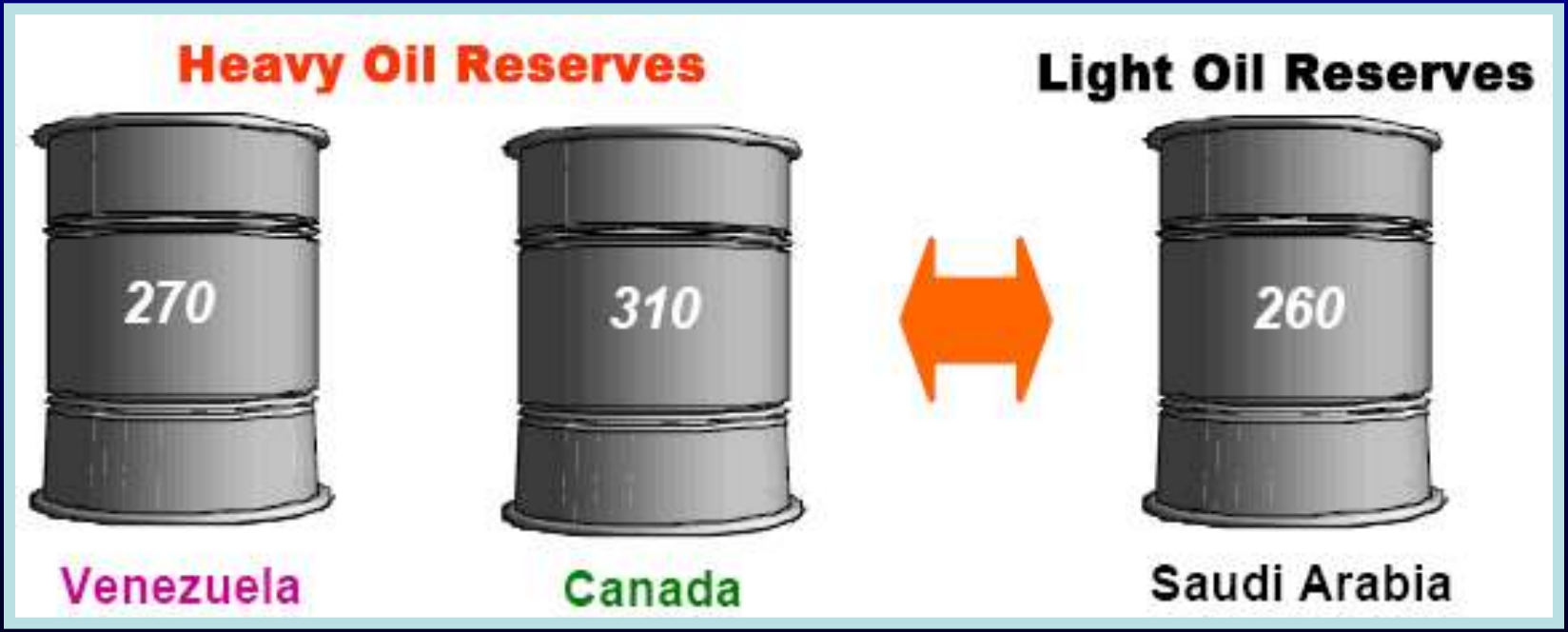


The Challenge of Supplying Global Oil Demand Growth: Historical and Future Components of Supply, Demand and Spare Capacity



"HEAVY OILS" Resources of 4000 to 5 000 Billion Barrels (OIP)

- **Considerable Potential Reserves : 500 to 1000 Gb**
  - **equivalent to 50-100% of worldwide conventional oil reserves**
  - **5 to 10 times (?) the ultra-deep offshore potential reserves**
  - **mainly (80%) in extra heavy oil, tar sands and bitumens**
  - **mainly (80%) in North and South America**
  - **less than 1% produced or under active development**



Source: Total 2003

WORLD OIL AND GAS RESERVES (in billion barrels)

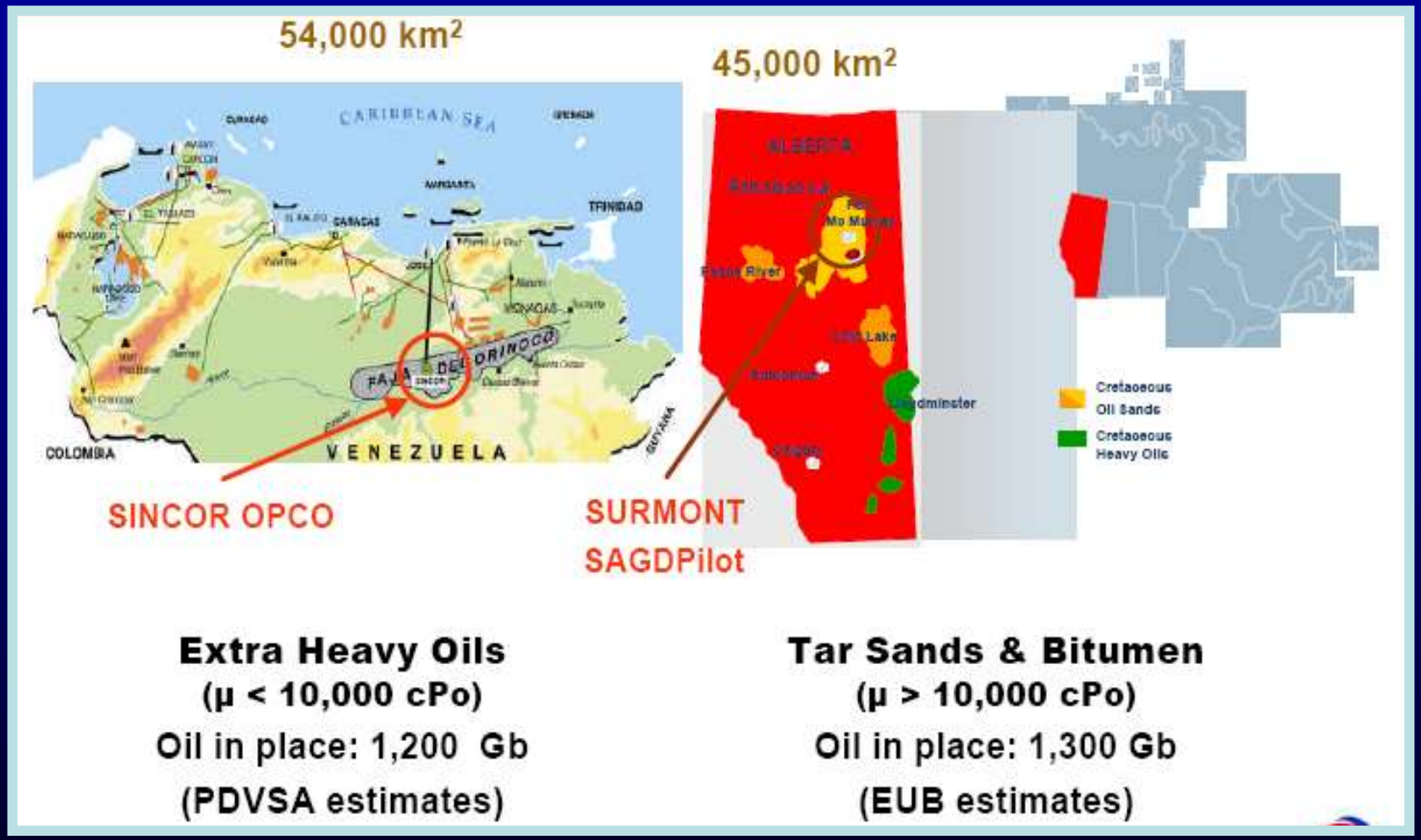
	ESTIMATED REMAINING RESERVES	ESTIMATED UNDISCOVERED RESERVES
Conventional Oil	1147	470
Heavy Oil	430	70
New Technologies	200	50
Gas	1153 (*)	850 (*)

(*) barrels of oil equivalent (boe)

Source: BP, TOTAL, USGS,CERA and IFP

Source: FT , 1 February 2011

Huge Untapped Resources in Orinoco and Athabasca



TECHNOLOGIES of PRODUCTION: MINING EXTRACTION

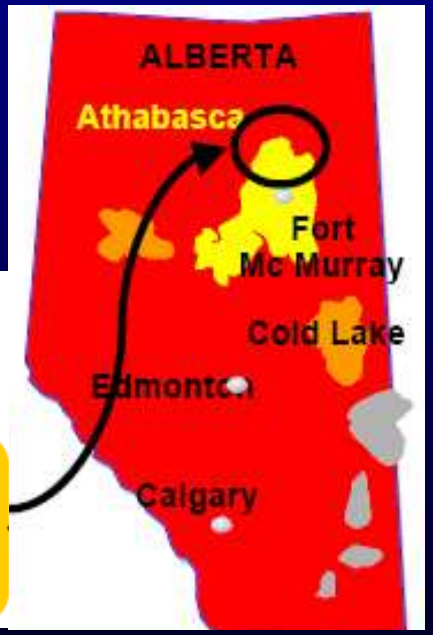
Mining Extraction

- Proven technology
- High Recovery Factor
- Decreasing operating costs :
  - ✓ 1980's : > 25 US$/bbl
  - ✓ 2002 : 8 - 12 US$/bbl
- Limited GHG emissions

BUT :

- Overburden limited to 50-75 m

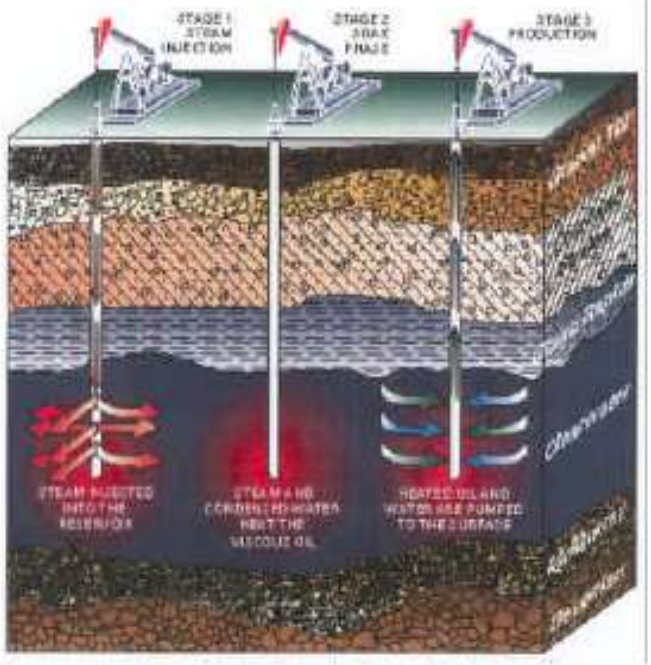
➡ suitable to less than 10% of Oil in Place in Athabasca



Source: FT , 1 February 2011

TECHNOLOGIES OF PRODUCTION: STEAM INJECTION

Huff & Puff



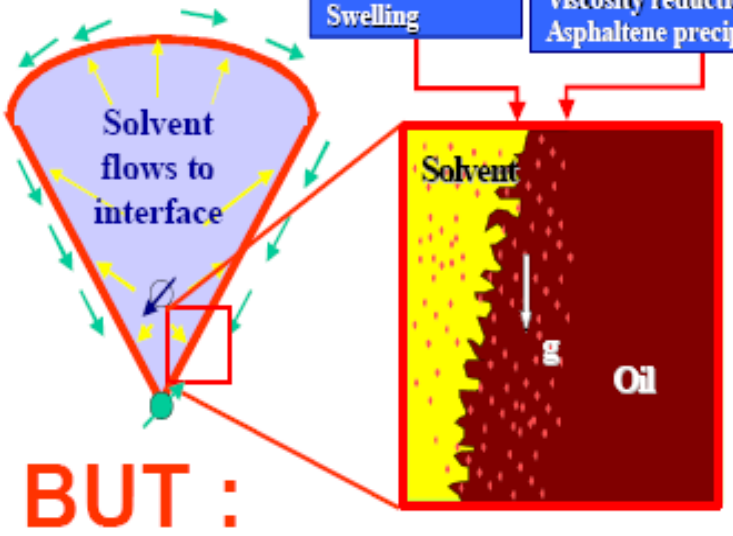
- Proven technology :
  - Canada : Cold Lake, Wolf Lake & Primrose
  - Venezuela : Maracaïbo & Oriente Basins
  - California : Kern River
- Limited operating costs :
  - 4 to 5 US$/bbl

