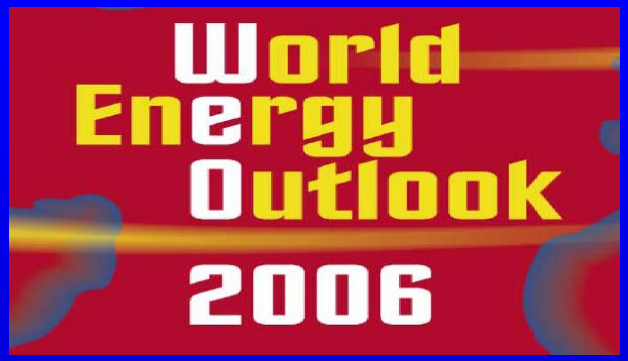
"El futuro del suministro global de petróleo y gas: desafíos e incertidumbres"

Mariano Marzo
(Facultat de Geologia, UB)

II CONFERENCIA
"CANARIAS ANTE LA CRISIS ENERGETICA"

Centro Cívico del Carrizal
Ingenio, Gran Canaria
17-2-2007

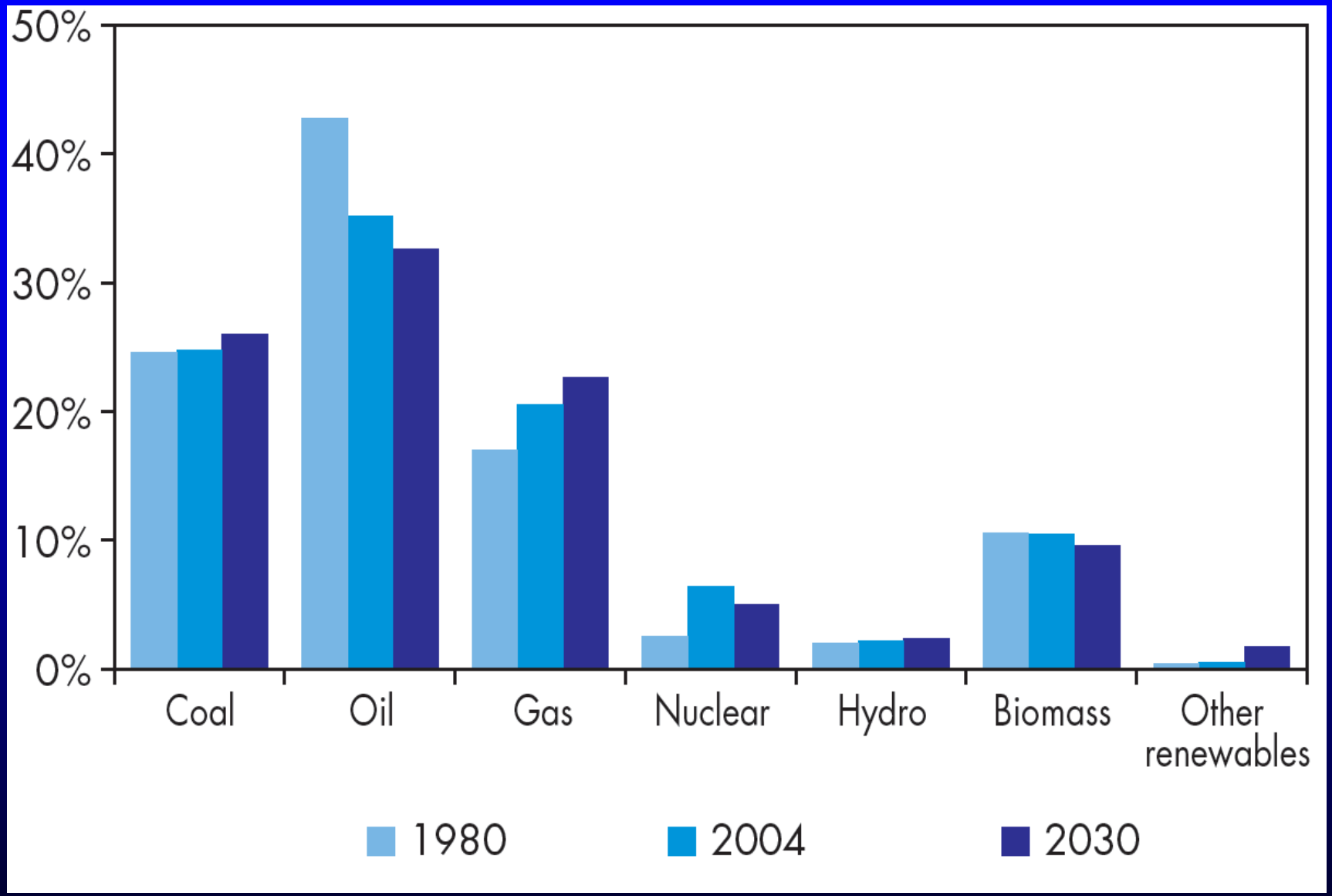
AGENCIA INTERNACIONAL DE LA ENERGIA



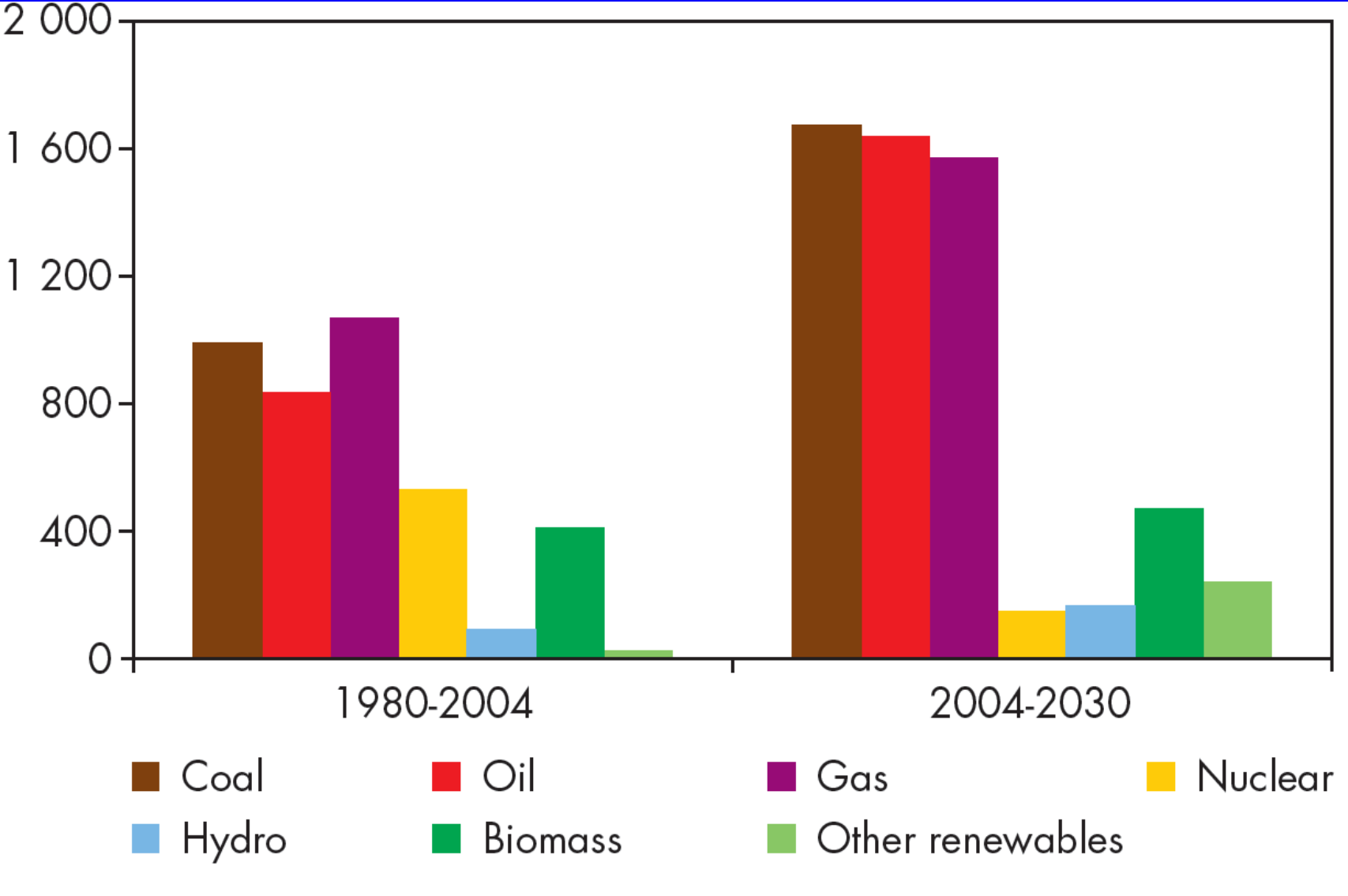
En su ultimo informe, "World Energy Outlook 2006" (WEO 2006), la Agencia Internacional de la Energía presenta un panorama preocupante sobre el futuro energético global.

En palabras de su director ejecutivo, Claude Mandil, el mundo encara un mañana "sucio, inseguro y caro", en el que los países consumidores serán cada vez más vulnerables a "severas" interrupciones del suministro, al mismo tiempo que se acelerarán los riesgos asociados al cambio climático global.

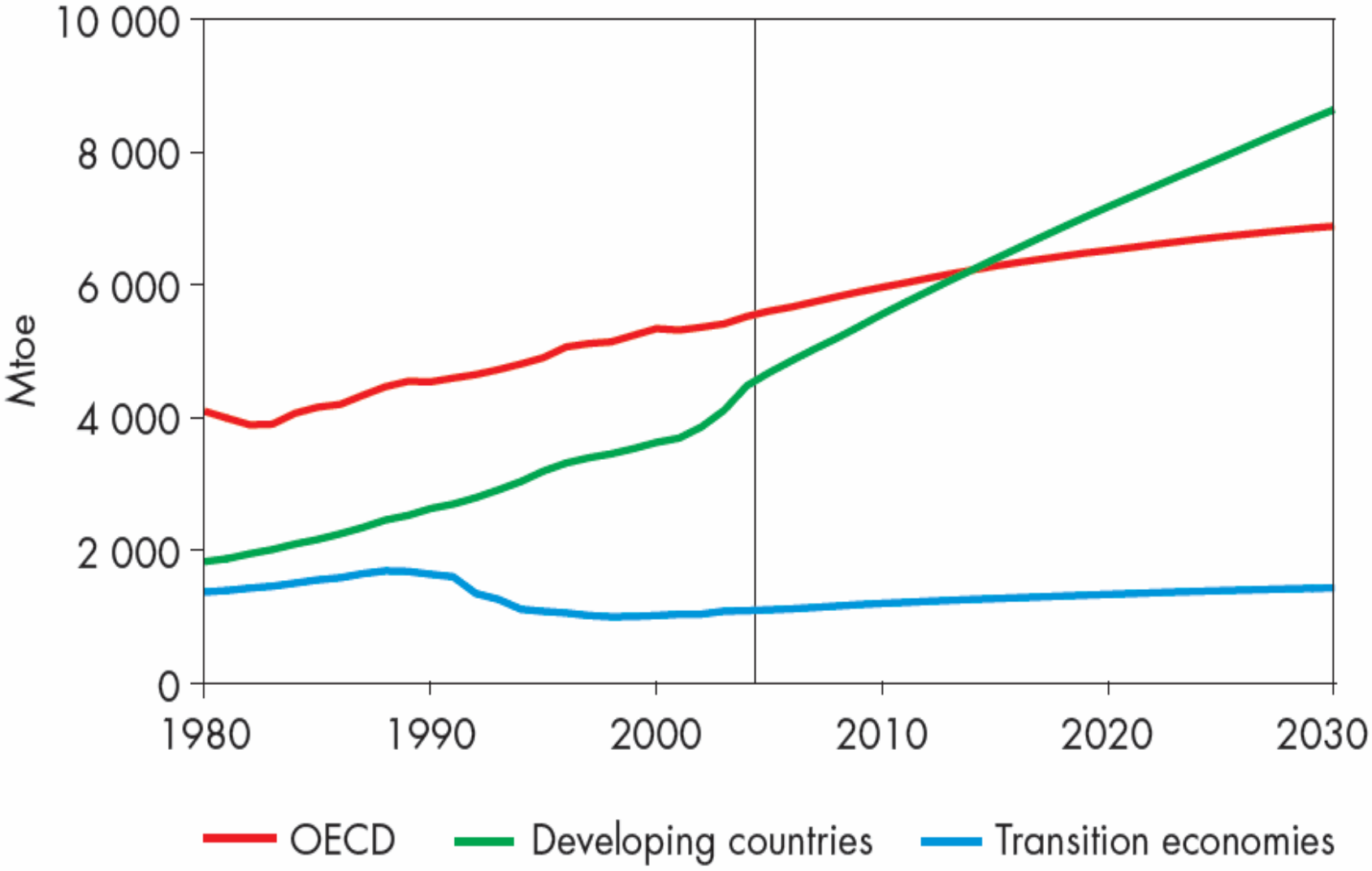
Mix de e. primarias en la demanda mundial