BUT :

- Limited recovery factors (< 15-20%) : only stimulation around wellbore
- Consumption of energy and increase of GHG emissions

Source: FT , 1 February 2011

TECHNOLOGIES of PRODUCTION: SOLVENT INJECTION



- High Recovery Factor :
  - up to 60%
- Low energy consumption
- In situ upgrading (asphaltene precipitation)
- No boiler feedwater treatment
- Limited GHG emissions

BUT :

- Slow process (molecular diffusivity much smaller than thermal diffusivity)
- Start-up not so easy : need for warming with steam ?
- Possible "killing factor" : solvent loss in reservoir ?
- Not yet field tested : first pilots being launched in Alberta
- Not mature enough for industrial application until some years

Source: FT , 1 February 2011

OIL CULTURE STILL DOMINANT FOR DECADES
- TENSION IN THE TRIANGLE -

OIL INDUSTRY EVOLUTION

- Oil PEAK NOT NOW; maybe in two or three DECADES
- Oil PEAK does not mean the End of Oil; means half oil was produced
- Effect of NON-CONVENTIONAL OIL (Heavy oil+Tar sands) in delaying peak
- Effect of EOR (today only 3% of world production
- Effect of TECHNOLOGY (Digital Field Concept)

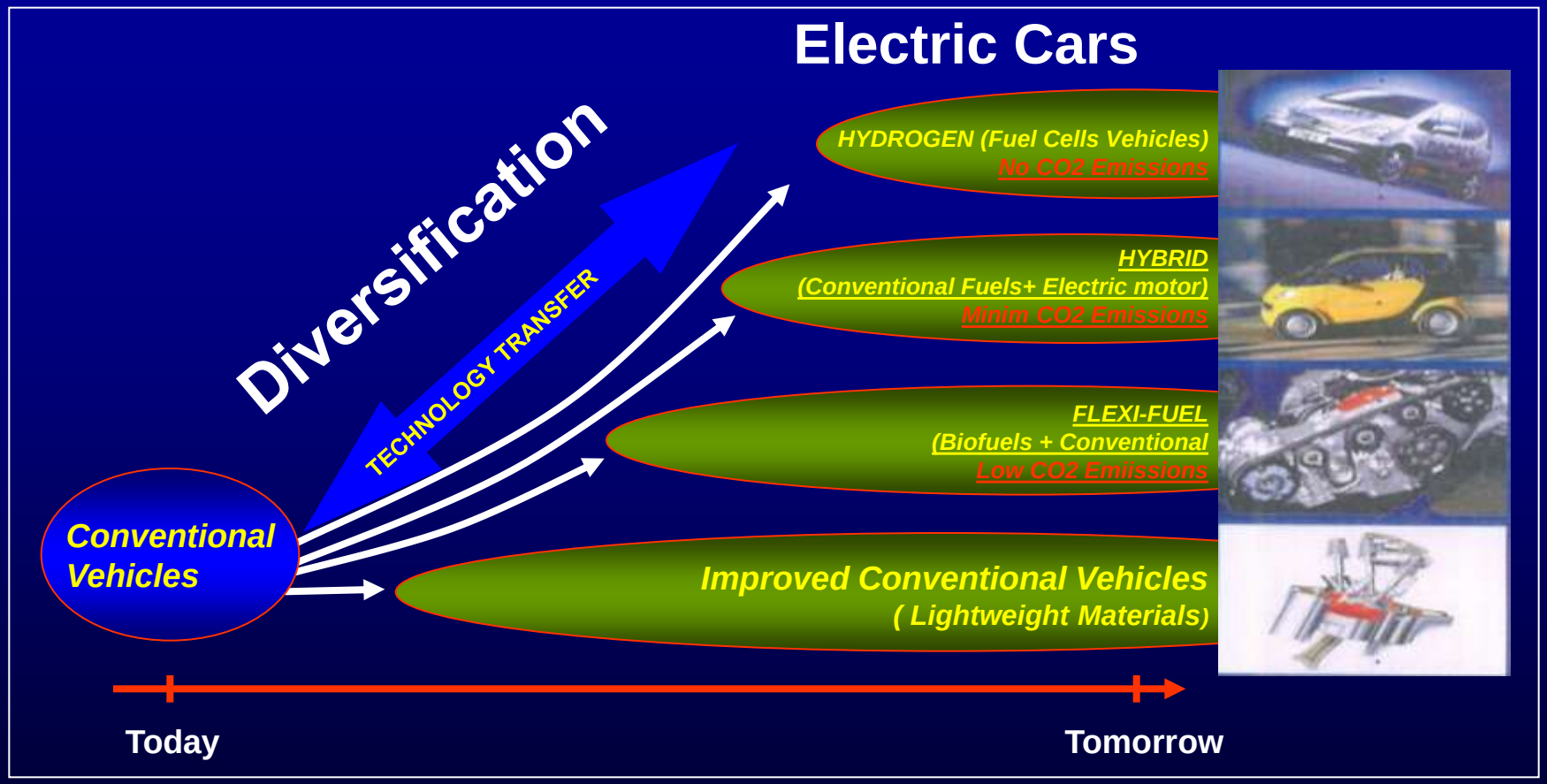
OIL INDUSTRY CHALLENGES

- Low RATE of new discoveries
- New discoveries: fields of less magnitude (Kashagan; Jack 2)
- Conversion of resources into Reserves more difficult / more complex
- High cost of COMMODITIES
- Low pace of investment

PERCEPTIONS OF THE MARKET/INVESTORS/CONSUMERS

- Perception of PEOPLE
- Energy not yet a Citizenship issue
- Governments not concerned with policies addressing consumption
- Level of policies of Energy conservation NOT adequate

TRANSPORTS: NEW PARADYGM



UNCONVENTIONAL OIL AND GAS RESOURCES

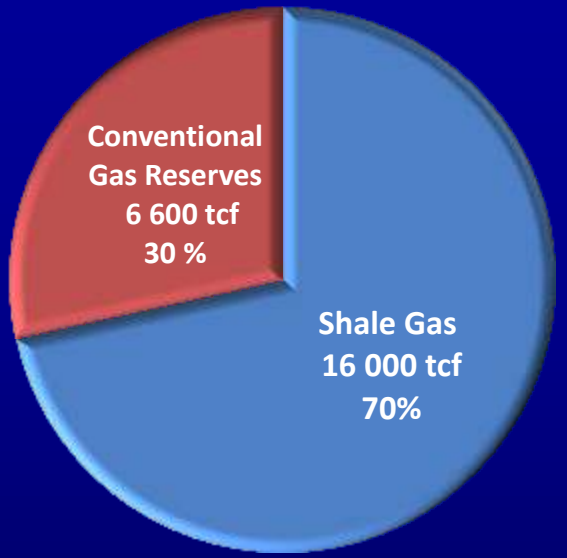
UNCONVENTIONAL GAS

- Coal Bed Methane
- Shale Gas
- Tight Gas and Ultradeep reservoirs

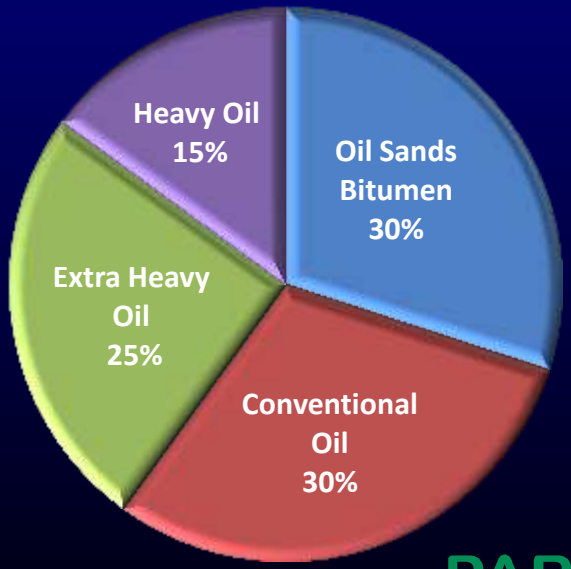
UNCONVENTIONAL OIL

- Oil sands
- Oil Tar sands
- Coal-base liquid
- Biomass-based liquid
- Liquids from chemical processing of natural gas

WORLD GAS RESERVES



TOTAL WORLD OIL RESERVES



Source: IFP

WORLD TOTAL GAS RESERVES

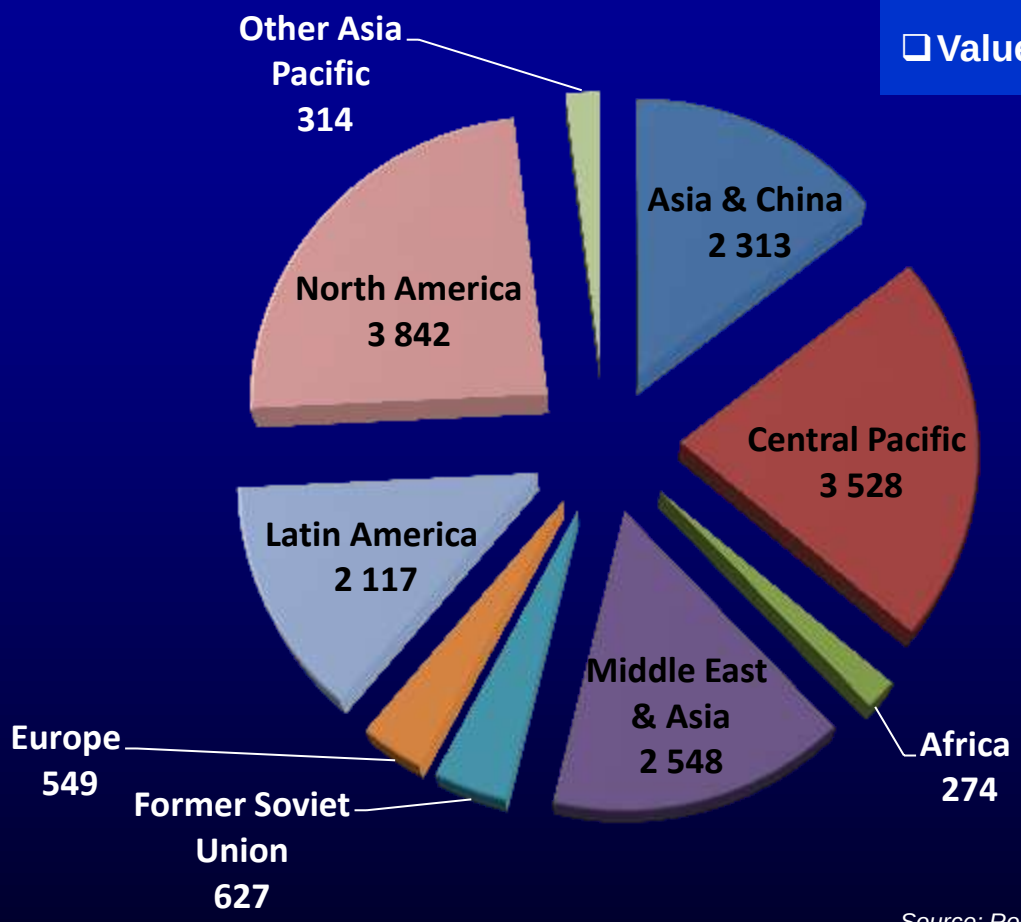
Source: The Economist, 6th August 2011

SHALE GAS

- **Produced from artificially fractured shales**
- **Source rock and Reservoir rock are the same**
- **Tight shales enriched in organic matter**
  - ✓ **2% < TOC < 20%**
  - ✓ **Very low K (micro to nano Darcies)**
  - ✓ **Very low ø (less than 5%)**
  - ✓ **Can be carbonated**
- **Most gas shales are marine source rocks**
- **Till today no large commercial gas shale project outside USA**
- **Estimated worldwide GAS SHALE RESOURCES: 16 000 tcf**

ESTIMATED GAS SHALE RESOURCES

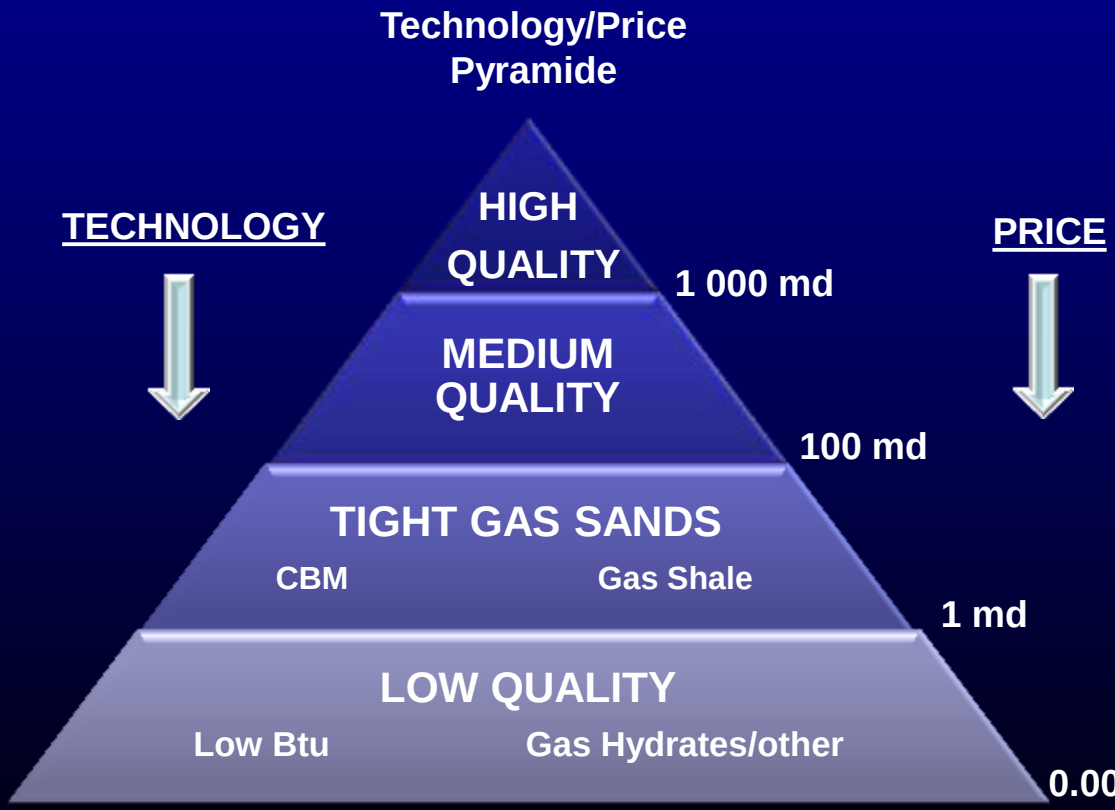
- Outside USA DATA is uncertain
- Values in TCF



*Source: Rogner **(1997)/IFP***

EXPLORATION and production of SHALE GAS

- Expensive and requires specific technologies
- In USA costs reduced by:
  - Limited/focused exploration phase
  - Production focused and pragmatism: - Drill, frac and see if it can be produced
    - Drill, as much as you can
- Gas transport to production wells requires conductive network of open fractures:



Source: Bustin, 2005/IFP

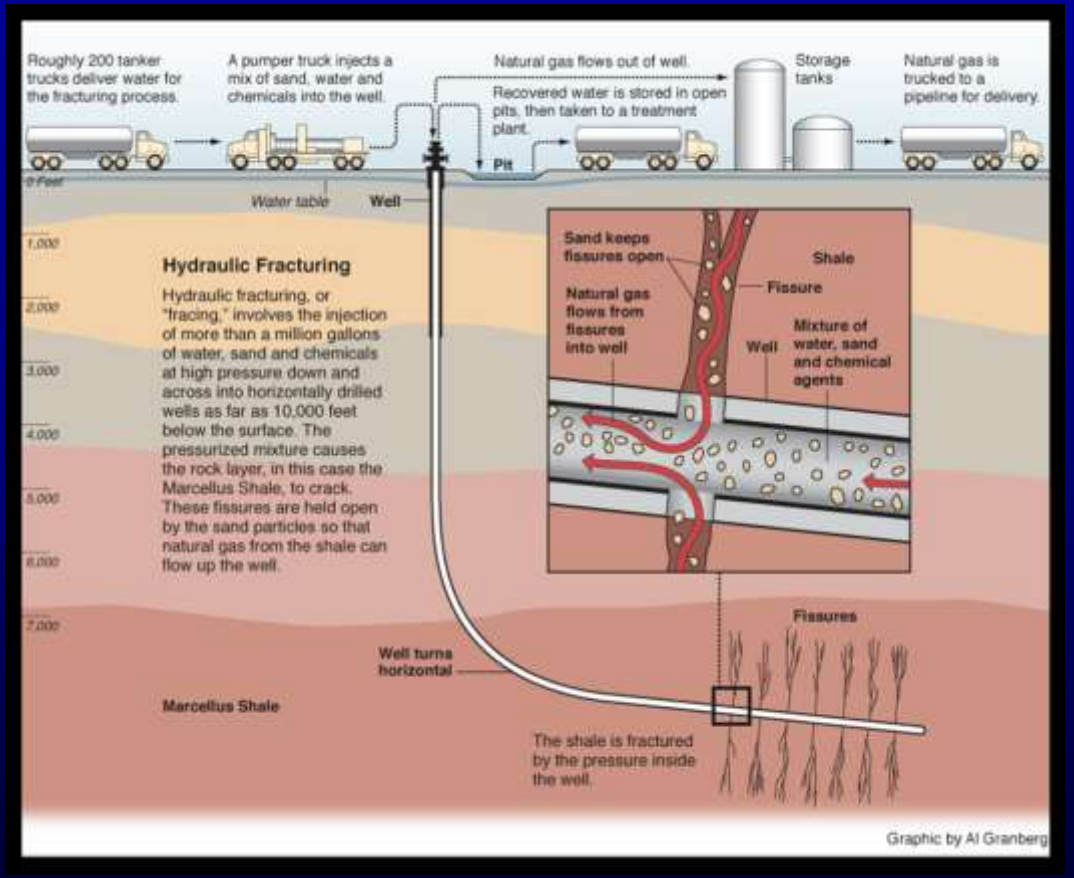
EXPLORATION of SHALE GAS

- Map areas where SHALES display high TOC content
- Focus on low depth, high TOC and high tickness zones
- Areas of very low or high thermal maturity
  - very low maturity ⇒ favourable to biogenic gas
  - very high maturity ⇒ favourable to thermogenic gas
  - Map transformation ratios and/or vitrinite reflectance

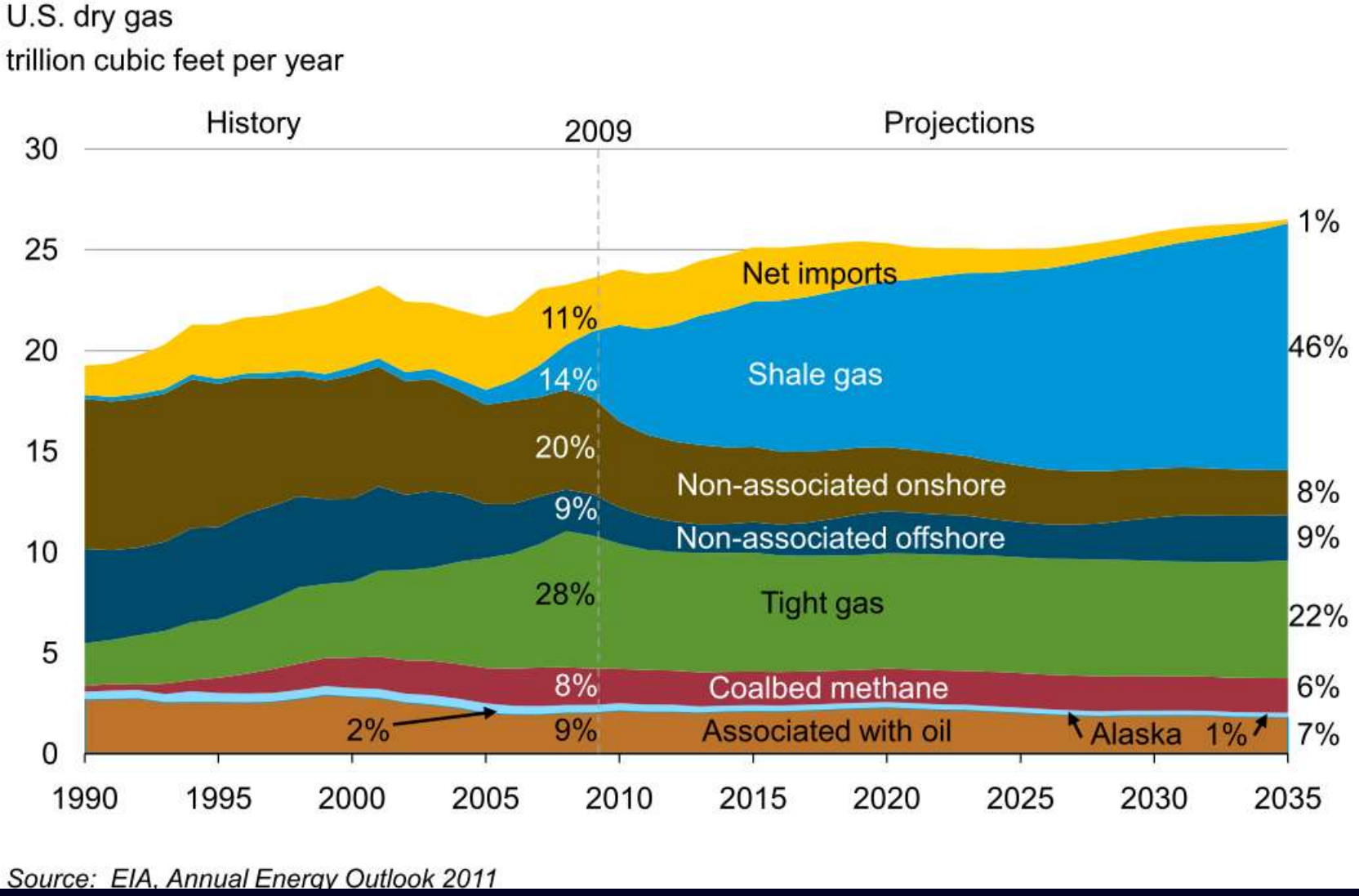
- Map Gas seepage if exist
- Advanced Exploration with Gas Risking Analysis require more time, money and data:
  - Geochemical Assessment (shale maturity/gas potential)
  - Geological Assessment (shale as “shallow” petroleum system)
  - Petrophysical Assessment (ø/K/Mineralogical properties)
  - Economic Assessment (Gas in-place estimation/CO_2 risk)

PRODUCTION SOLUTION: HYDRAULIC FRACTURING

- **Fracture Technology is responsible for USA success in gas shales**
  - **Use large amount of water in a short period of time to develop a gas well**
- **Addition of sand or other material (proppants) to the fluid to keep induced fractures open**
  - **Most wells are horizontal with one or more horizontal legs extending to the target sections**
  - **The legs may extend more than 2 Km from the surface location of the well**