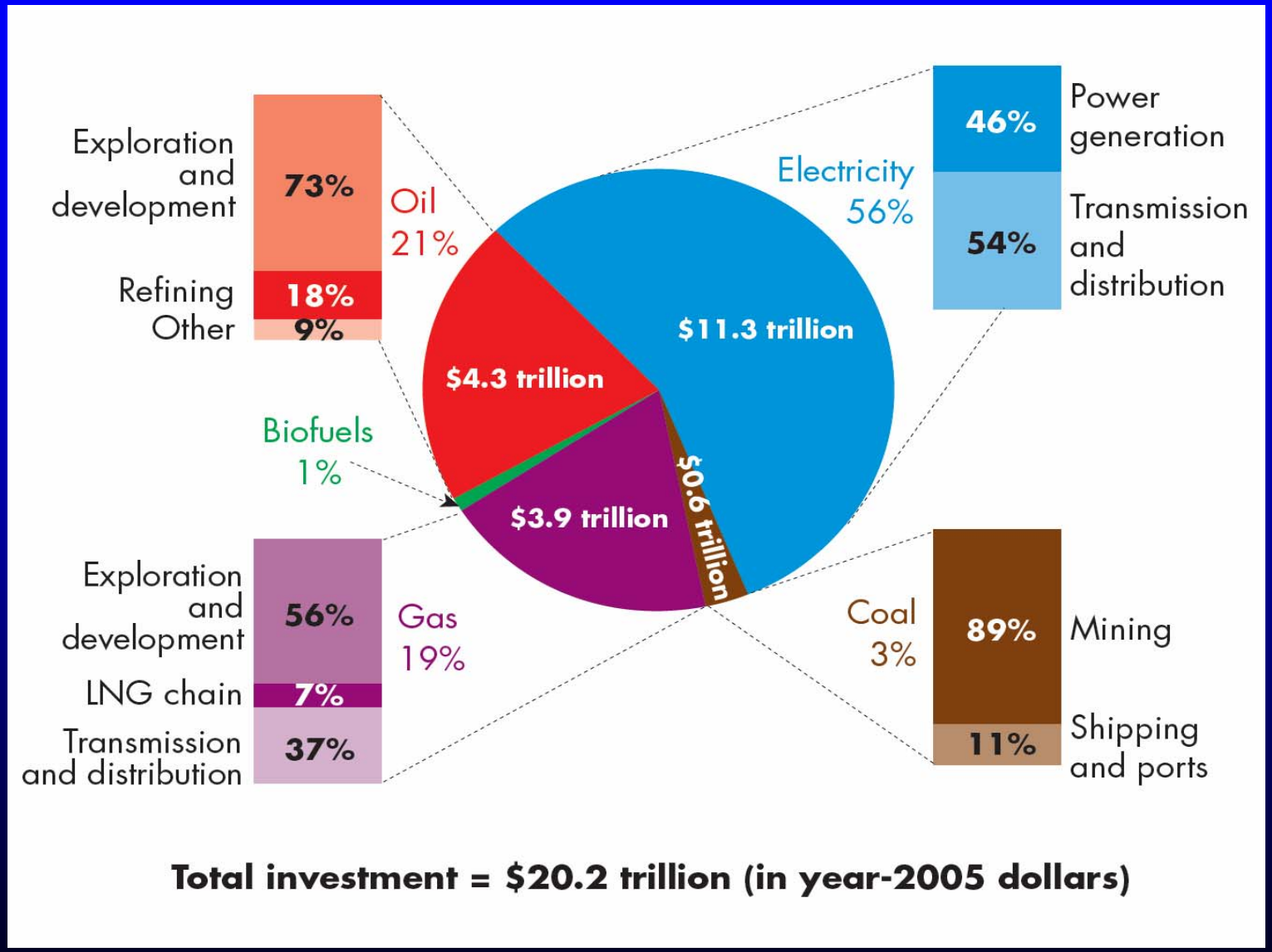
Demanda mundial de e. primarias (10^6 tep)



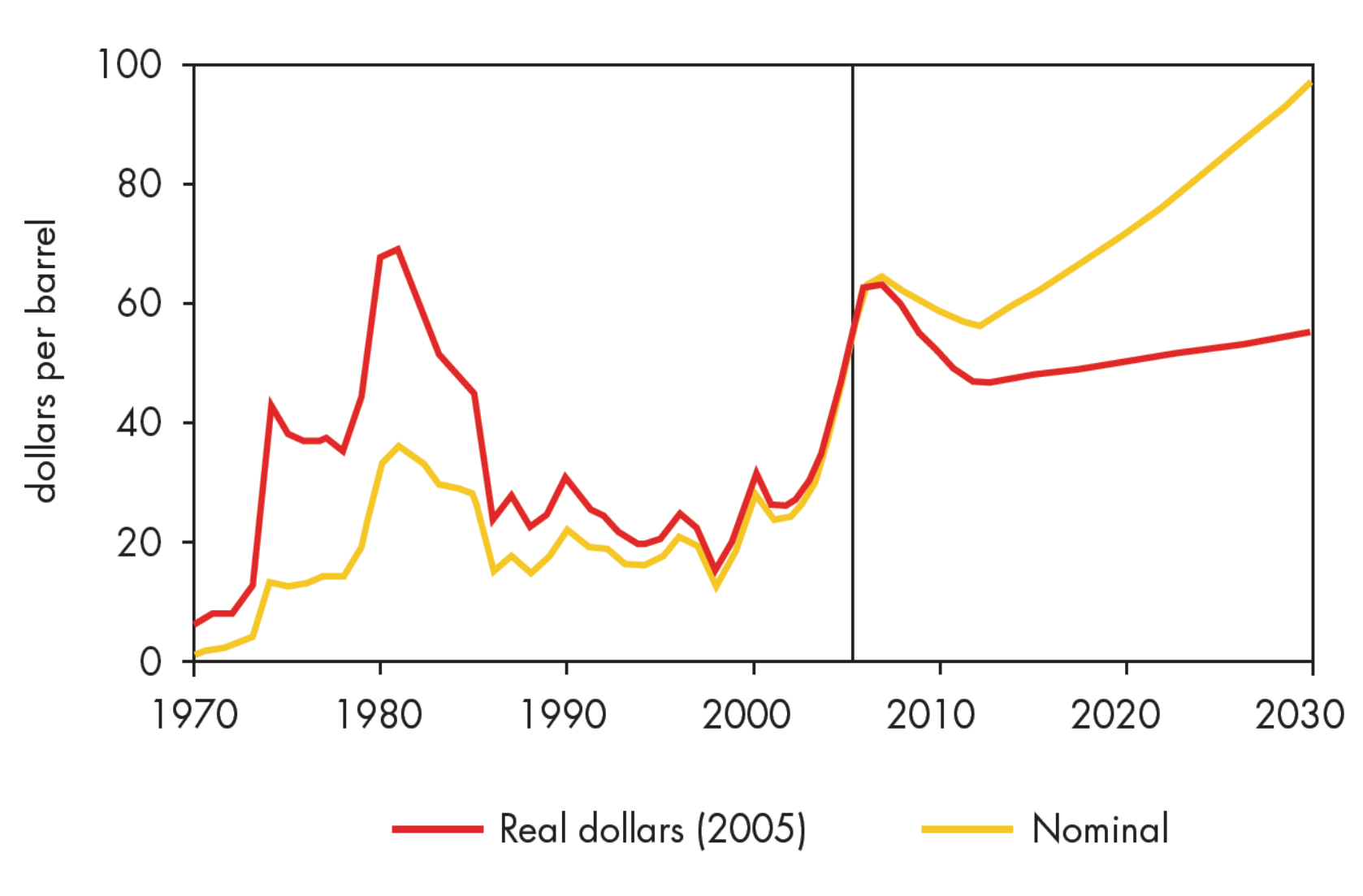
Demanda mundial de e. primarias por región



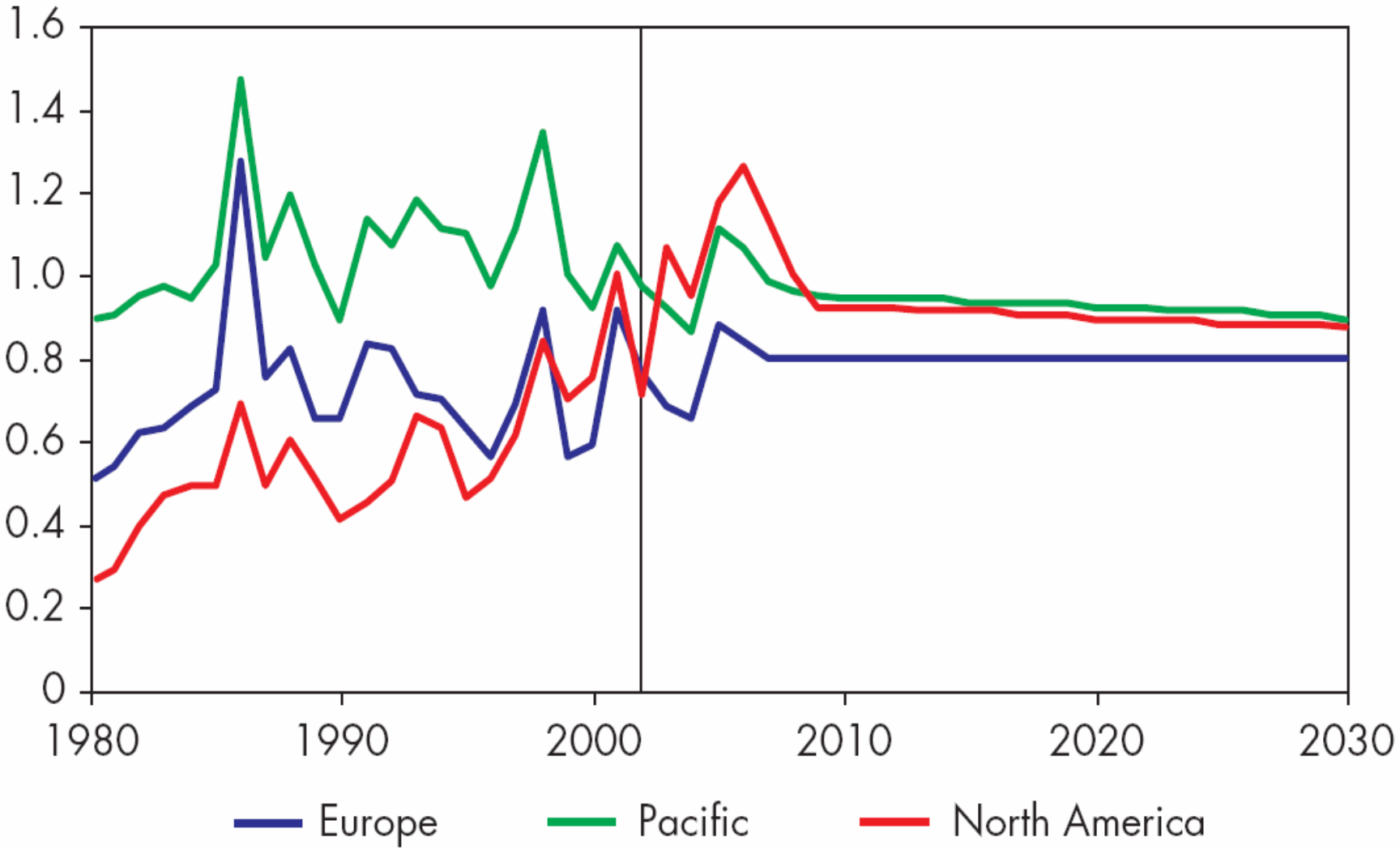
Inversión acumulada en infraestructuras energéticas por combustible y actividad



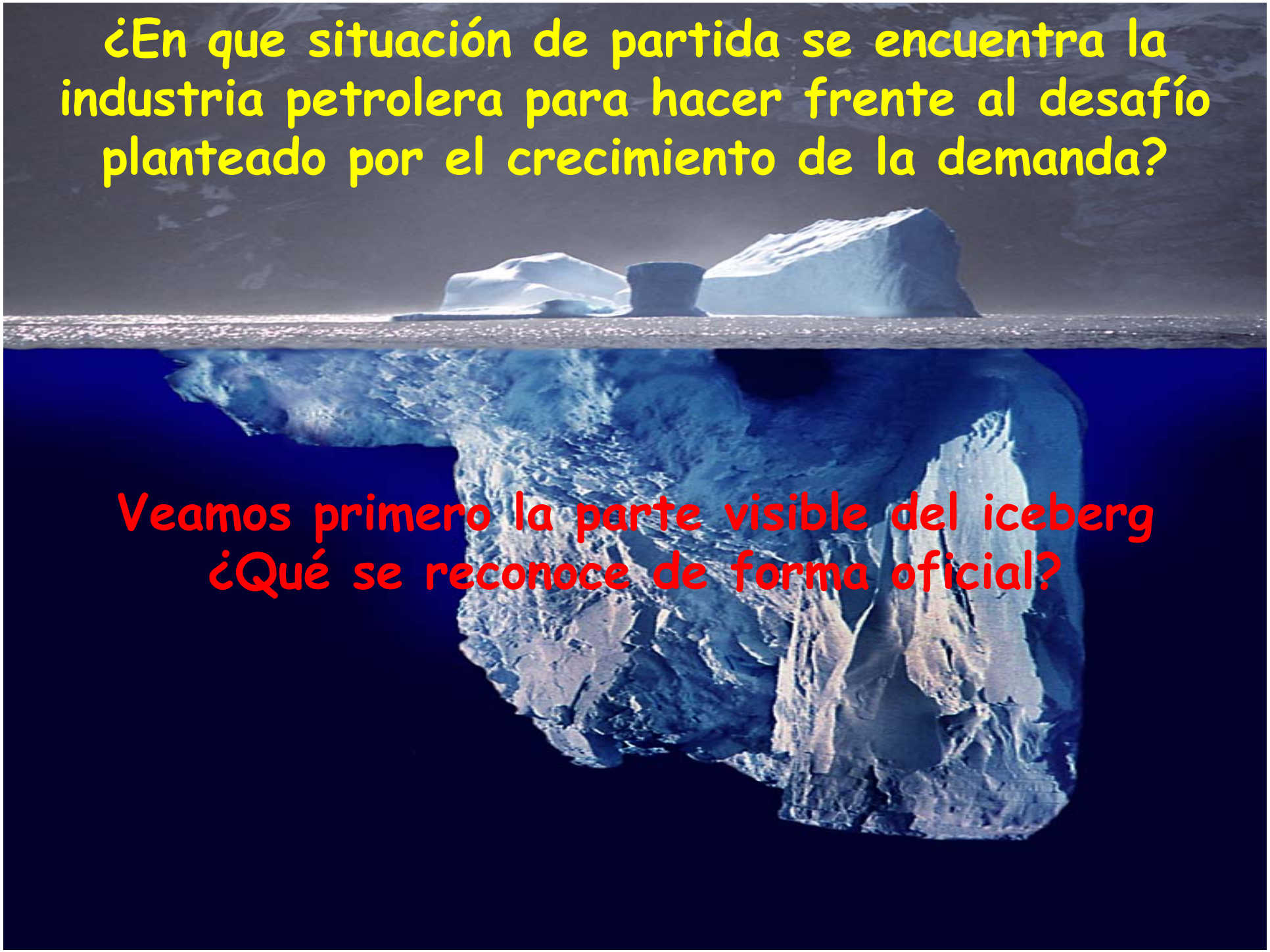
Precio promedio del crudo de importación de la IEA (escenario de referencia)



Relación entre precios del gas y del petróleo



IEA, WEO 2004


¿En que situación de partida se encuentra la industria petrolera para hacer frente al desafío planteado por el crecimiento de la demanda?
Veamos primero la parte visible del iceberg
¿Qué se reconoce de forma oficial?