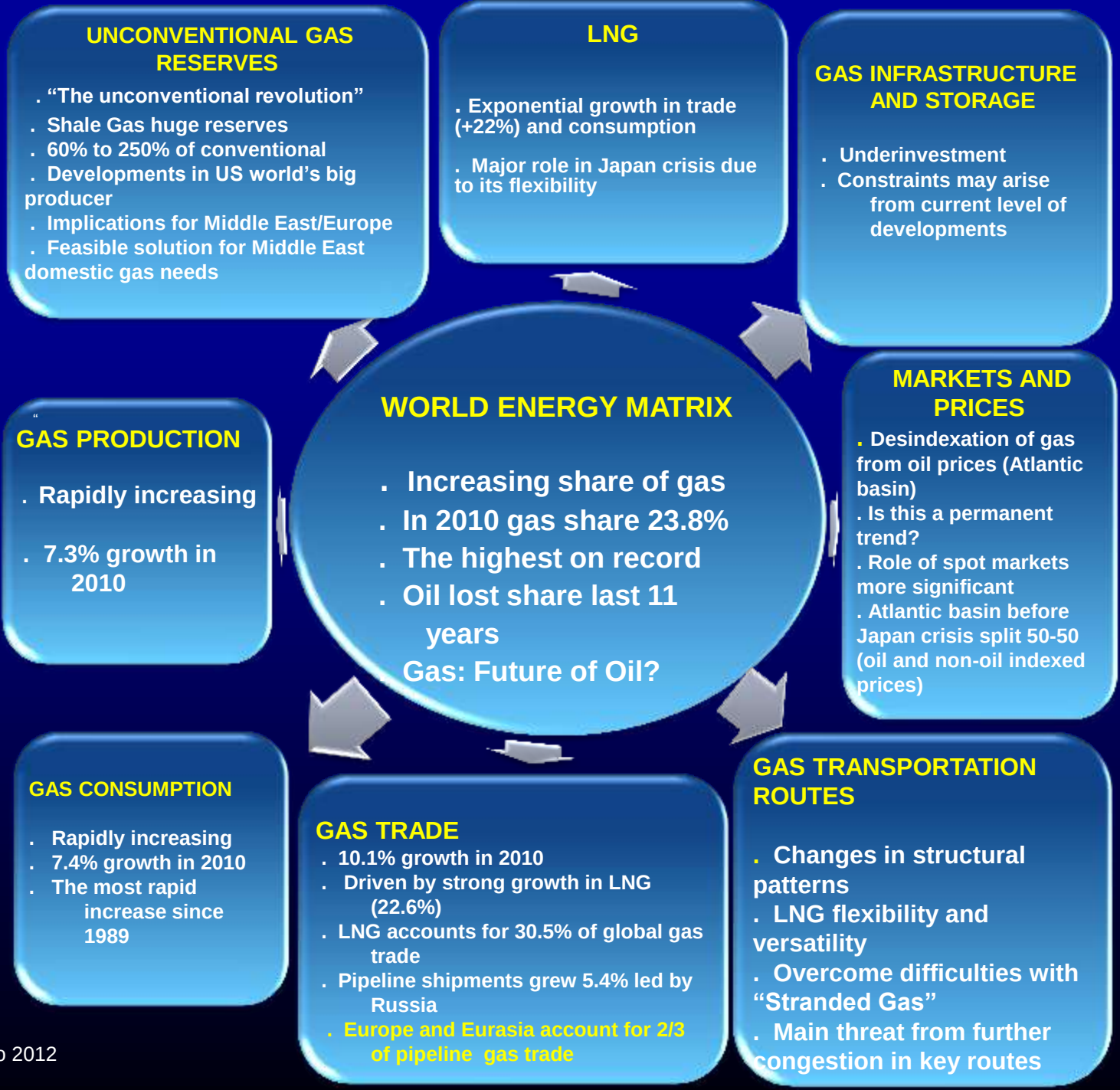


Shale gas offsets declines in other U.S. supply to meet consumption growth and lower import needs



Source: EIA, Annual Energy Outlook 2011

TRENDS SHAPING THE GAS INDUSTRY



TRENDS SHAPING THE GAS INDUSTRY

DRIVERS FOR FURTHER GAS DEVELOPMENTS

APPLICATIONS

. Gas is most versatile of fossil fuels
. Used both in power generation and transportation
. GTL may be competitive solution for transport in Medium Term

DECARBONIZATION OF ECONOMY

. Gas is the least poluent of fossil fuels
. May play key role in transition of energy paradigm

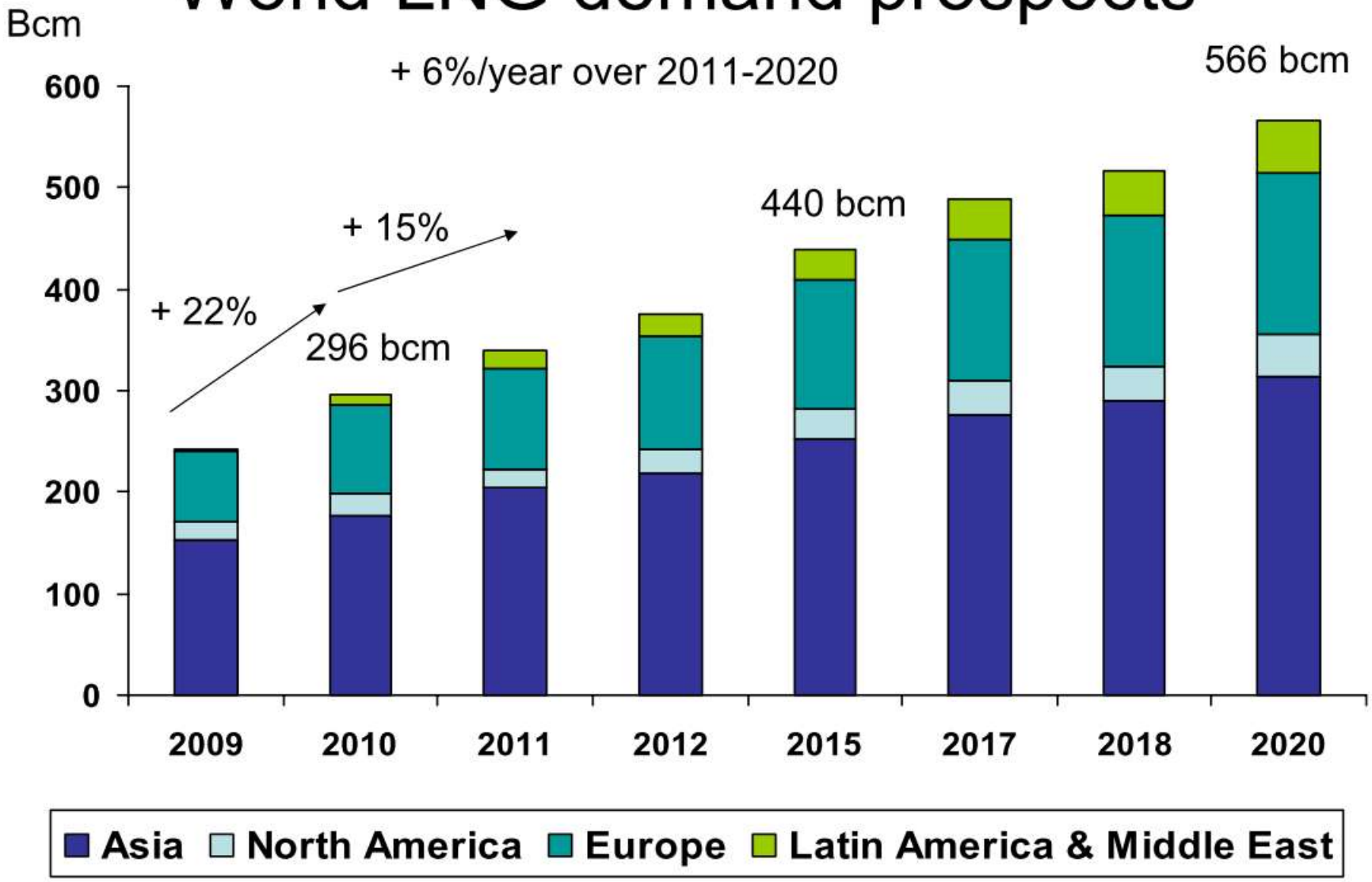
EFFECTS OF JAPAN NUCLEAR CRISIS

. Decision of some countries to slowdown nuclear power (Germany, Italy, Japan)

. Opens a more decisive role for Gas

DRIVERS FOR FURTHER GAS DEVELOPMENTS

World LNG demand prospects



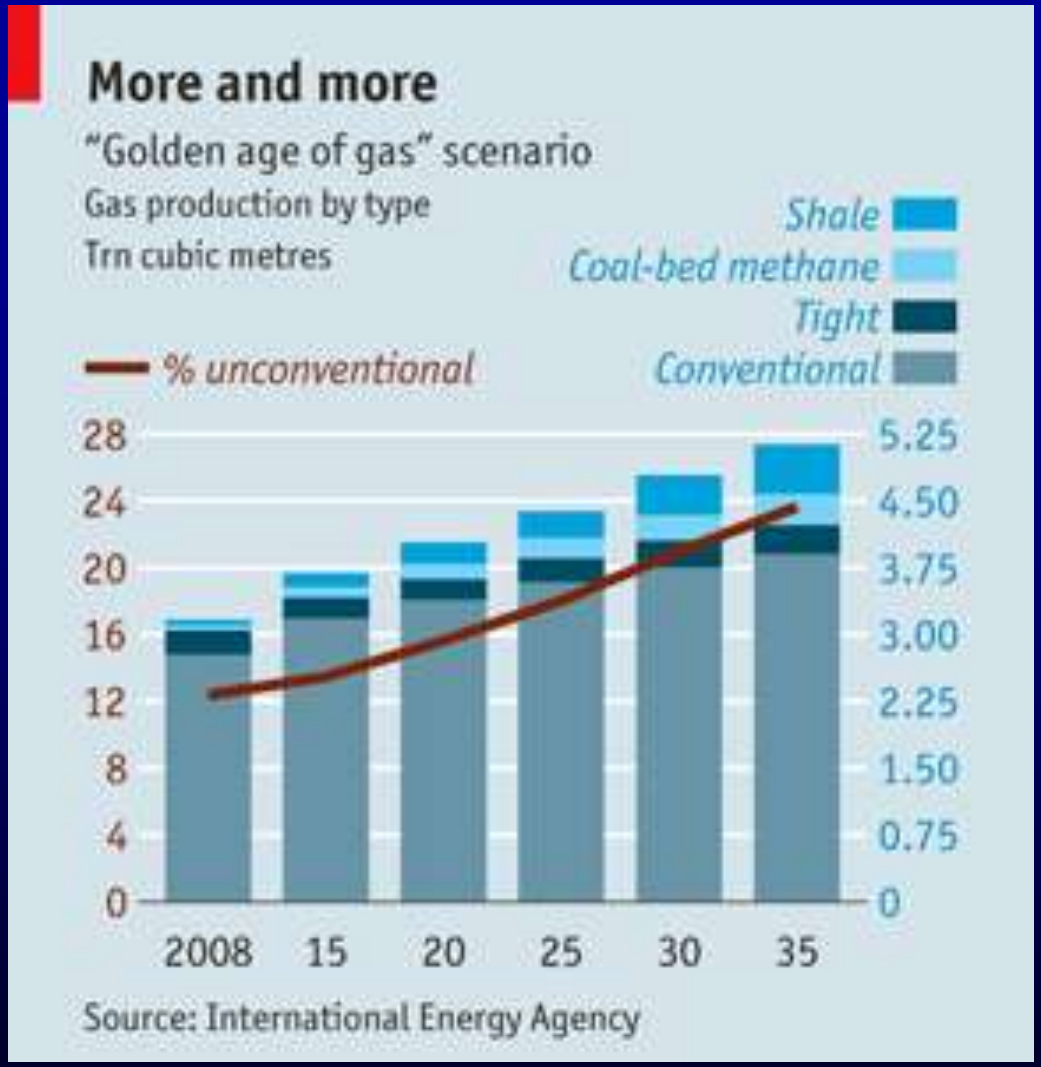
Source: Cedigaz

THE FUTURE OF NATURAL GAS

Gas should make the world a cleaner, safer place

Source: The Economist, 6th August 2011

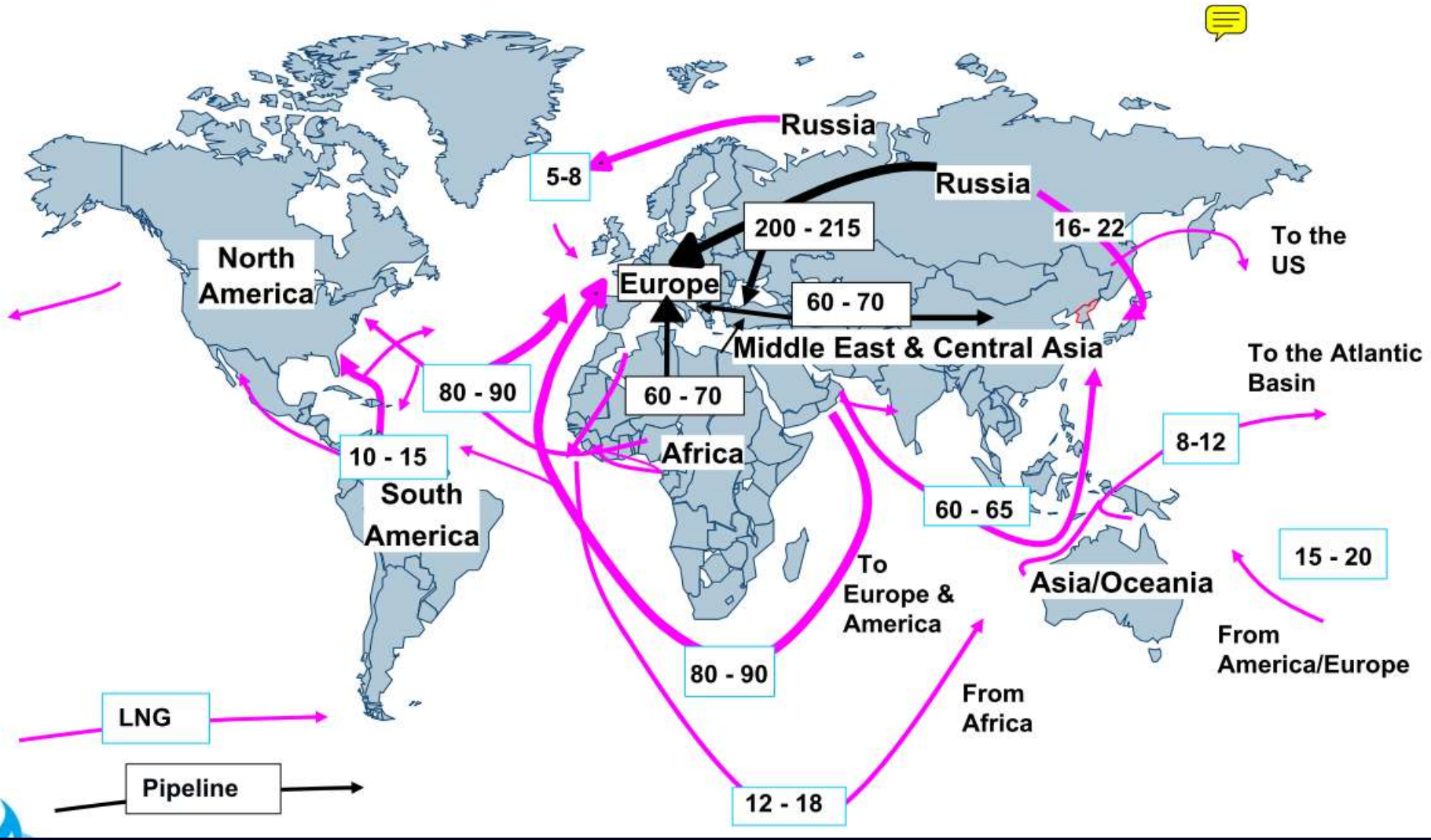
WORLD TOTAL GAS PRODUCTION



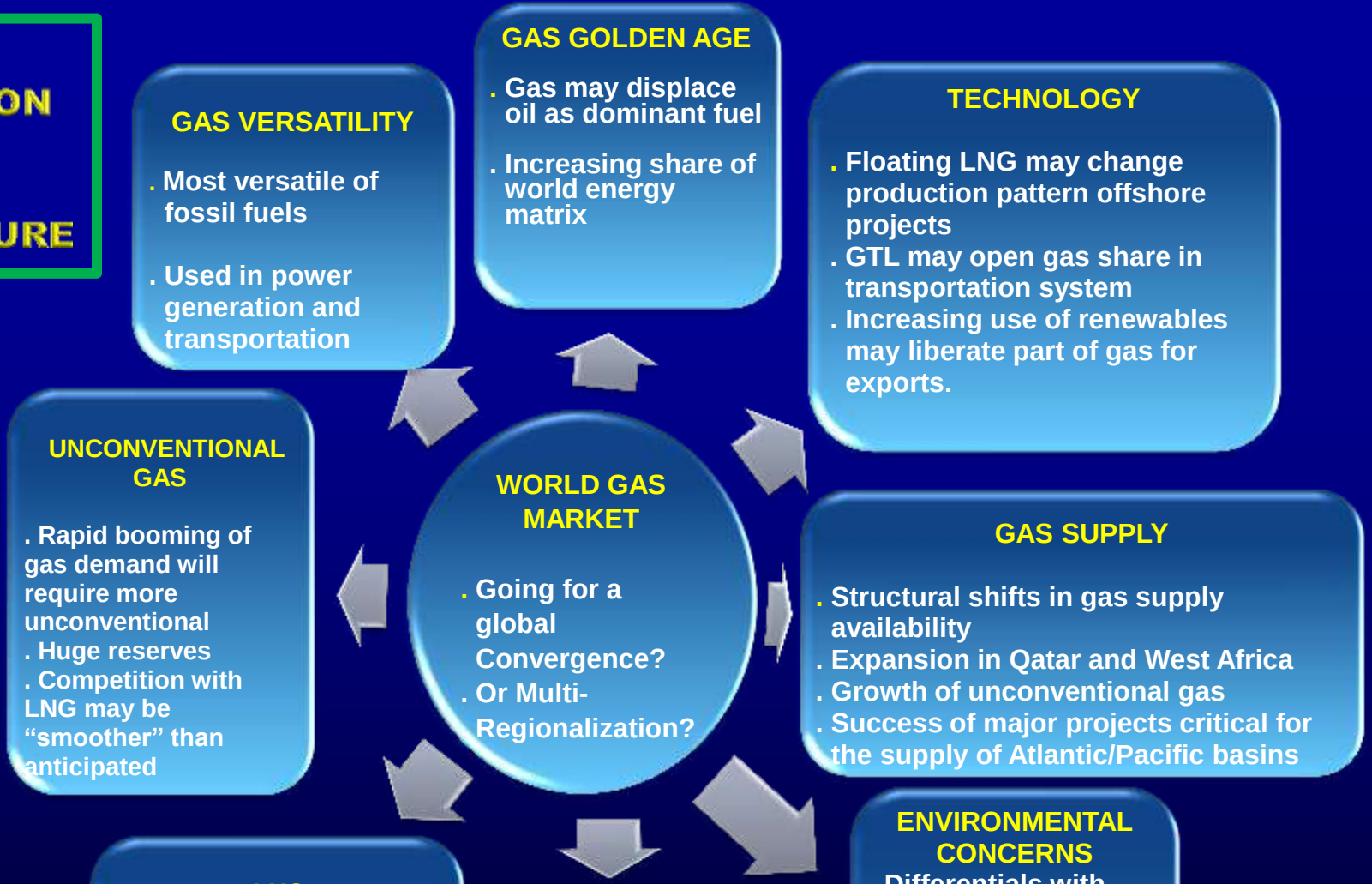
Source: The Economist, 6th August 2011

The growing role of international trade