What Can Replace Cheap Oil—and When

The road from old to new energy sources can be bumpy, but the transitions have gone pretty smoothly in the past. After millennia of dependence on wood, society added coal and gravity-driven water to the energy mix. Industrialization took off. Oil arrived, and transportation by land and air soared, with hardly a worry about where the next log or lump of coal was coming from, or what the explosive growth in energy production might be doing to the world.

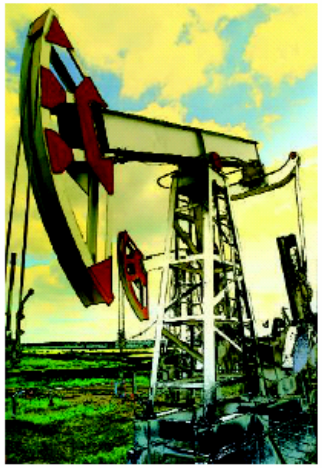
Times have changed. The price of oil has been climbing, and ice is melting around both poles as the mercury in the global thermometer rises. Whether the next big energy transition will be as smooth as past ones will depend in large part on three sets of questions: When will world oil production peak? How sensitive is Earth's climate to the carbon dioxide we are pouring into the atmosphere by burning fossil fuels? And will alternative energy sources be available at reasonable costs? The answers rest on science and technology, but how society responds will be firmly in the realm of politics.

There is little disagreement that the world will soon be running short of oil. The debate is over how soon. Global demand for oil has been rising at 1% or 2% each year, and we are now sucking almost 1000 barrels of oil from the ground every second. Pessimists—mostly former oil company geologists—expect oil production to peak very soon. They point to American geologist M. King Hubbert's successful 1956 prediction of the 1970 peak in U.S. production. Using the same method involving records of past production and discoveries, they predict a world oil peak by the end of the decade. Optimists—mostly resource economists—argue that oil production depends more on economics and politics than on how much happens to be in the ground. Technological innovation will intervene, and production will continue to rise, they say. Even so, midcentury is about as far as anyone is willing to push the peak. That's still "soon" considering that the United States, for one, will need to begin replacing oil's 40% contribution to its energy consumption by then. And as concerns about climate change intensify, the transition to nonfossil fuels could become even more urgent (see p. 100).

If oil supplies do peak soon or climate concerns prompt a major shift away from fossil fuels, plenty of alternative energy supplies are waiting in the wings. The sun bathes Earth's surface with 86,000 trillion watts, or terawatts, of energy at all times, about 6600 times the amount used by all humans on the planet each year. Wind, biomass, and nuclear power are also plentiful. And there is no shortage of opportunities for using energy more efficiently.

Of course, alternative energy sources have their issues. Nuclear fission supporters have never found a noncontroversial solution for disposing of long-lived radioactive wastes, and concerns over liability and capital costs are scaring utility companies off. Renewable energy sources are diffuse, making it difficult and expensive to corral enough power from them at cheap prices. So far, wind is leading the way with a global installed capacity of more than 40 billion watts, or gigawatts, providing electricity for about 4.5 cents per kilowatt hour.

That sounds good, but the scale of renewable energy is still very small when compared to fossil fuel use. In the United States, renewables account for just 6% of overall energy production. And, with global energy demand expected to grow from approximately 13 terawatts a year now to somewhere between 30 and 60 terawatts by the middle of this century, use of renewables will have to expand enormously to displace current sources and have a significant impact on the world's future energy needs.



CREDIT: JUPITER IMAGES

What needs to happen for that to take place? Using energy more efficiently is likely to be the sine qua non of energy planning—not least to buy time for efficiency improvements in alternative energy. The cost of solar electric power modules has already dropped two orders of magnitude over the last 30 years. And most experts figure the price needs to drop 100-fold again before solar energy systems will be widely adopted. Advances in nanotechnology may help by providing novel semiconductor systems to boost the efficiency of solar energy collectors and perhaps produce chemical fuels directly from sunlight, CO_2, and water.

But whether these will come in time to avoid an energy crunch depends in part on how high a priority we give energy research and development. And it will require a global political consensus on what the science is telling us.

–RICHARD A. KERR AND ROBERT F. SERVICE

The following six mathematics questions are drawn from a list of seven outstanding problems selected by the Clay Mathematics Institute. (The seventh problem is discussed on p. 96.) For more details, go to www.claymath.org/millennium.

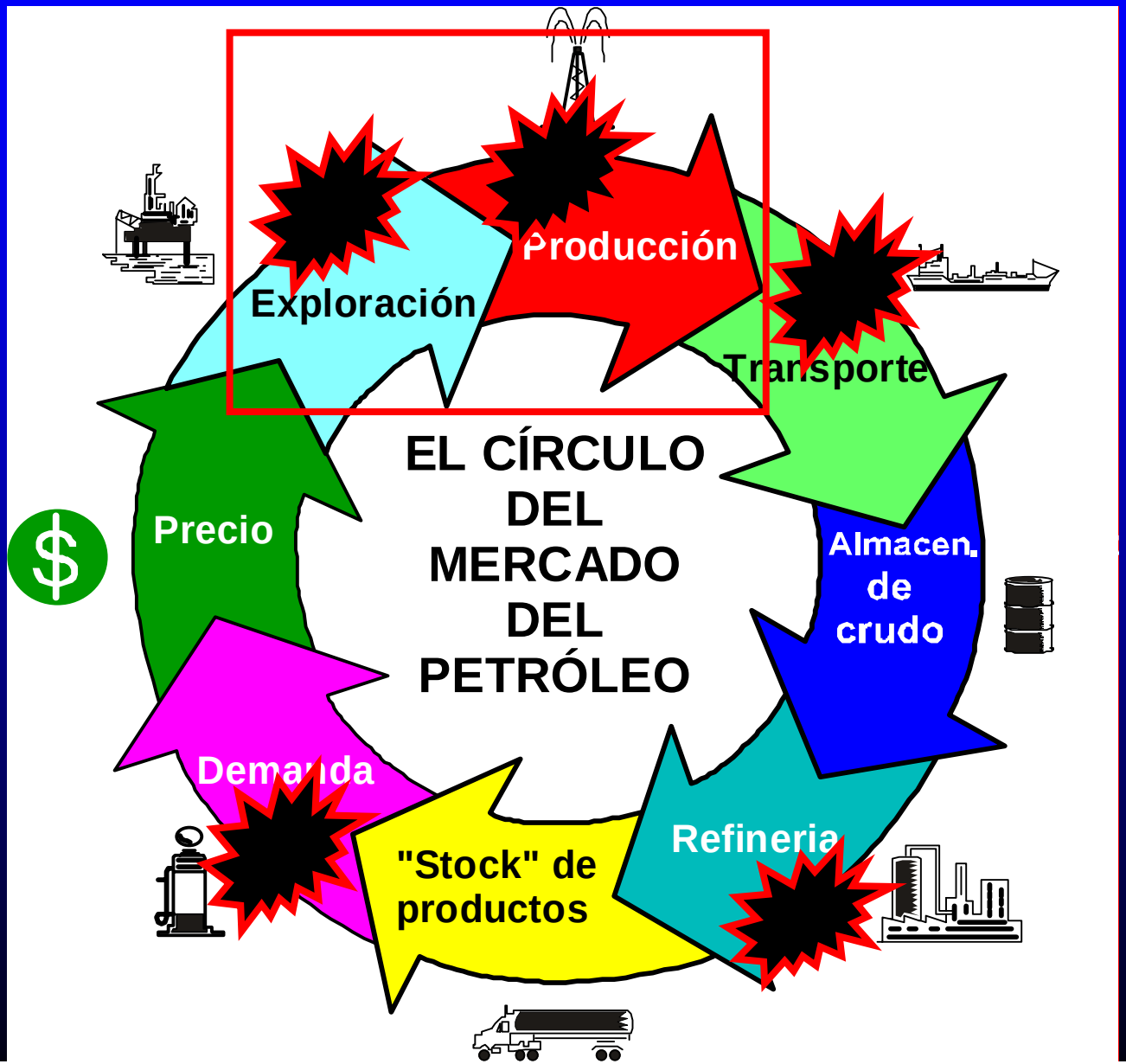
Is there a simple test for determining whether an elliptic curve has an infinite number of rational solutions?
Equations of the form $y^2 = x^3 + ax + b$ are powerful mathematical tools. The Birch and Swinnerton-Dyer conjecture tells how to determine how many solutions they have in the realm of rational numbers—information that could solve a host of problems, if the conjecture is true.

continued >>

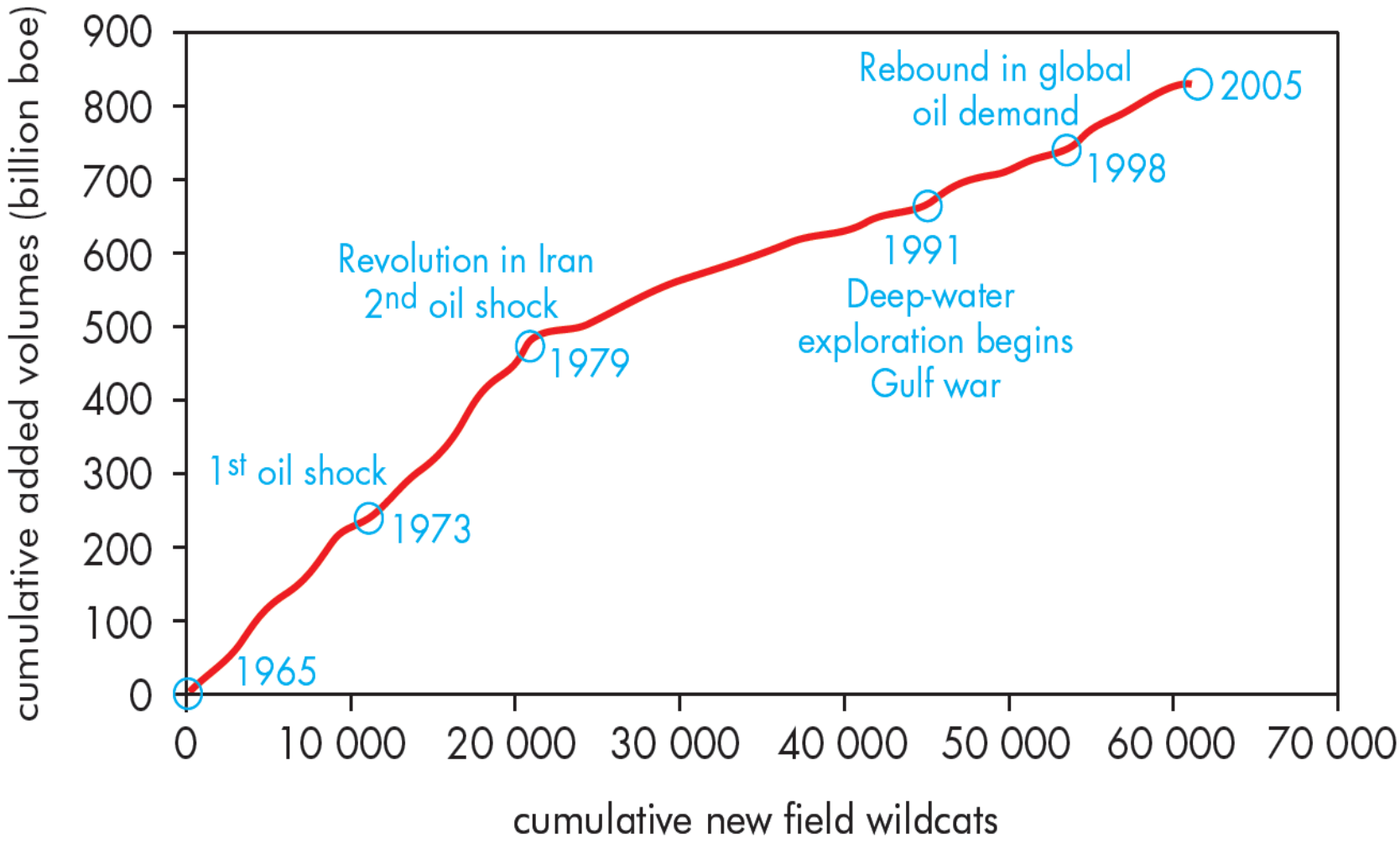
Can a Hodge cycle be written as a sum of algebraic cycles?
Two useful mathematical structures arose independently in geometry and in abstract algebra. The Hodge conjecture posits a surprising link between them, but the bridge remains to be built.

Published by AAAS

Problemas en "upstream" y "downstream"



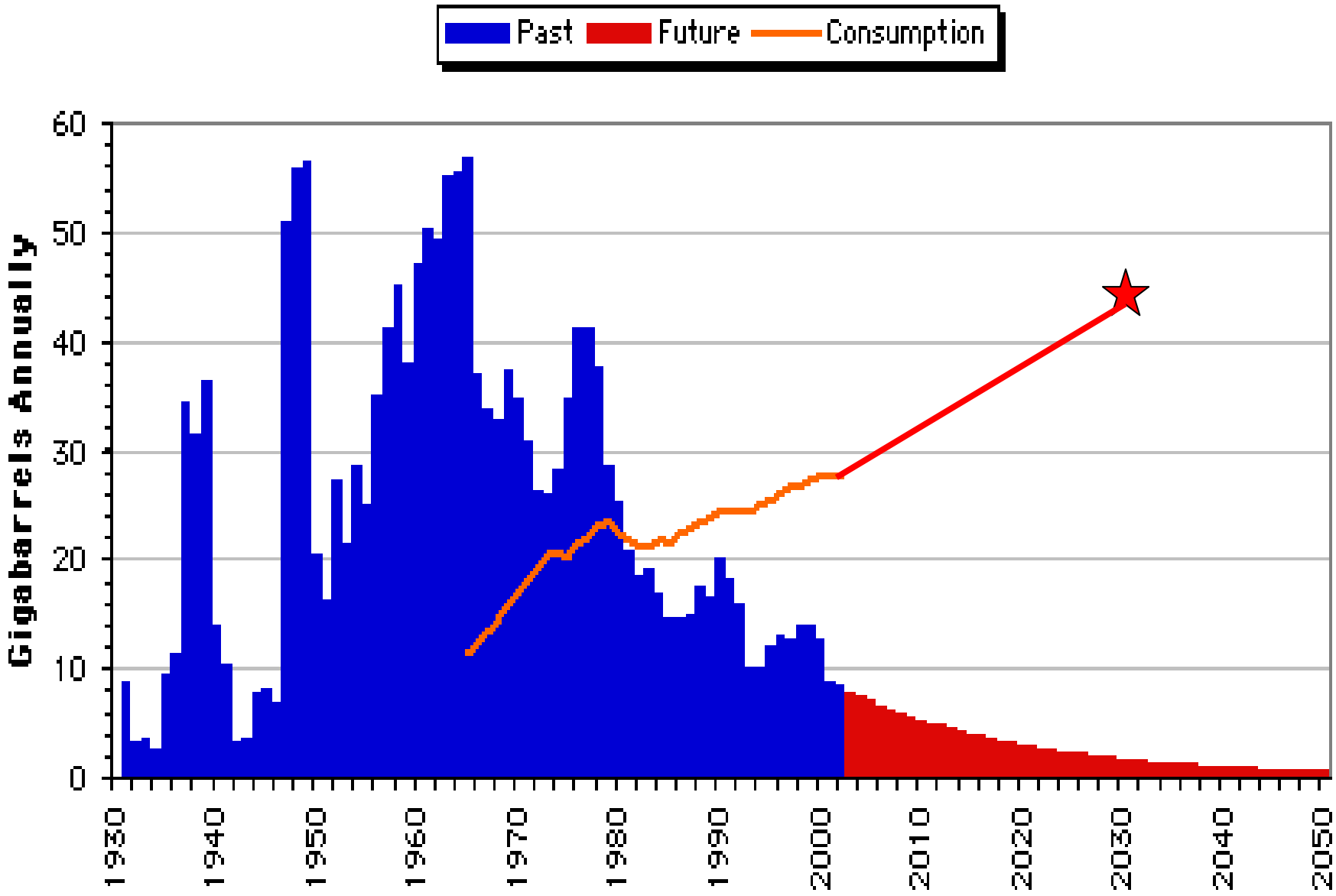
Descubrimientos de petróleo y gas y número de pozos de exploración nuevos



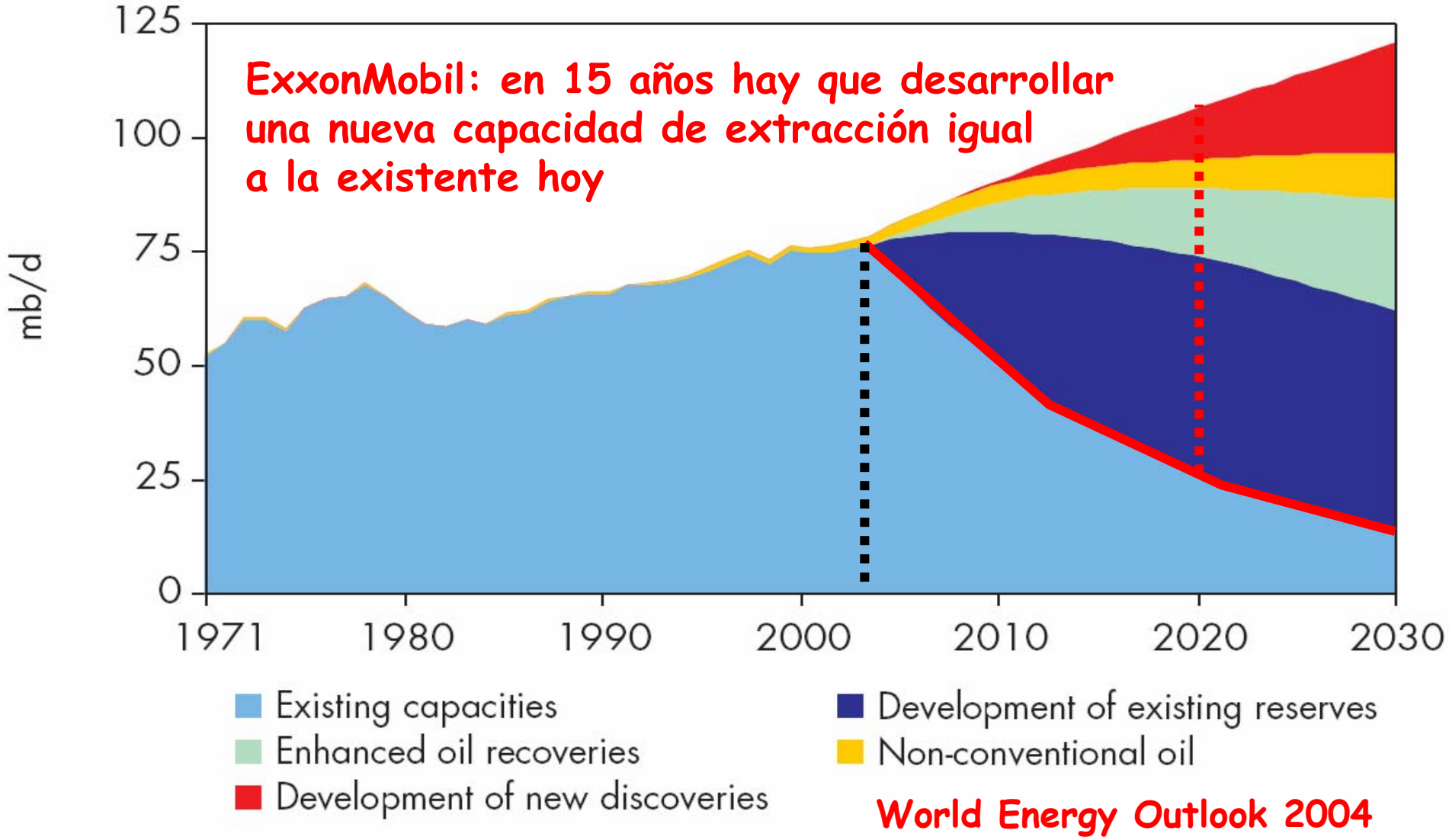
A pesar de la intensa actividad exploratoria y del empleo de una tecnología muy avanzada, encontrar nuevos campos se ha convertido en una tarea cada vez más complicada y los que se encuentran son más pequeños y de peor calidad.

Además, los costes para hallar y desarrollar nuevas reservas se están disparando. Esta tendencia no resulta sorprendente si se tiene en cuenta que cada vez se explora en regiones más remotas, bajo condiciones más adversas y los objetivos son más pequeños y menos prolíficos.

Estamos viviendo de las joyas de la abuela… y el agujero crece

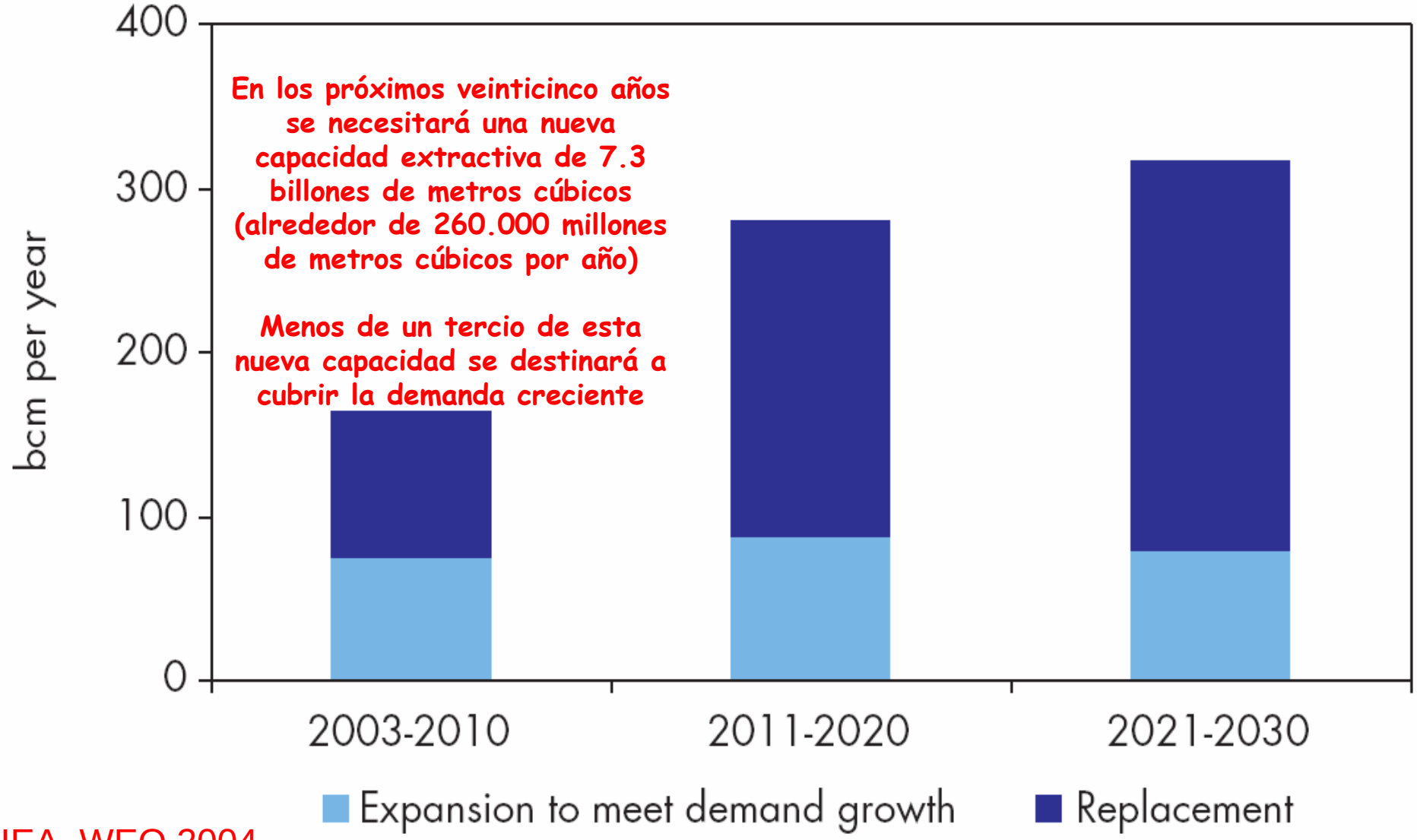


Ante la incapacidad de promover un "relevo generacional", muchos yacimientos han sido sobrexplotados (AIE: declive 5-11% anual)