Inter regional flows = 605 Bm³ (75% for Europe) by 2020



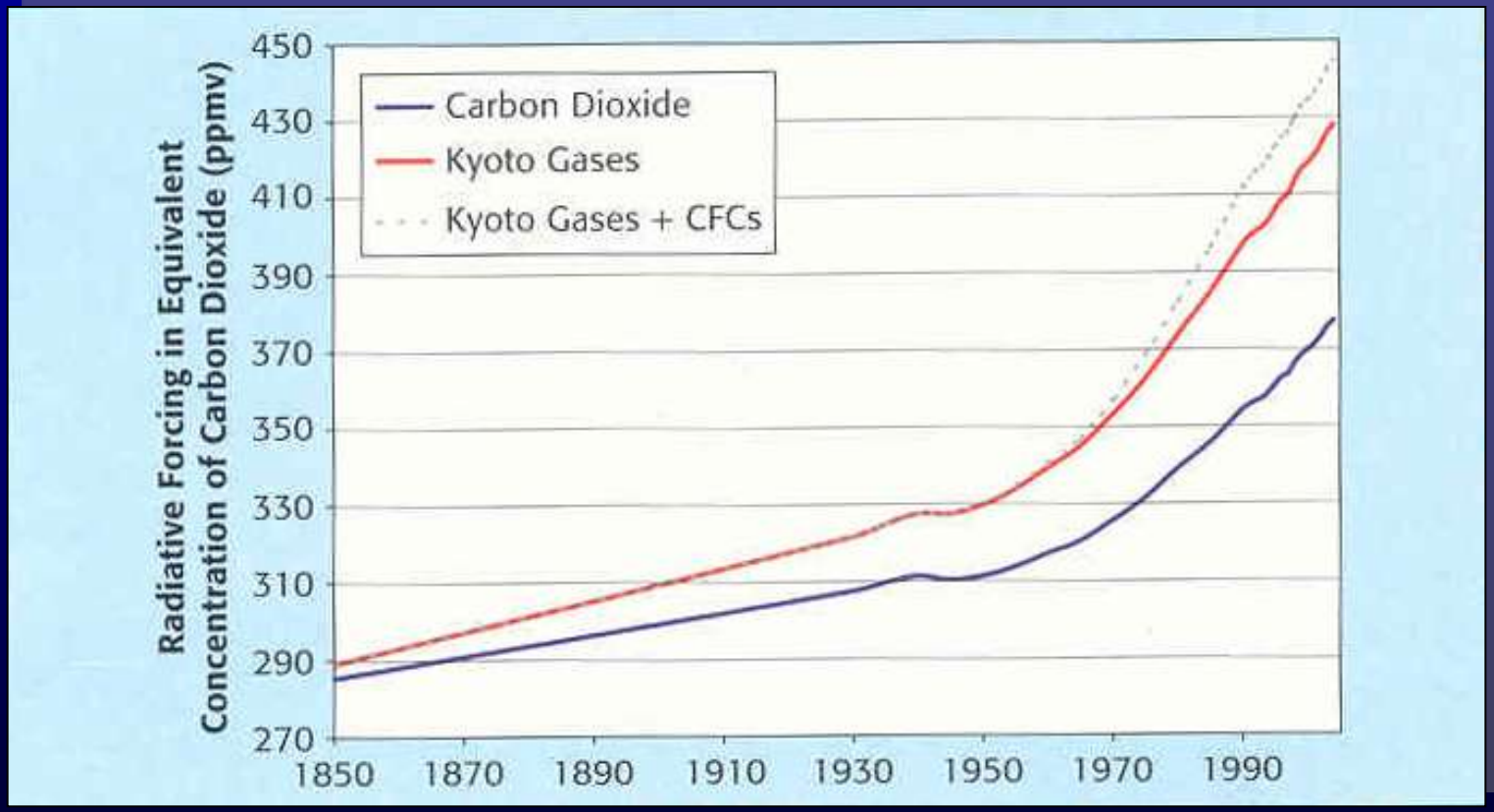
A VISION FOR THE FUTURE



PARTEX OIL AND GAS

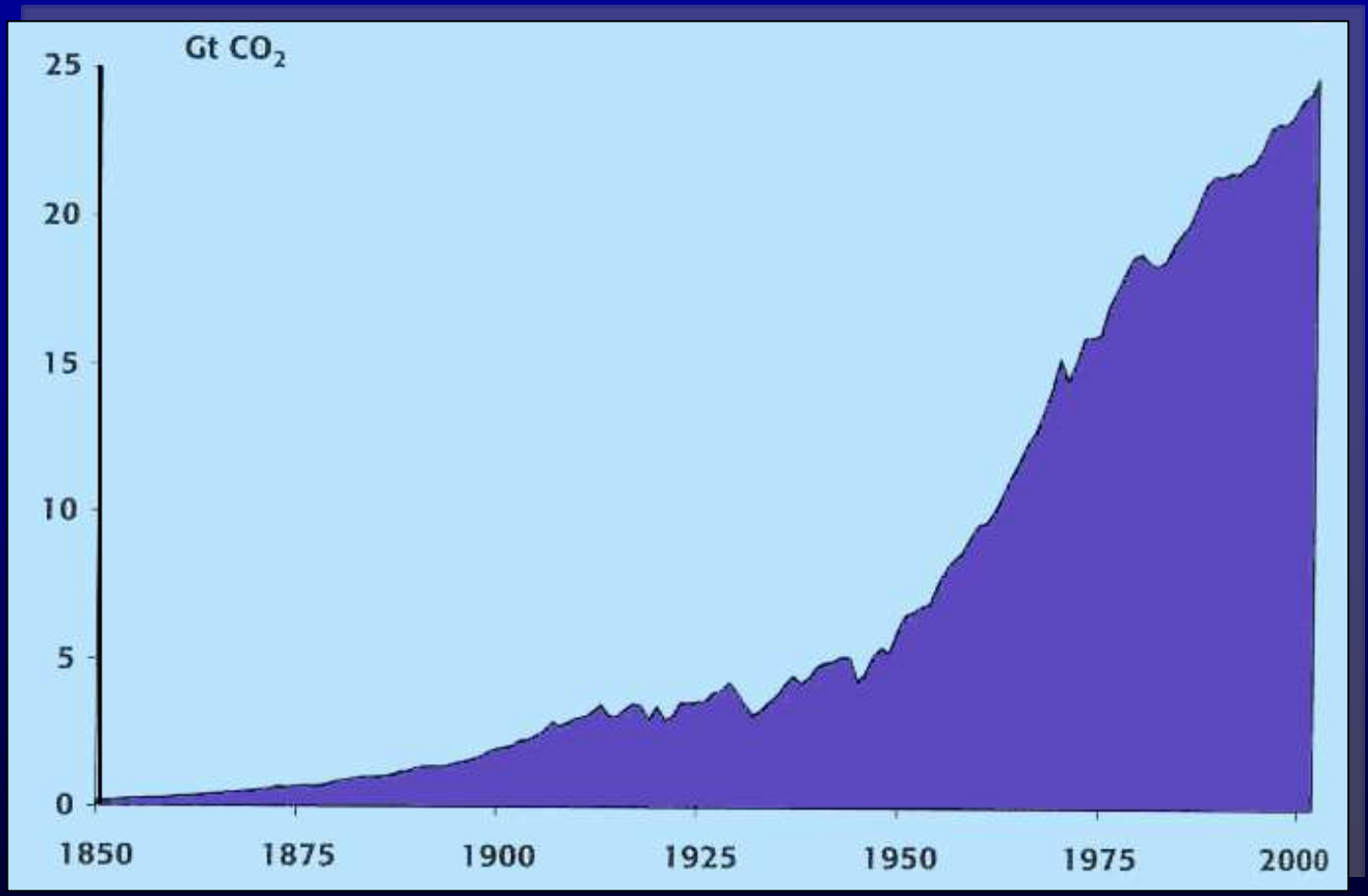
3. AS ALTERAÇÕES CLIMÁTICAS, UM MUNDO SEM CO_2 E O IMPACTO NA ECONOMIA

Rising levels of greenhouse gases



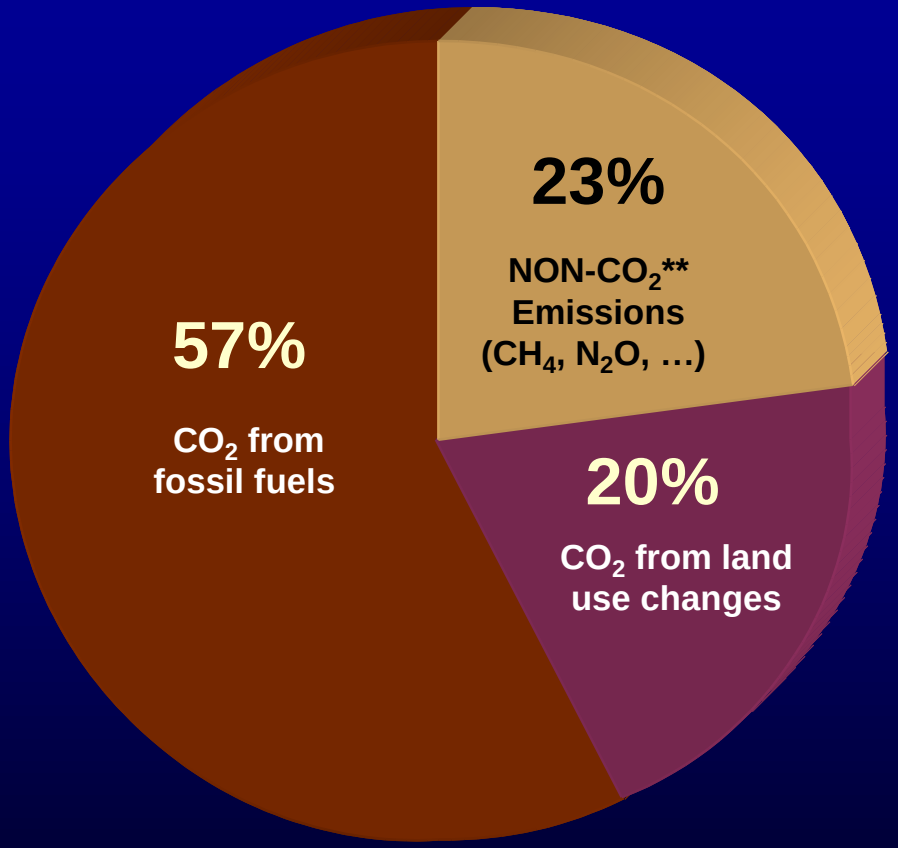
Source: Gohar and Shine

Global Co_2 Emissions from Fossil-Fuel



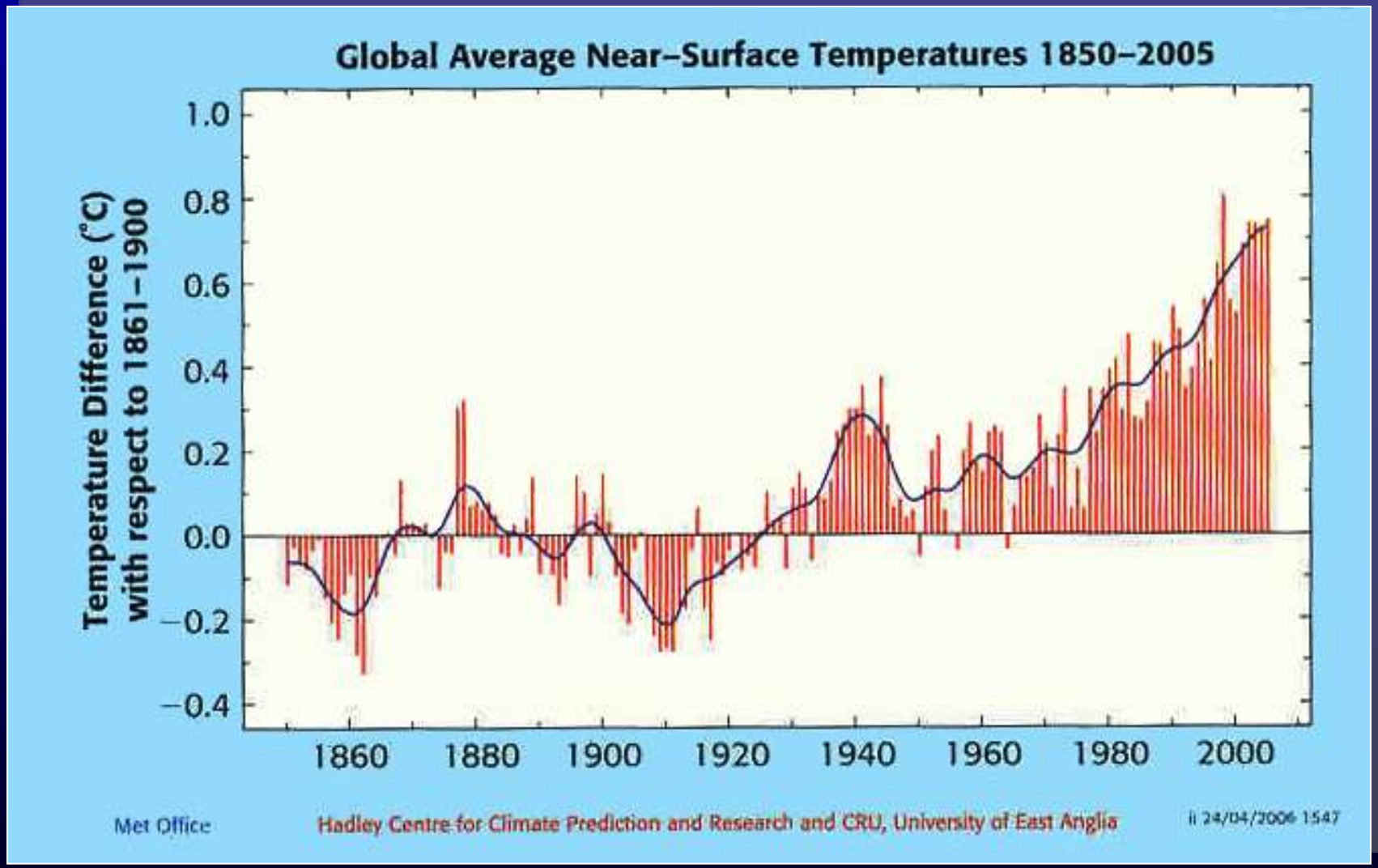
Source: Nicholas Stern / Brohan et al (2006)