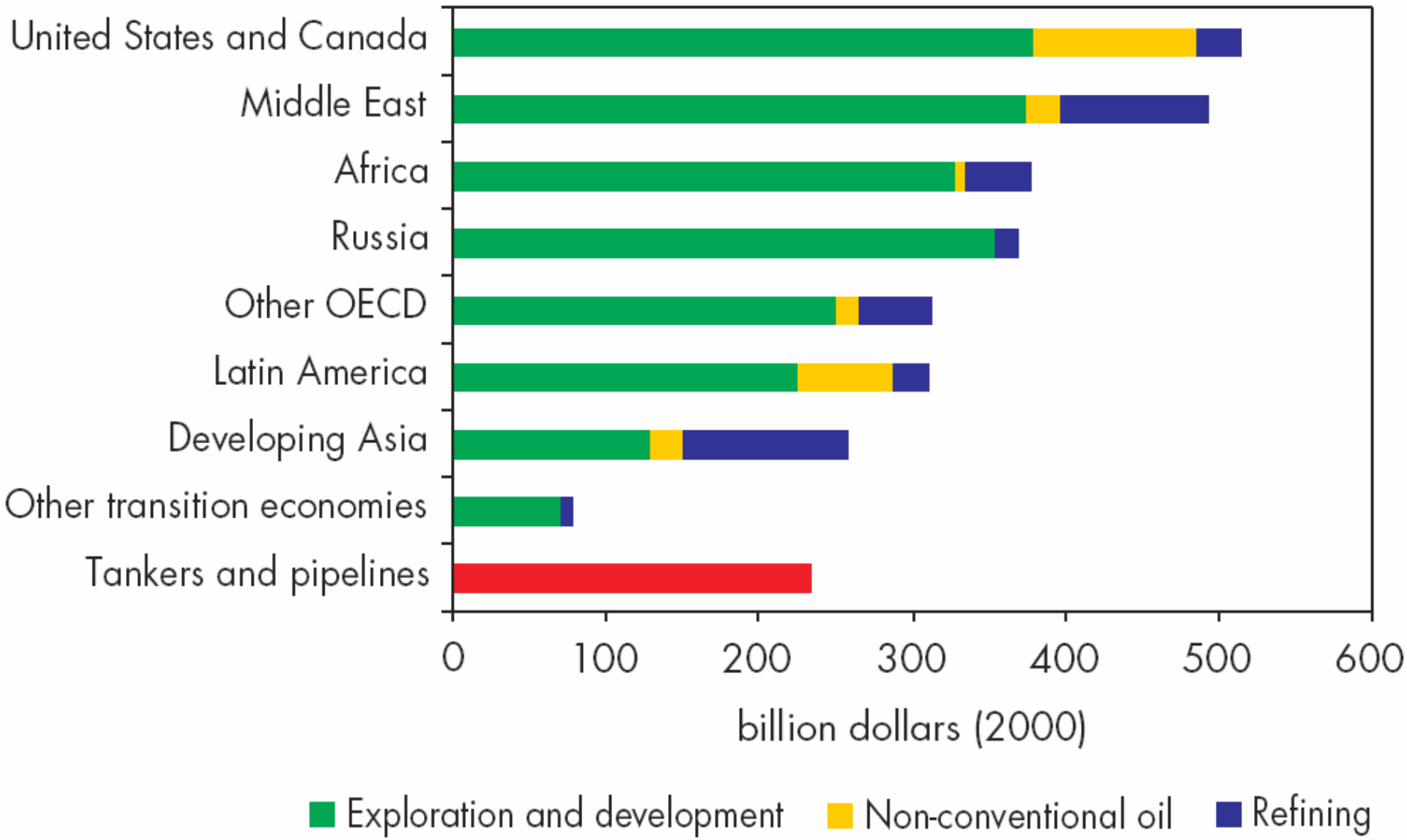
World Energy Outlook 2004

Lo mismo sucede para el gas natural



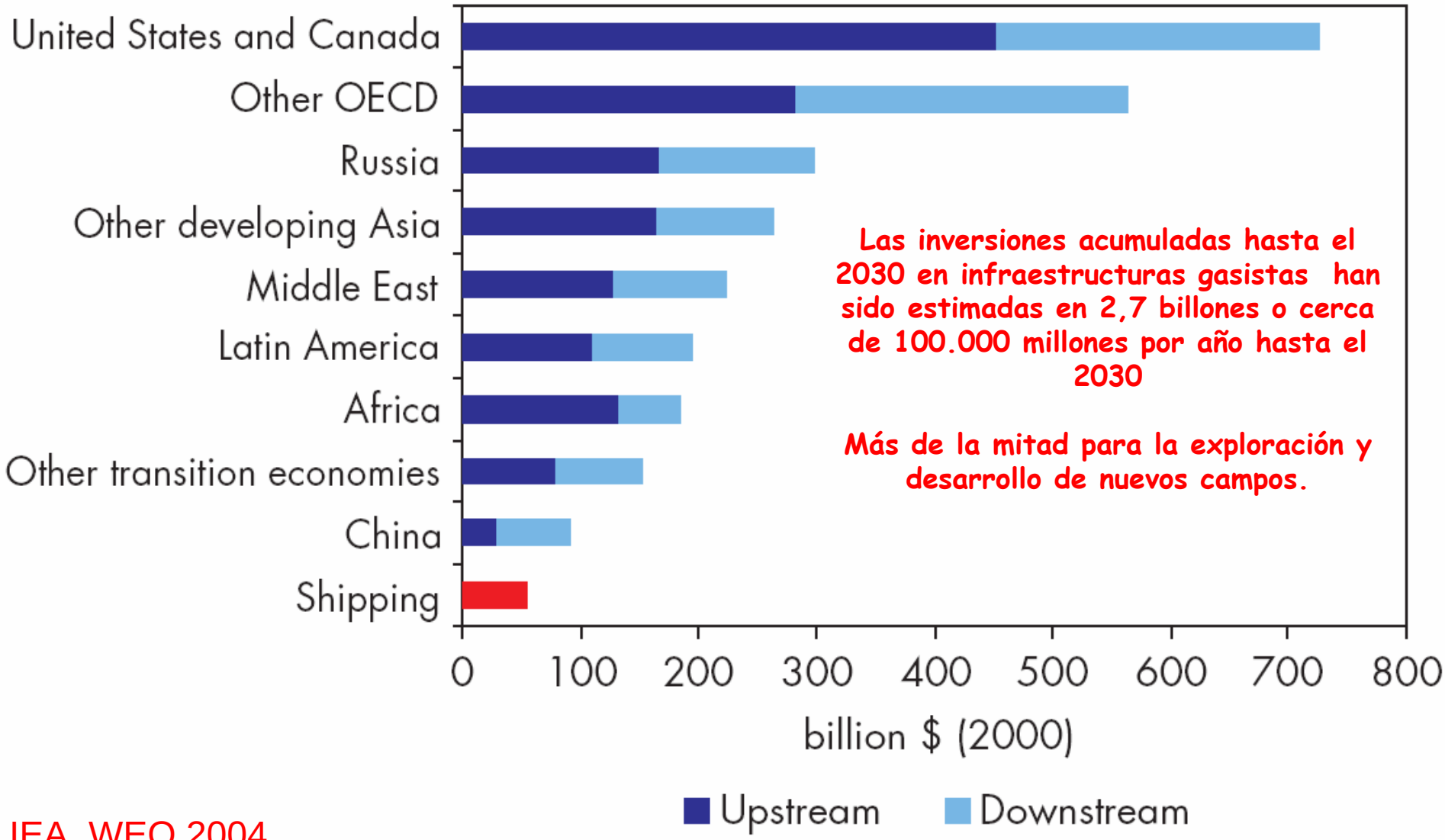
IEA, WEO 2004

2000-2030: 3×10^{12} US $ (E & P 70%)
105.000×10^6 anuales / $287,7 \times 10^6$ diarios



World Energy Outlook 2004

Inversiones en gas natural, 2003-2030



Las inversiones acumuladas hasta el 2030 en infraestructuras gasistas han sido estimadas en 2,7 billones o cerca de 100.000 millones por año hasta el 2030

Más de la mitad para la exploración y desarrollo de nuevos campos.

IEA, WEO 2004

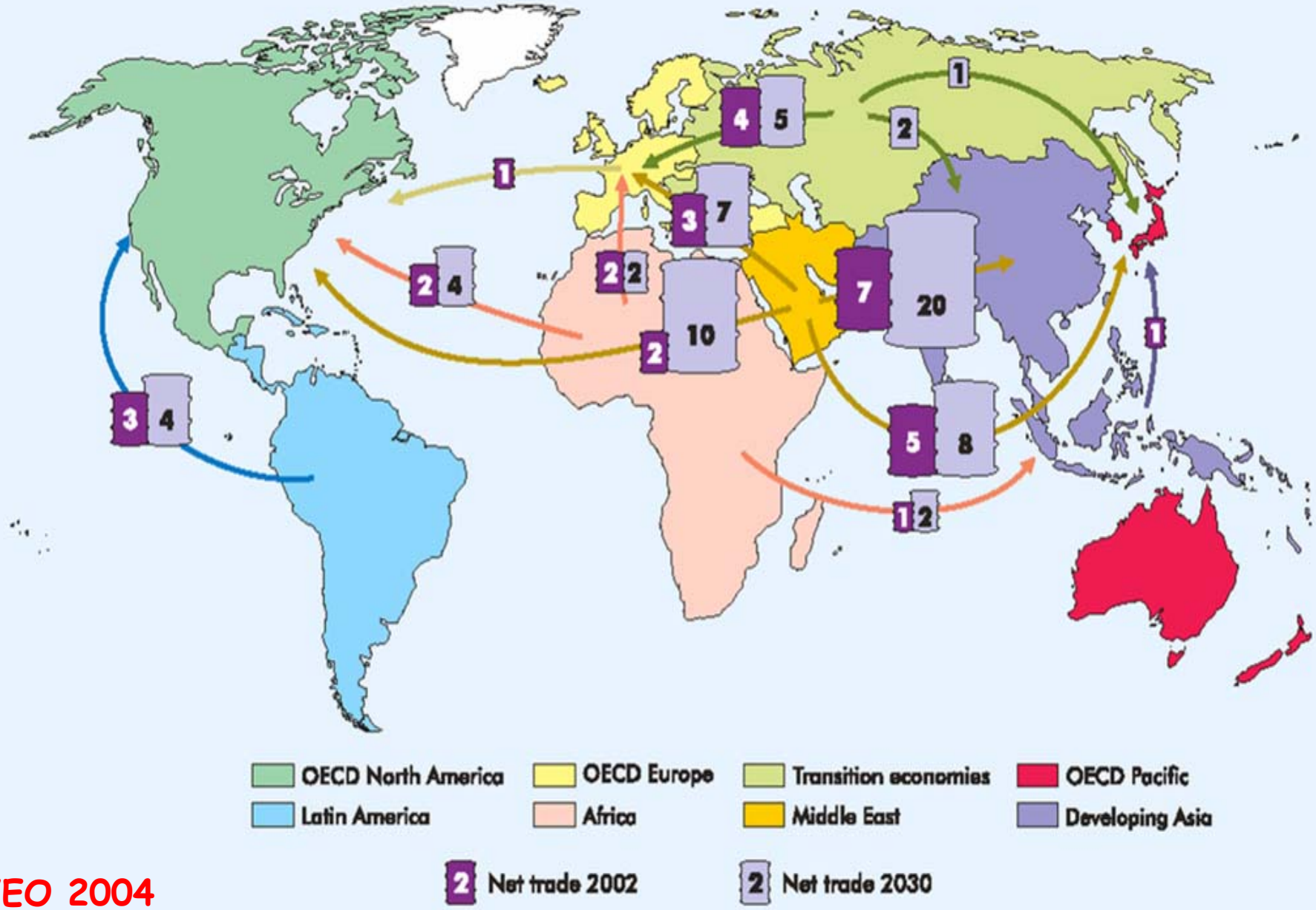
Dependencia de las importaciones

	2002	2010	2020	2030
OECD total	**63**	**68**	**79**	**85**
OECD North America	36	35	47	55
OECD Europe	54	68	80	86
OECD Pacific	90	94	94	95
Developing Asia	**43**	**59**	**72**	**78**
China	34	55	68	74
India	69	80	87	91
Other Asia	40	54	68	76
European Union	*76*	*85*	*91*	*94*

Note: Imports include non-conventional oil.

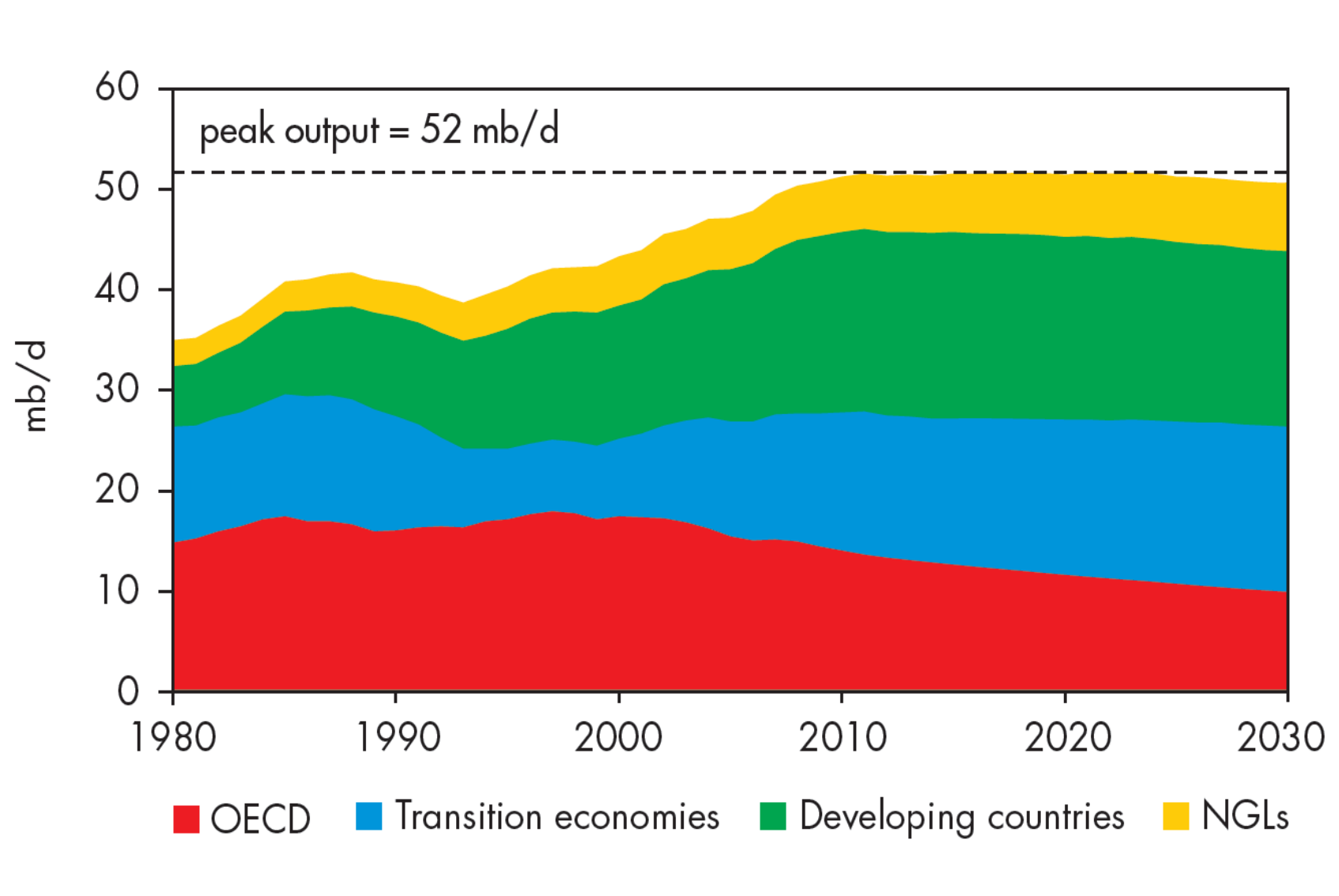
WEO 2004

Comercio mundial de petróleo (millones barriles/día)

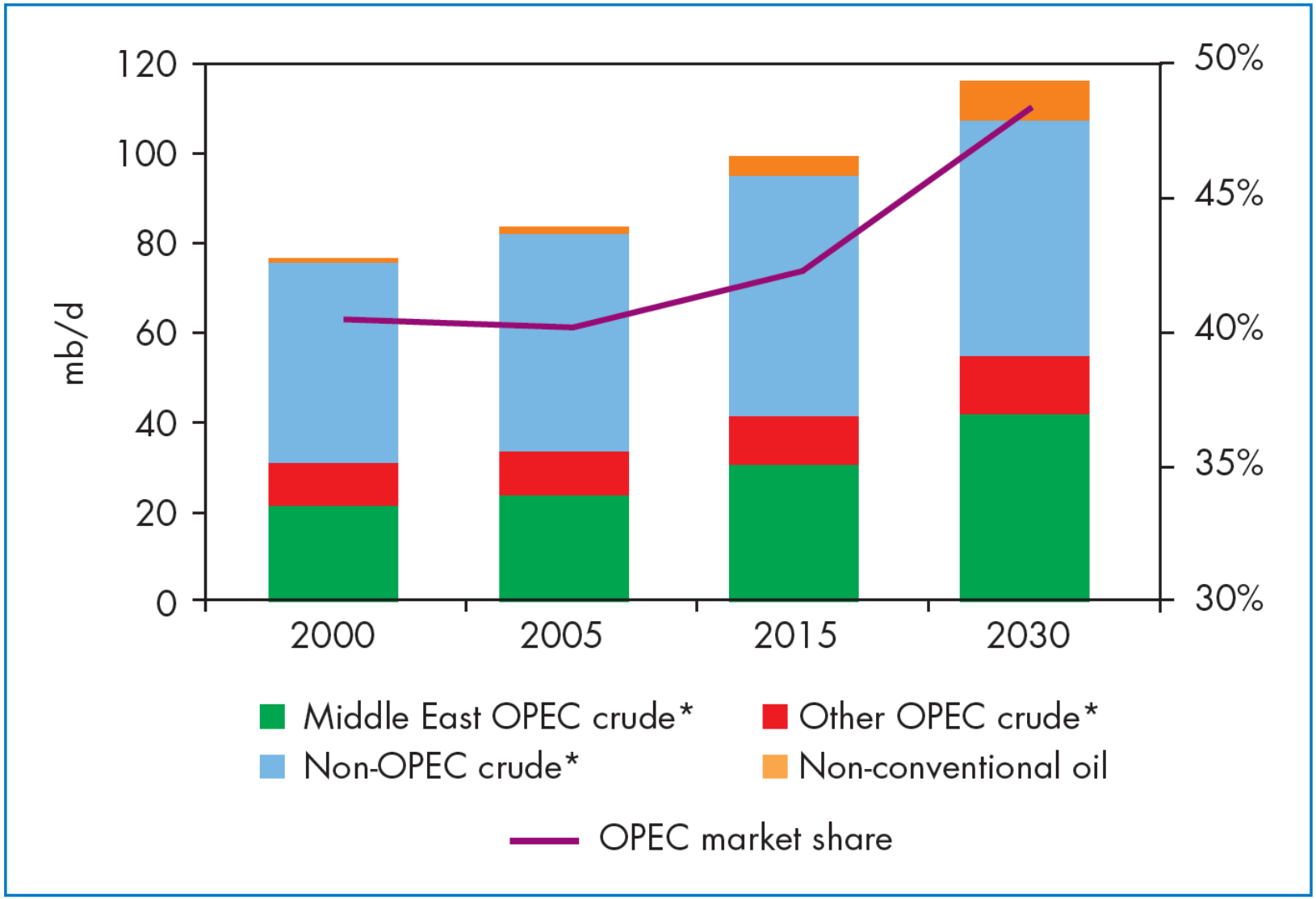


WEO 2004

No-OPEP: extracción de crudo convencional y LGN

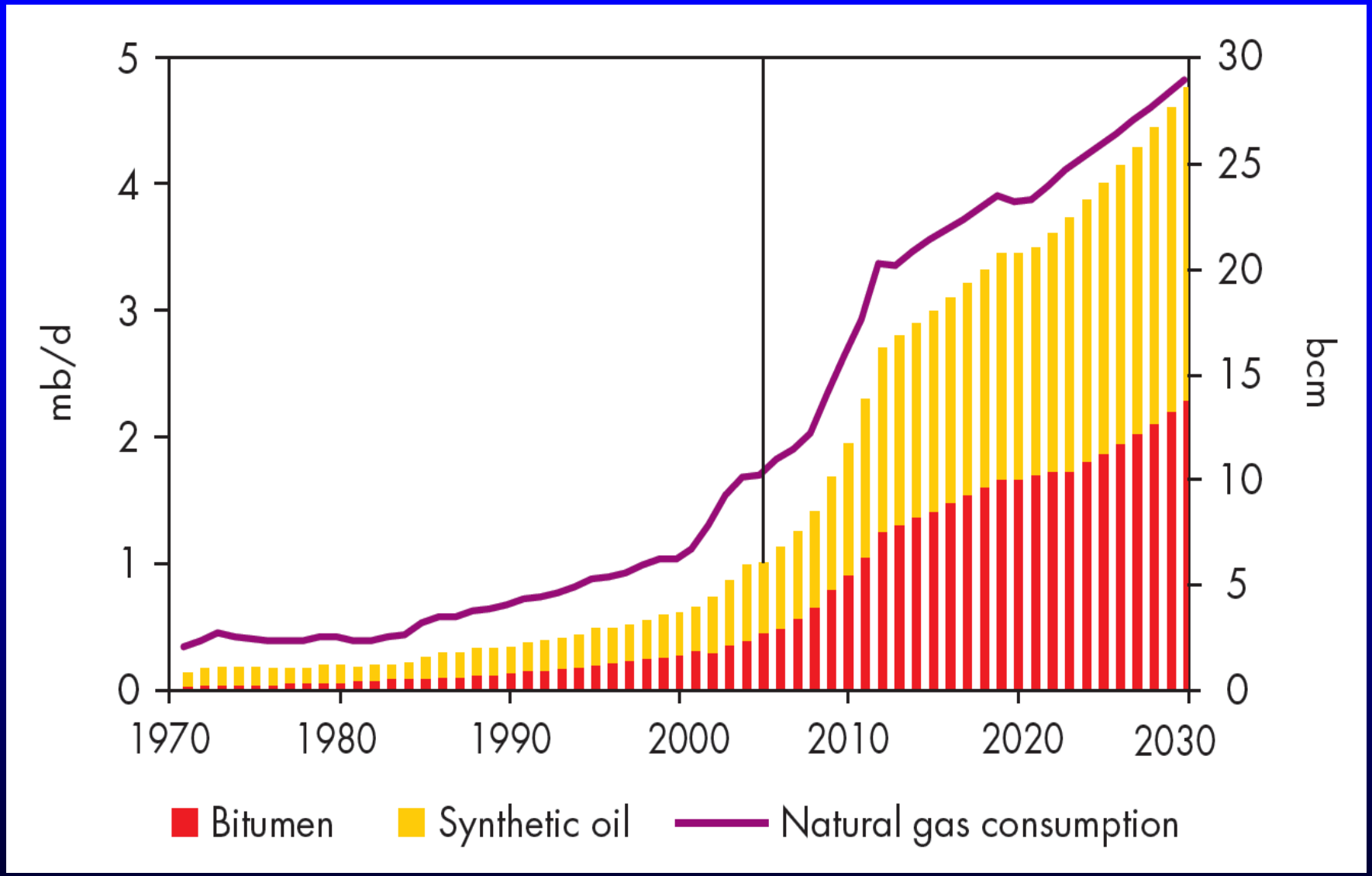


OPEP vs No-OPEP



*Including NGLs.

Extracción de crudo no convencional y consumo de gas en Canadá



Dependencia de las importaciones de gas natural

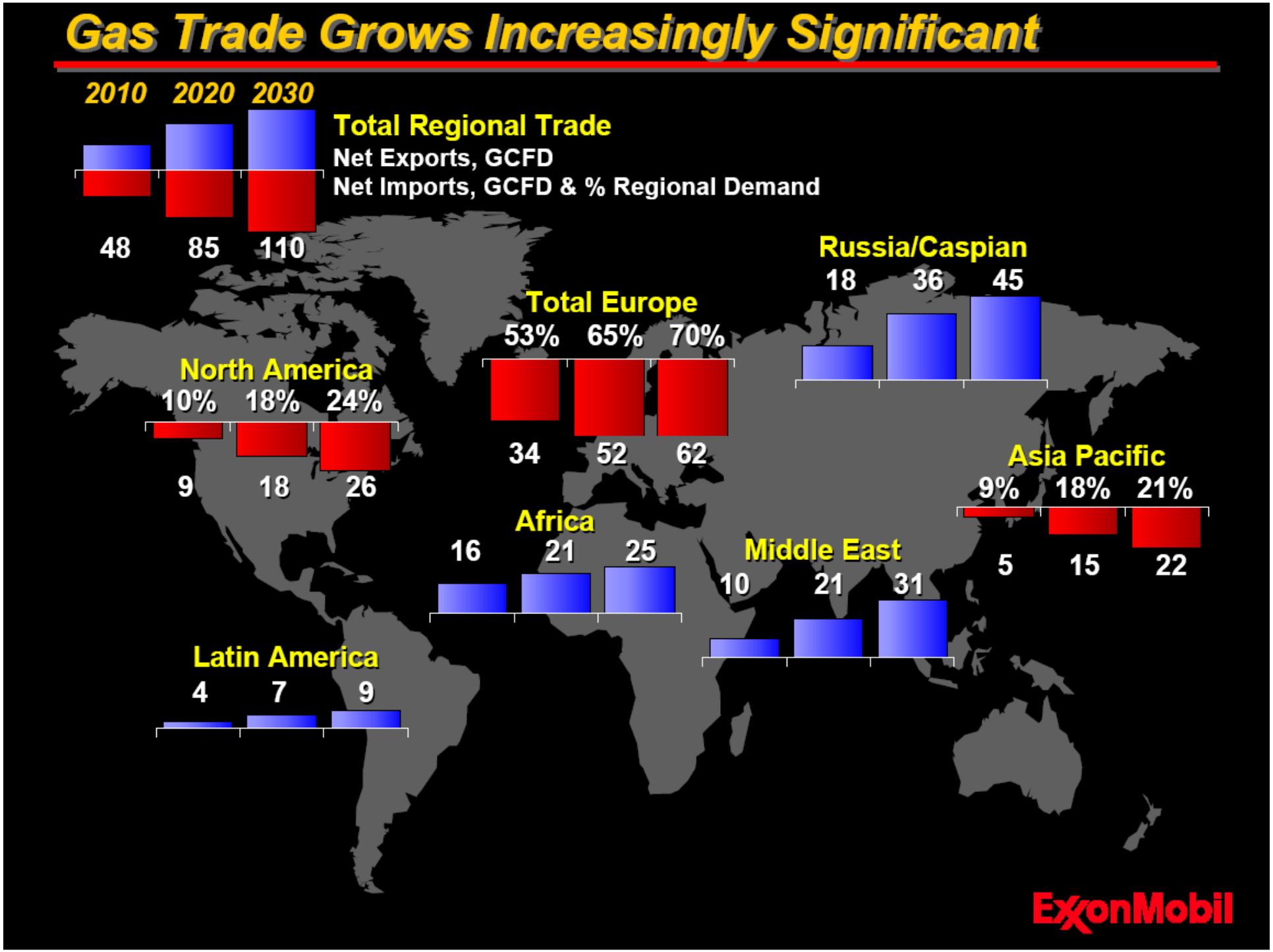
	2002		2010		2030	
	Bcm*	%**	Bcm*	%**	Bcm*	%**
OECD North America	0	0	33	4	197	18
OECD Europe	162	36	267	46	525	65
OECD Asia	98	98	130	97	183	94
China	0	0	9	15	42	27
India	0	0	10	23	44	40
European Union	*233*	*49*	*342*	*60*	*639*	*81*

* Net imports.