Rough Breakdown of Global Greenhouse Gas Emissions in 2004

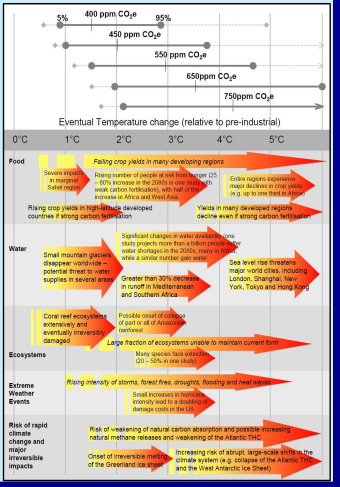


Fonte: IPCC, 2007

The Earth has warmed 0.7ºC since around 1900



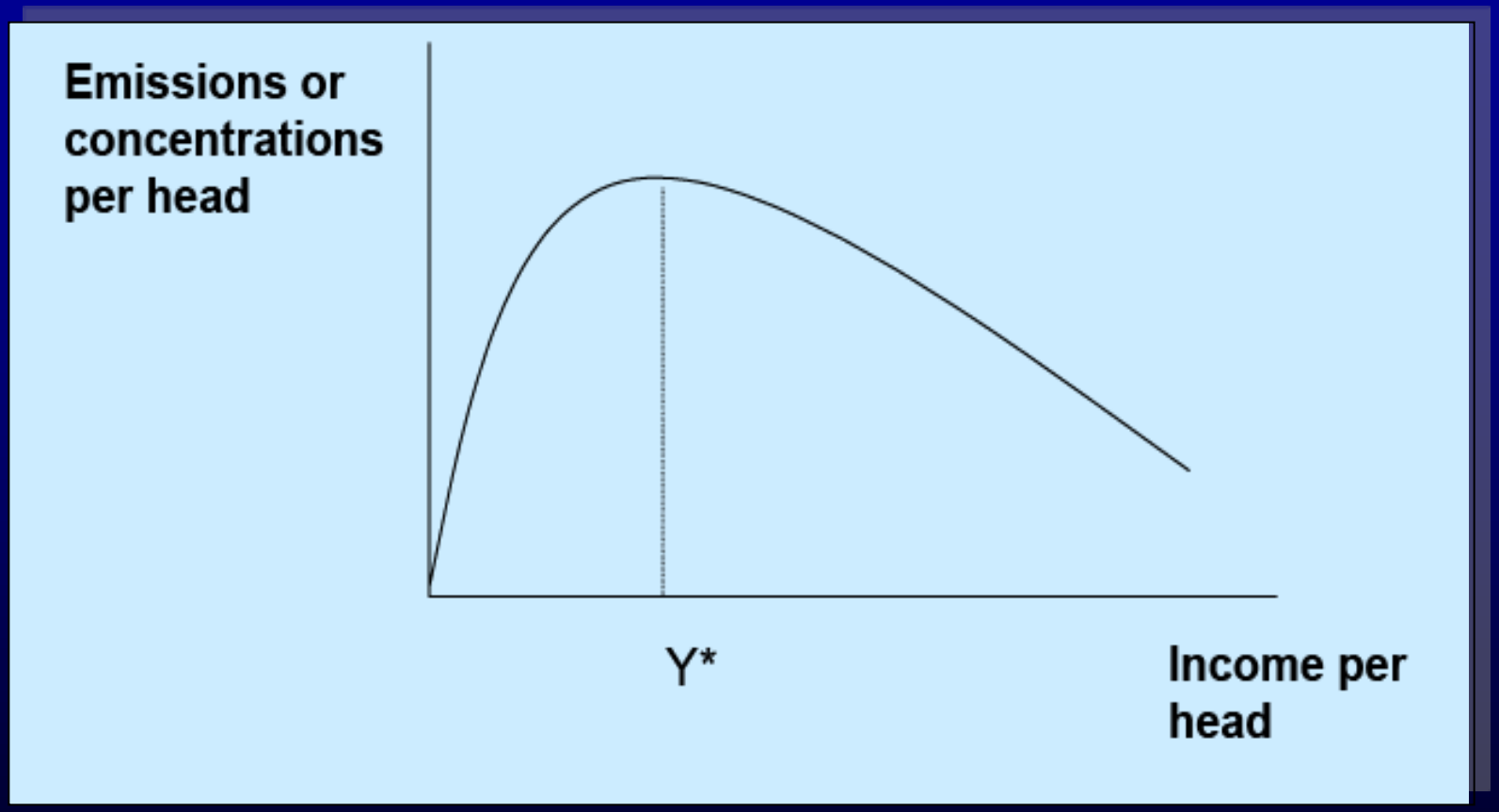
Fonte: Nicholas Stern / Brohan et al (2006)



Effects of Temperature Rise

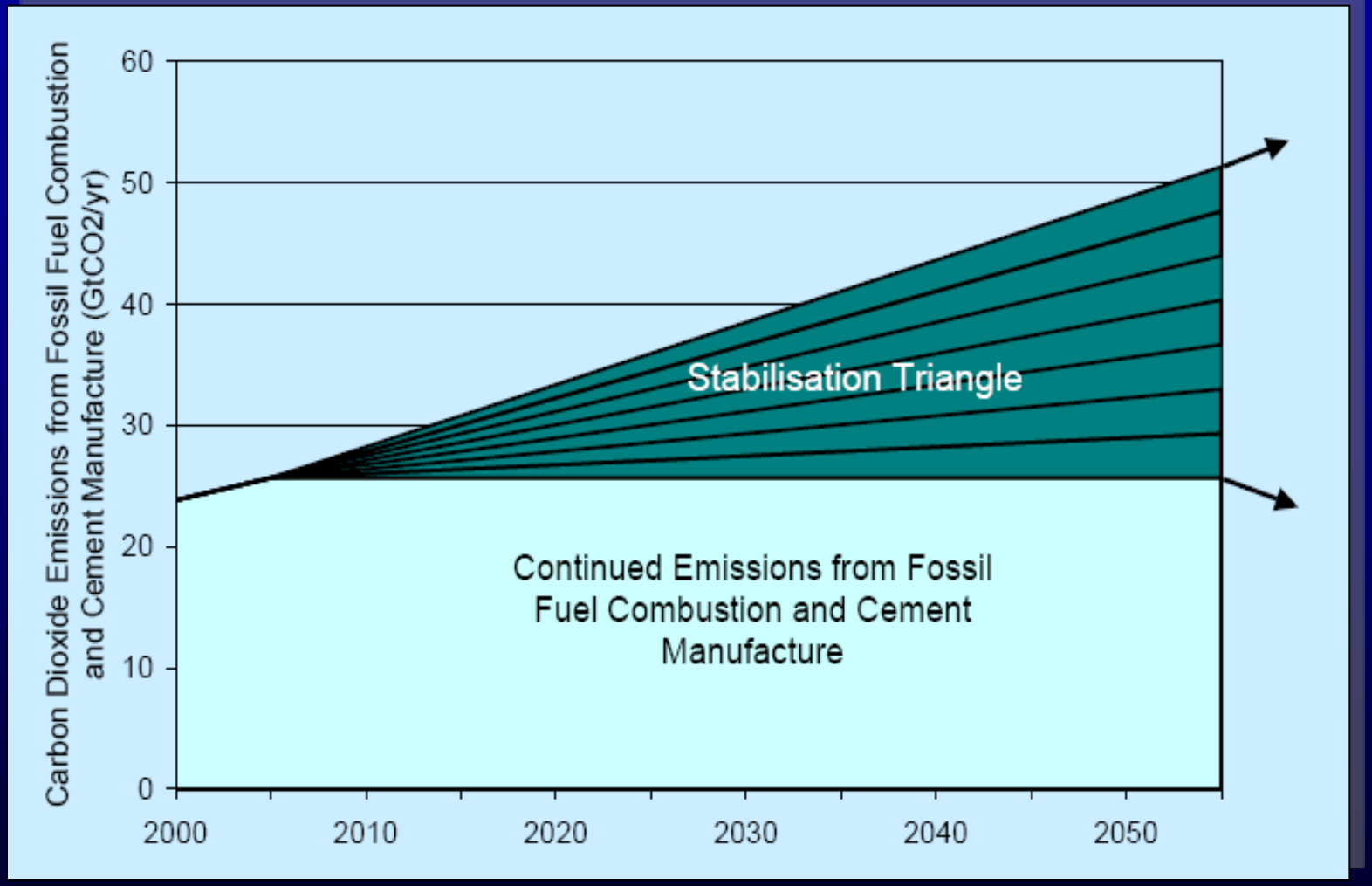
Fonte: Nicholas Stern / Stern Review web site

A hypothetical environmental Kuznet's curve



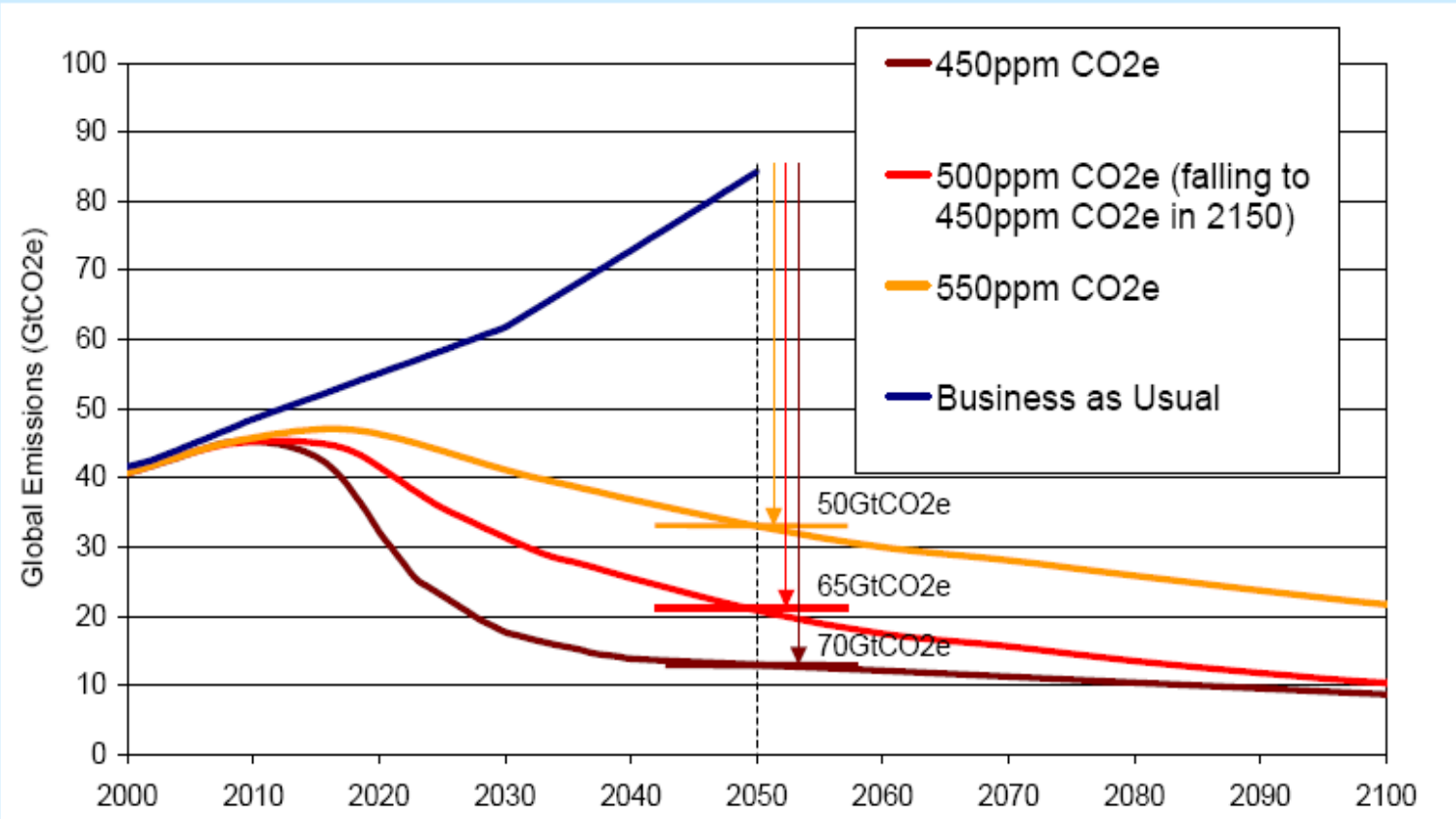
Source: Nicholas Stern

Socolow and Pacala's "wedges"



Source: Pacala and Socolow (2004)

Socolow and Pacala's "wedges"



Fonte: Nicholas Stern

UM MUNDO SEM CO_2?