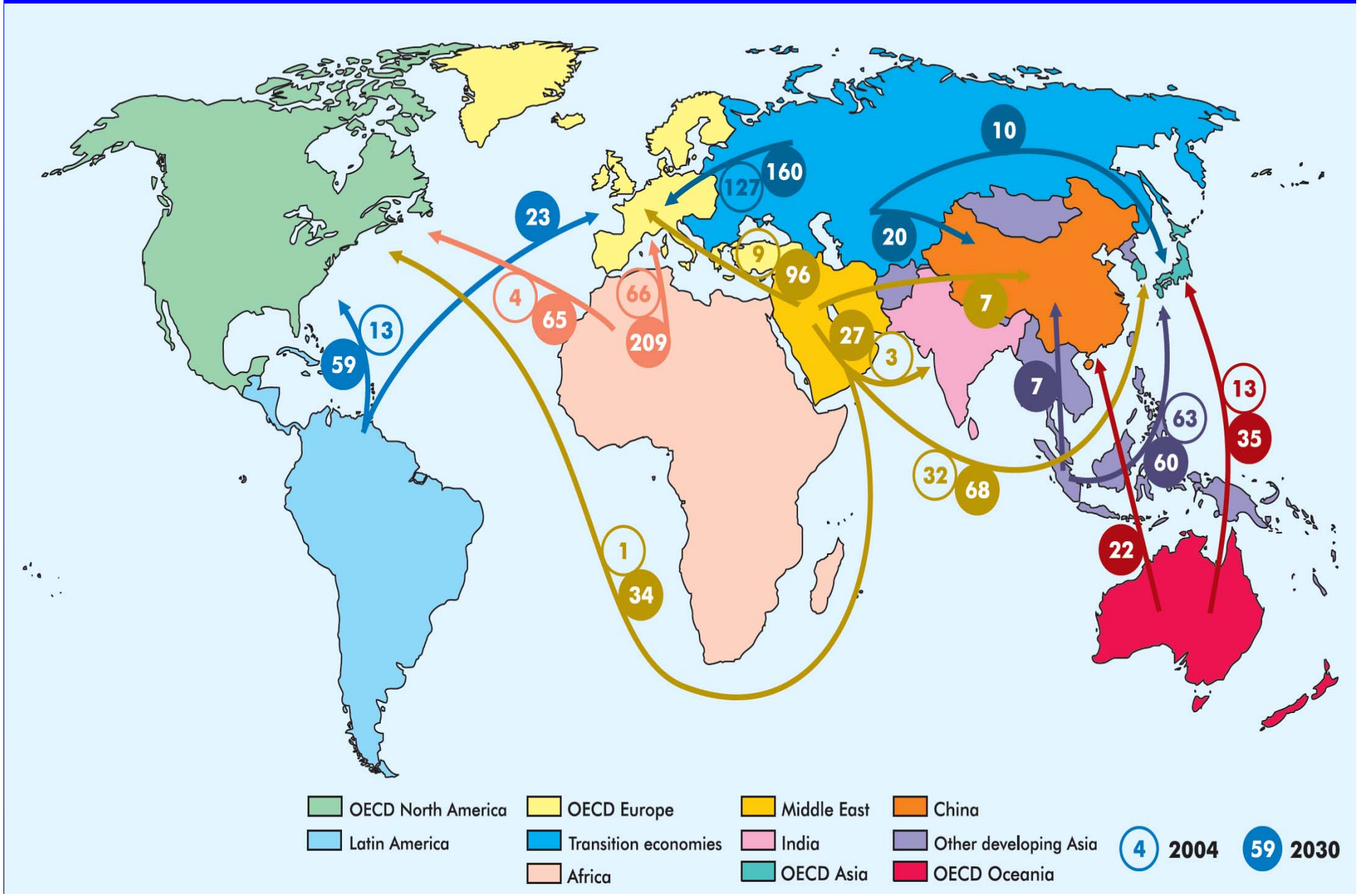
** Per cent of primary gas supply.

IEA, WEO 2004

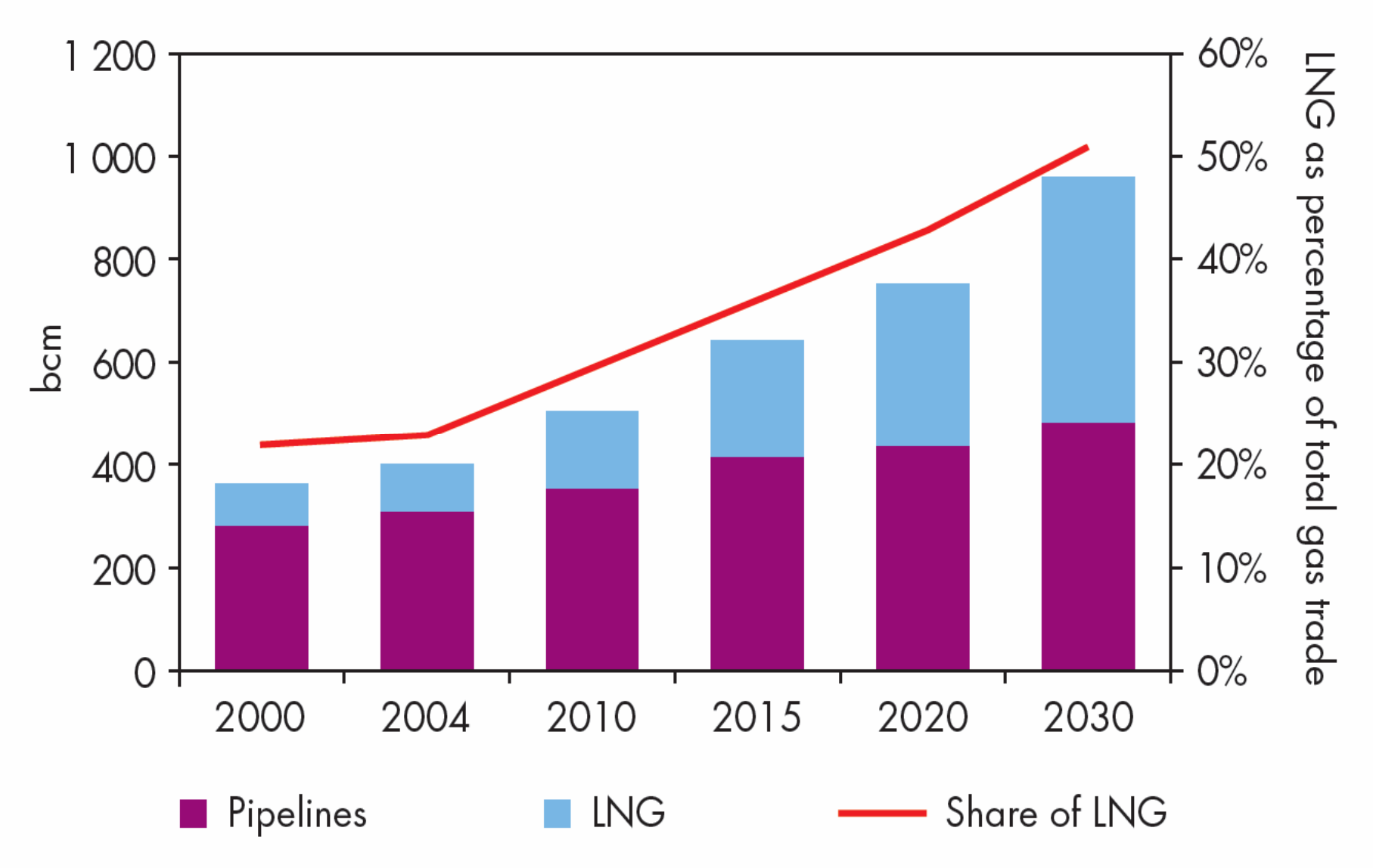
Gas Trade Grows Increasingly Significant



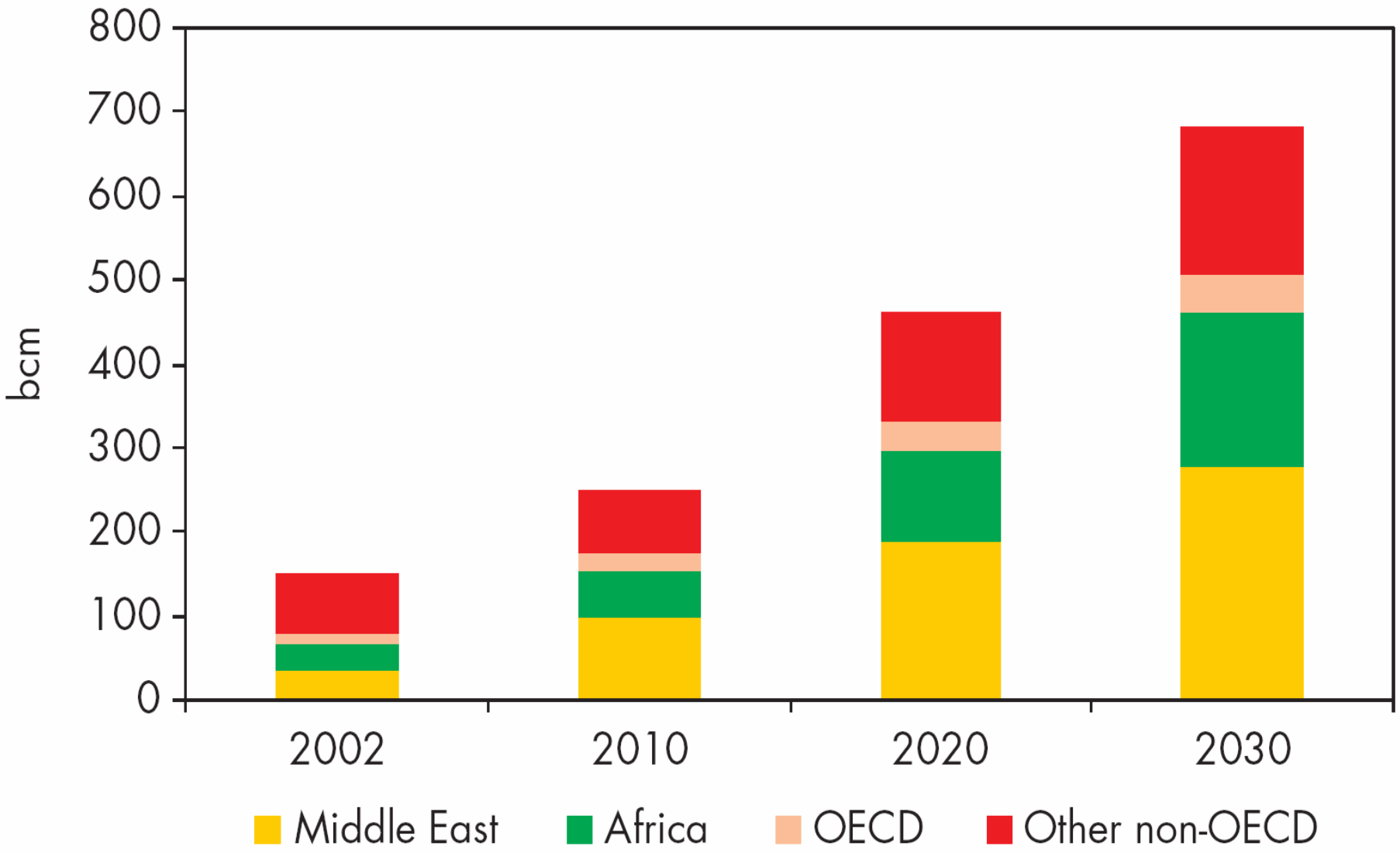
Comercio mundial de gas (10^9 metros cúbicos)