OS PRINCIPAIS POLUIDORES E O PROTOCOLO DE QUIOTO

. EUA não ratificaram

. China e Índia?

. Distribuição assimétrica de emissões

. Até 2025 as emissões na China vão subir 118%

. O efeito de Kuznetz

TRANSPORTES

. 95% da Frota Mundial depende do petróleo

. 1985-2005: 950 mt para 2500 mt

EQUAÇÃO ENERGÉTICA

. Como responder ao desenvolvimento económico e ao crescimento demográfico?

. Economias emergentes consomem 50% da energia e são responsaveis por 80% do aumento do consumo nos últimos 5 anos

. Parque Automóvel: até 2030 cresce 4 vezes

. Urbanização/Industrialização//Motorização

.Planeta consumiu 11.400 Mtep e emitiu 27.000 Mt CO_2 (2007)

. 2000-2030: consumo de energia vai crescer 60% (17.700 Metp) e emissões CO_2 precisam descer 15% (23.000 Mt)

DESENVOLVIMENTO ECONÓMICO DOS PAÍSES EMERGENTES E ENERGIA

. Carvão: 70% da matriz energética da China

.China: em cada 5 dias há uma nova central a carvão

. EUA/CHINA/INDIA: a relação com o carvão

. Consumo do carvão é o que mais cresce: 5% ao ano

. A ineficiência energética: China consome 7 vezes mais recursos que Japão/Unidade PIB

"DESIGN MECHANISM" para a Redução das Emissões de CO_2

. "Cap-and-trade" não é o ideal

. Papel entidades financeiras que dominam o mercado e aprisionam os ganhos

. Os recursos financeiros NÃO financiam as inovações Tecnológicas que reduzem as emissões

. 1990-2005: Emissões CO2 aumentaram 35% no mundo

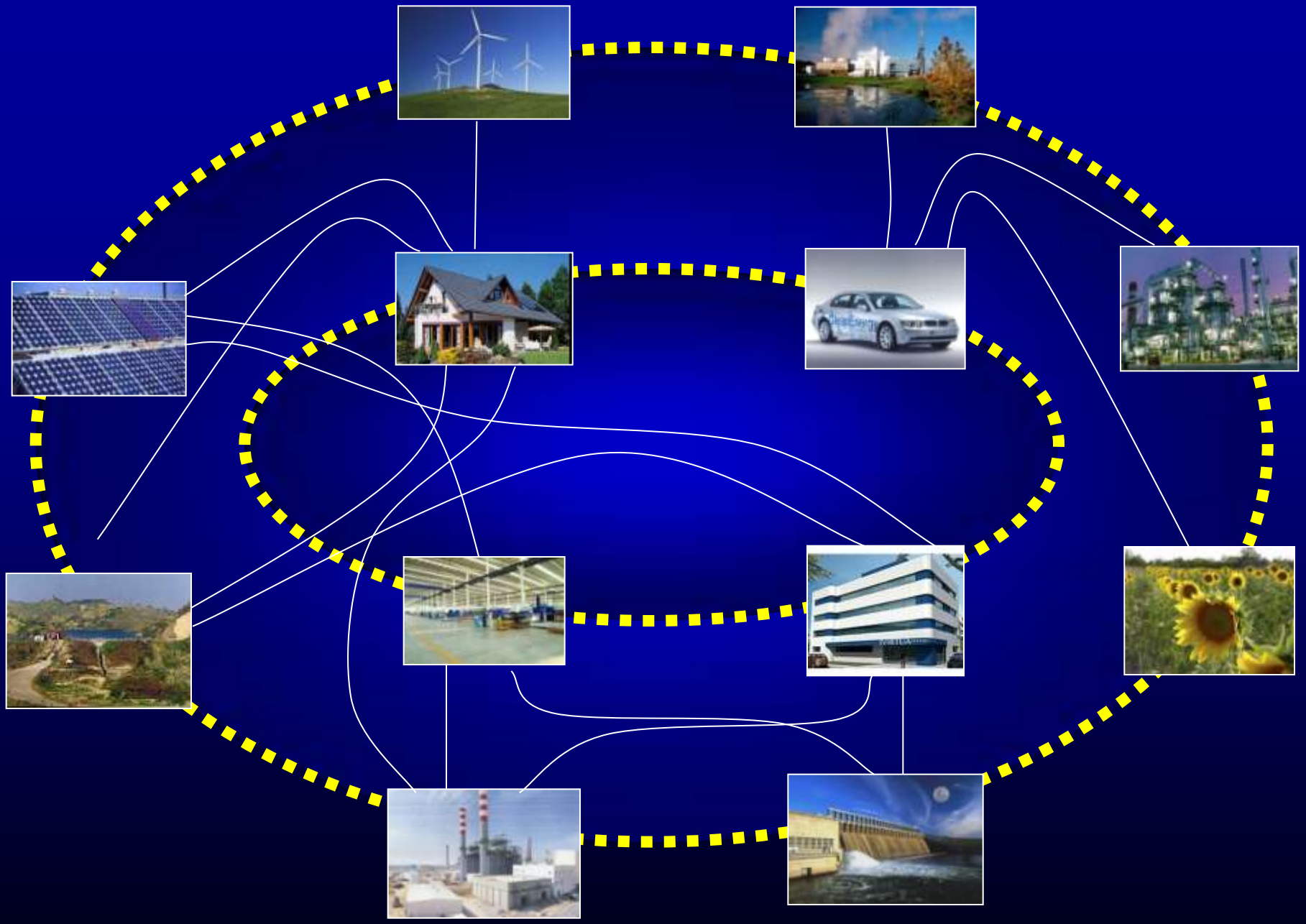
"GAS FLARING"

. Planeta queima 150 mil milhões m^3 gás/ano.

. Consumo da América Latina e Central mais 15%

. Emissão de 400 milhões ton CO_2/ano

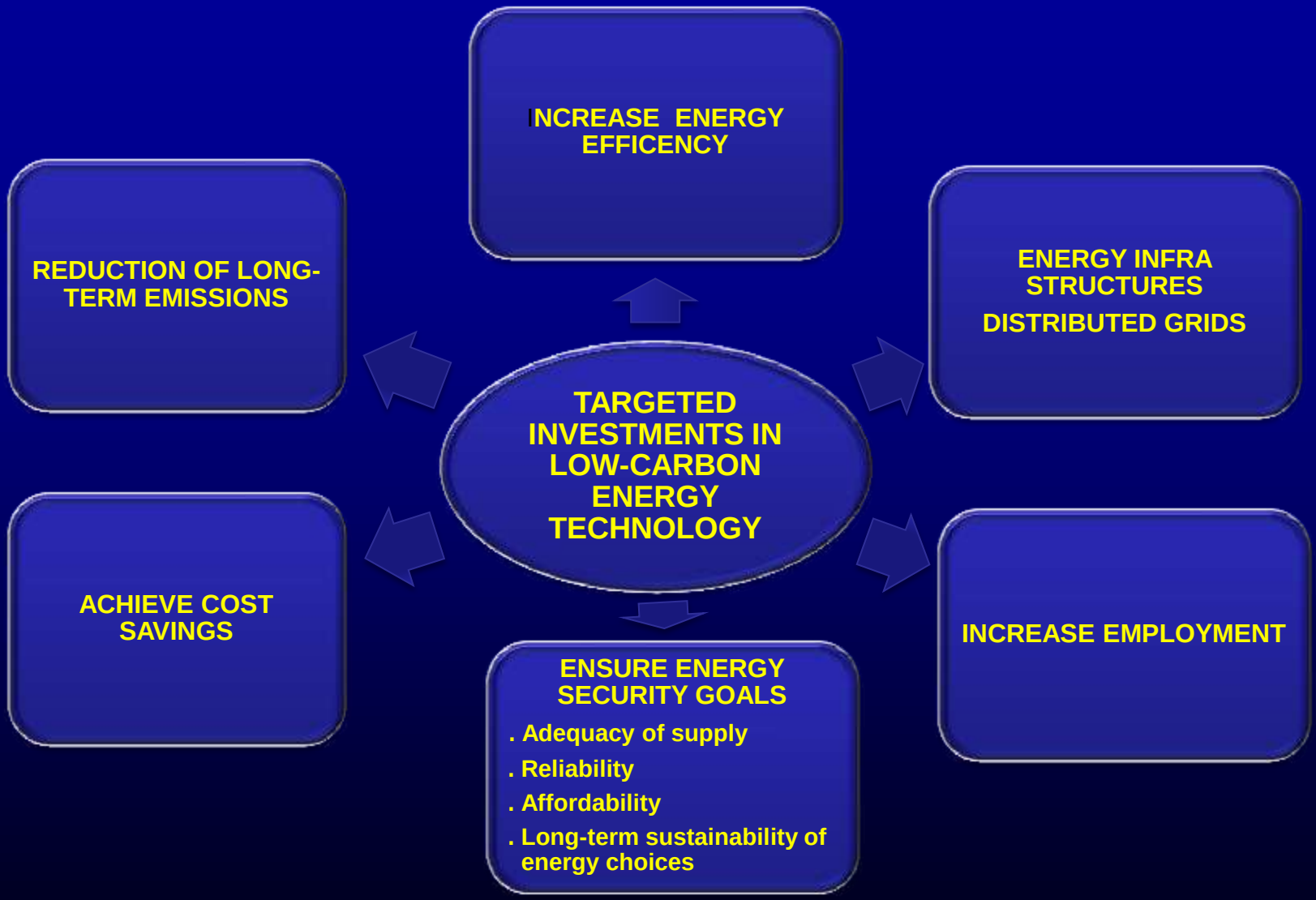
. Eliminação é equivalente a 3.000 projectos do "CLEAN DEVELOPMENT MECHANISM"



A "GREEN ECONOMY" RECOVERY?

- **NEED of a New Engine for economic growth**
- **NEED of a New Energy Matrix to reduce the dependence on fossil fuels**
- **MINIMIZE Climatic Threat and Reduction of Emissions**
- **"GREEN ECONOMY" can create jobs and stimulate the economy**
- **ACHIEVE significant Energy Cost Savings**
- **WAY OUT of Deep Economic Recession needs Strategic Axis of Development**
- **Energy is one of the most important industries of the Global Economy**

A "GREEN ECONOMY" RECOVERY?



"GREEN ECONOMY" : CRITICAL ISSUES

- **It is a "wishful thinking" concept if not supported by:**
  - **Long term strategic vision**
  - **Solid public policies based on well designed market mechanisms**
  - **Dedicated commitment from governments on sustainable public policies**
- **Implies a RADICAL CHANGE and CHANGE in a recession may not be a priority**
- **Costs are too high (45 trillion US$ to reduce CO emissions 50% by 2050)**
- **Past history shows (e.g. second oil shock) that new cycles of low oil price remove pressure on change and create conditions for failure**
- **The market alone cannot tackle climate change or provide energy security**

"GREEN ECONOMY" : CRITICAL ISSUES

- **Recession fatal dynamics: steep decline in consumption/low energy prices/alternatives discouraged**
- **DEVELOPED ECONOMIES focused on fixing the financial system, stimulate the economy and increase employment: "green initiatives" may loose ground**
- **"Green stimulus" is no replacement for climate and energy policy but can reduce future costs**
- **The end of recession will bring a new energy crisis if "Green Initiatives" are not materialized due to the chronic sub-investment in energy infrastructure (e.g. storage)**

THE FUTURE of WORLD ENERGY MATRIX

- IEA : Global Energy use will increase 50% (2006-2030)
- By 2030 oil still provides 30% of world's energy
- To smooth the DEMAND growth it is not possible to roll back economic growth

WHAT IS THE SOLUTION?

Find new technologies
Find alternatives to oil that can be:
- Economically competitive
- Convenient
- Reliable

OBRIGADO