El creciente protagonismo del GNL

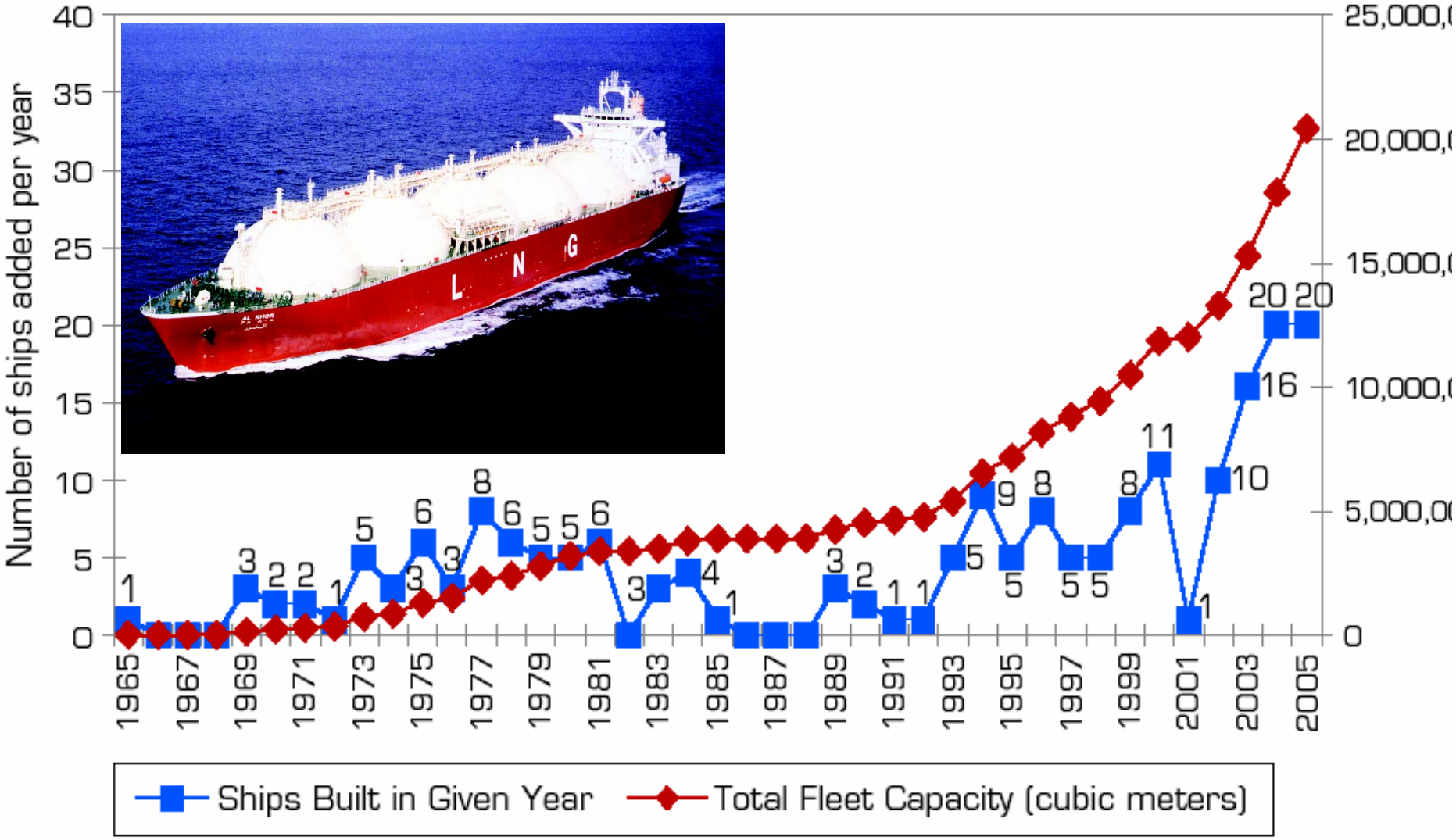


Procedencia del GNL

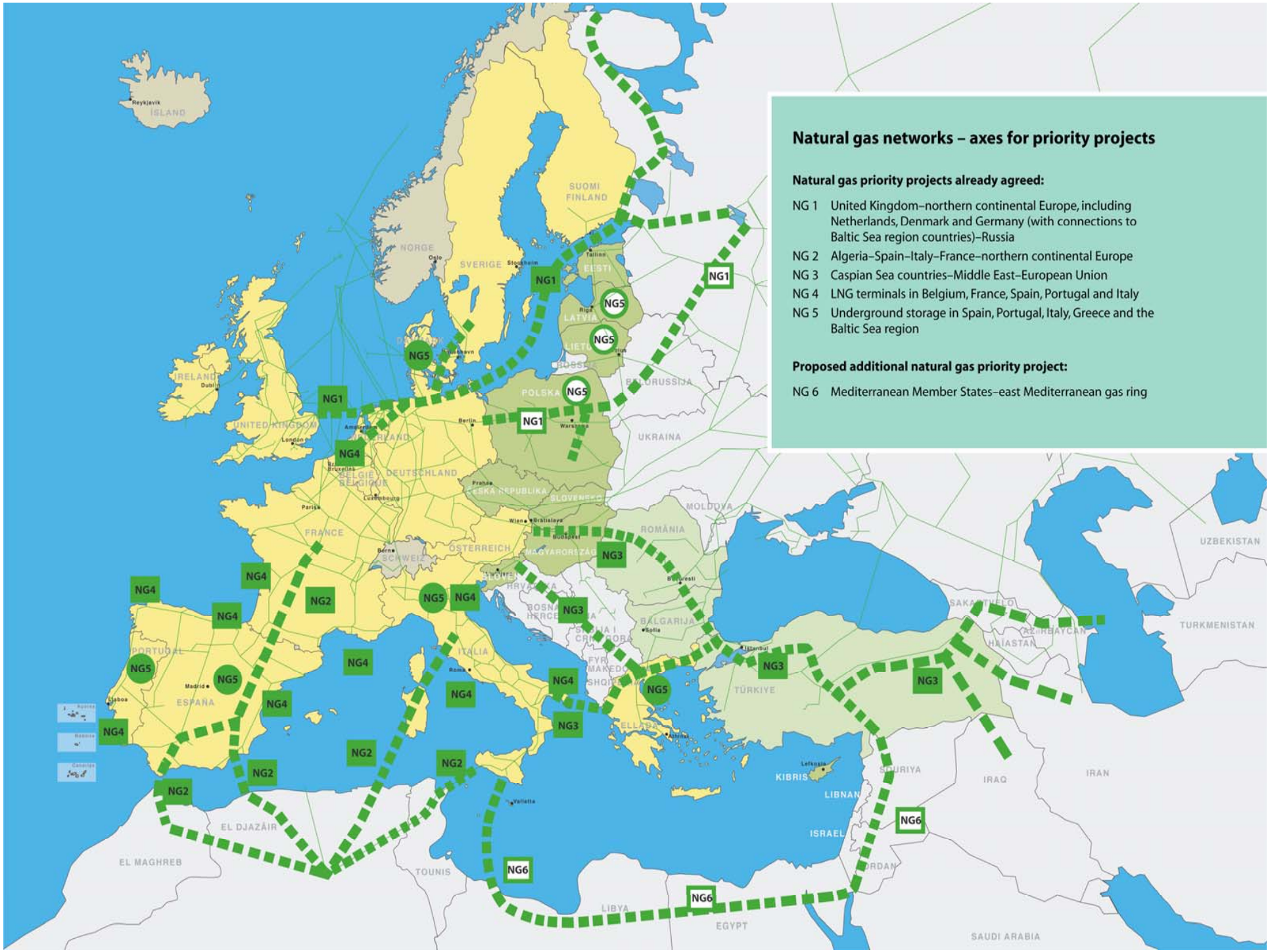


IEA, WEO 2004

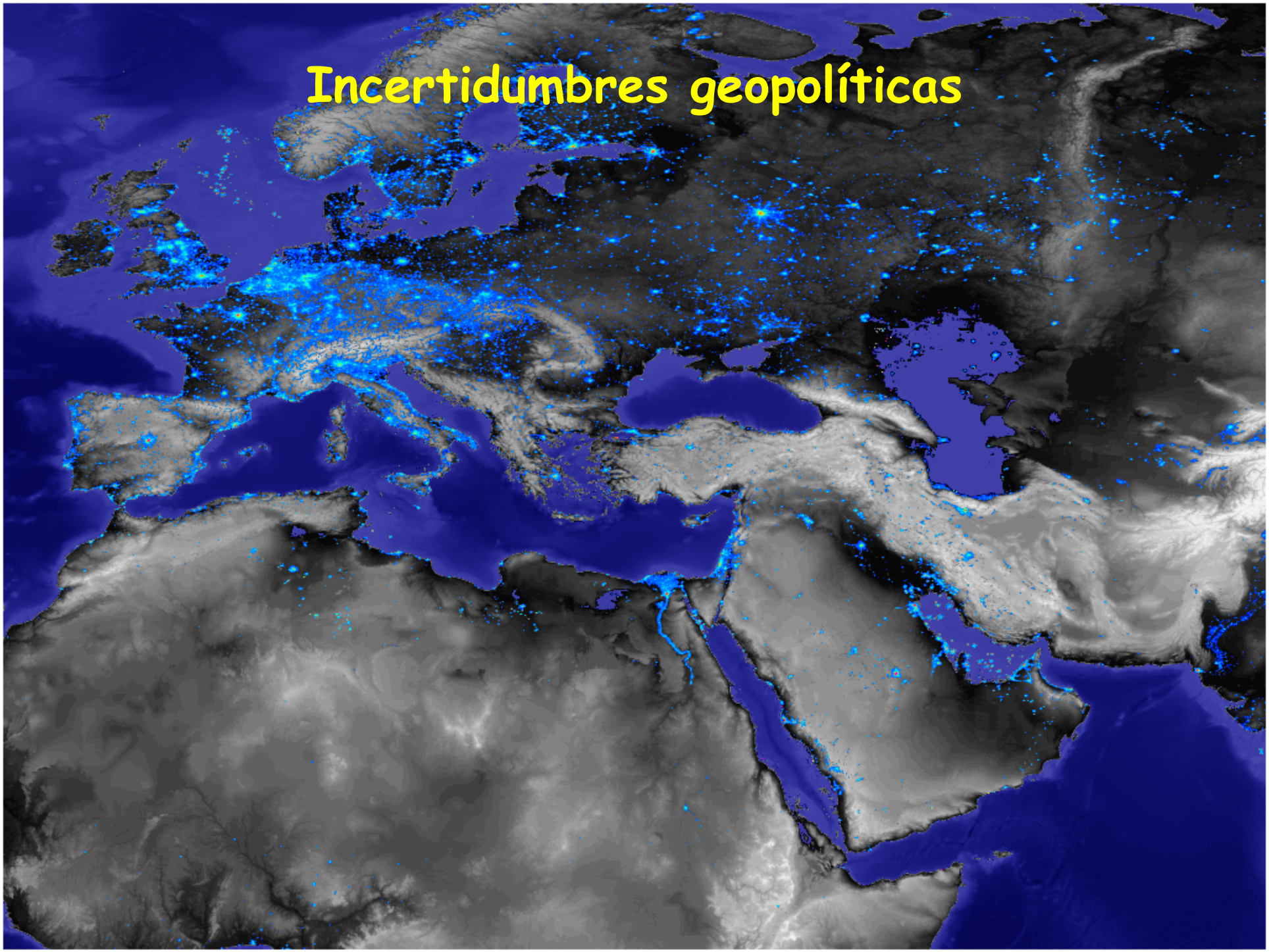
Flota de metaneros, 1965-2006



Source: LNG Shipping Solutions

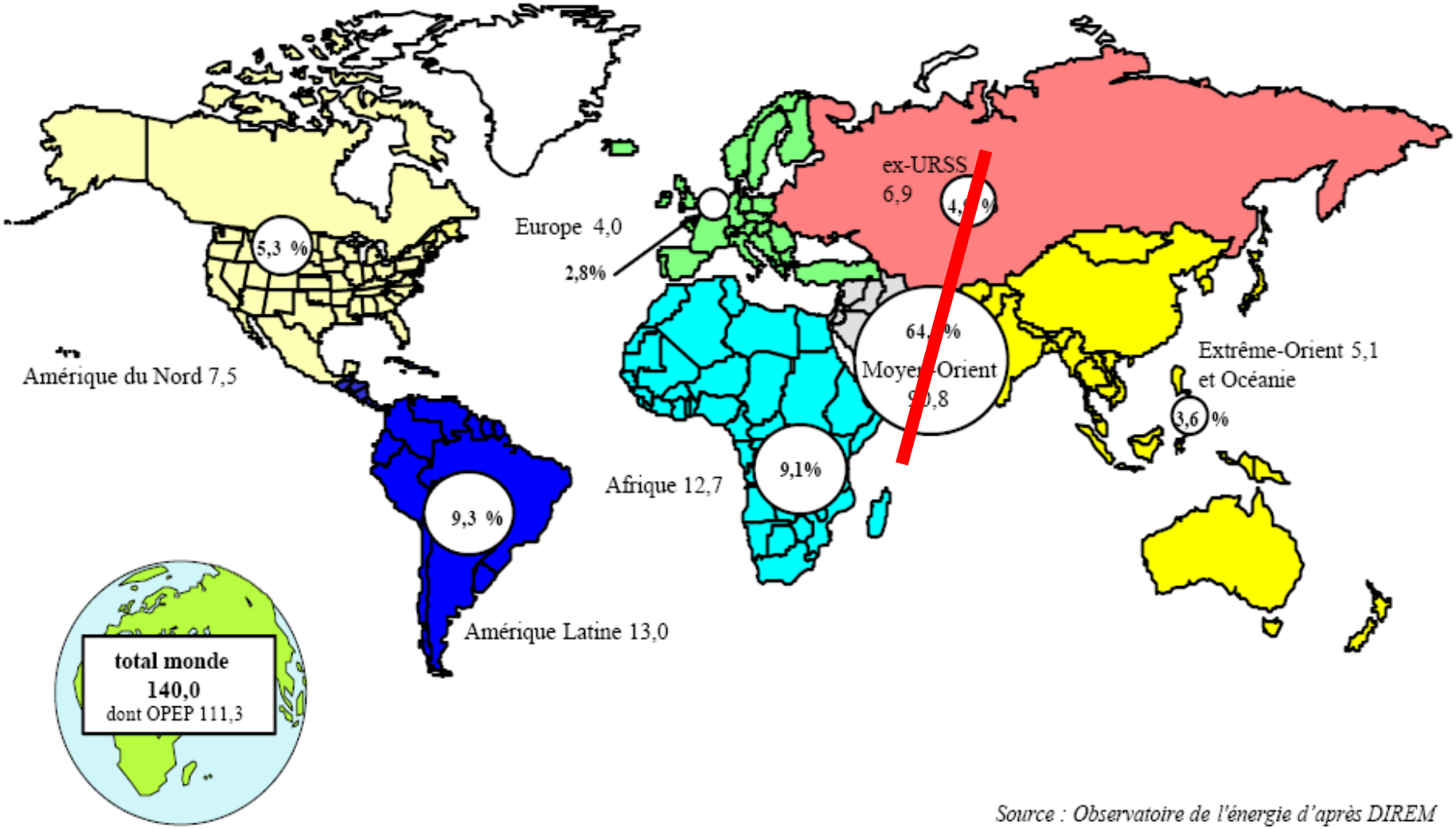

Natural gas networks – axes for priority projects
Natural gas priority projects already agreed:
NG 1 United Kingdom–northern continental Europe, including Netherlands, Denmark and Germany (with connections to Baltic Sea region countries)–Russia
NG 2 Algeria–Spain–Italy–France–northern continental Europe
NG 3 Caspian Sea countries–Middle East–European Union
NG 4 LNG terminals in Belgium, France, Spain, Portugal and Italy
NG 5 Underground storage in Spain, Portugal, Italy, Greece and the Baltic Sea region
Proposed additional natural gas priority project:
NG 6 Mediterranean Member States–east Mediterranean gas ring
ISLAND
NORGE
SVERIGE
SUOMI FINLAND
EESTI
LATVIJA
LIETUVA
BELARUSSIJA
UKRAINA
POLSKA
IRELAND
UNITED KINGDOM
DEUTSCHLAND
BELGIE BELGIQUE
FRANCE
SCHWEIZ
ÖSTERREICH
MAGYARORSZÁG
ROMÂNIA
MOLDOVA
BALGARIJA
ITALIA
PORTUGAL
ESPAÑA
ELLADA
TÜRKIYE
KIBRIS
LIBNAN
ISRAEL
IRAQ
IRAN
UZBEKISTAN
TURKMENISTAN
EL DJAZÂIR
EL MAGHREB
TOUNIS
LIBYA
EGYPT
SAUDI ARABIA
NG1
NG2
NG3
NG4
NG5
NG6

Incertidumbres geopolíticas



Réserves mondiales prouvées de pétrole brut (1er janvier 2004)

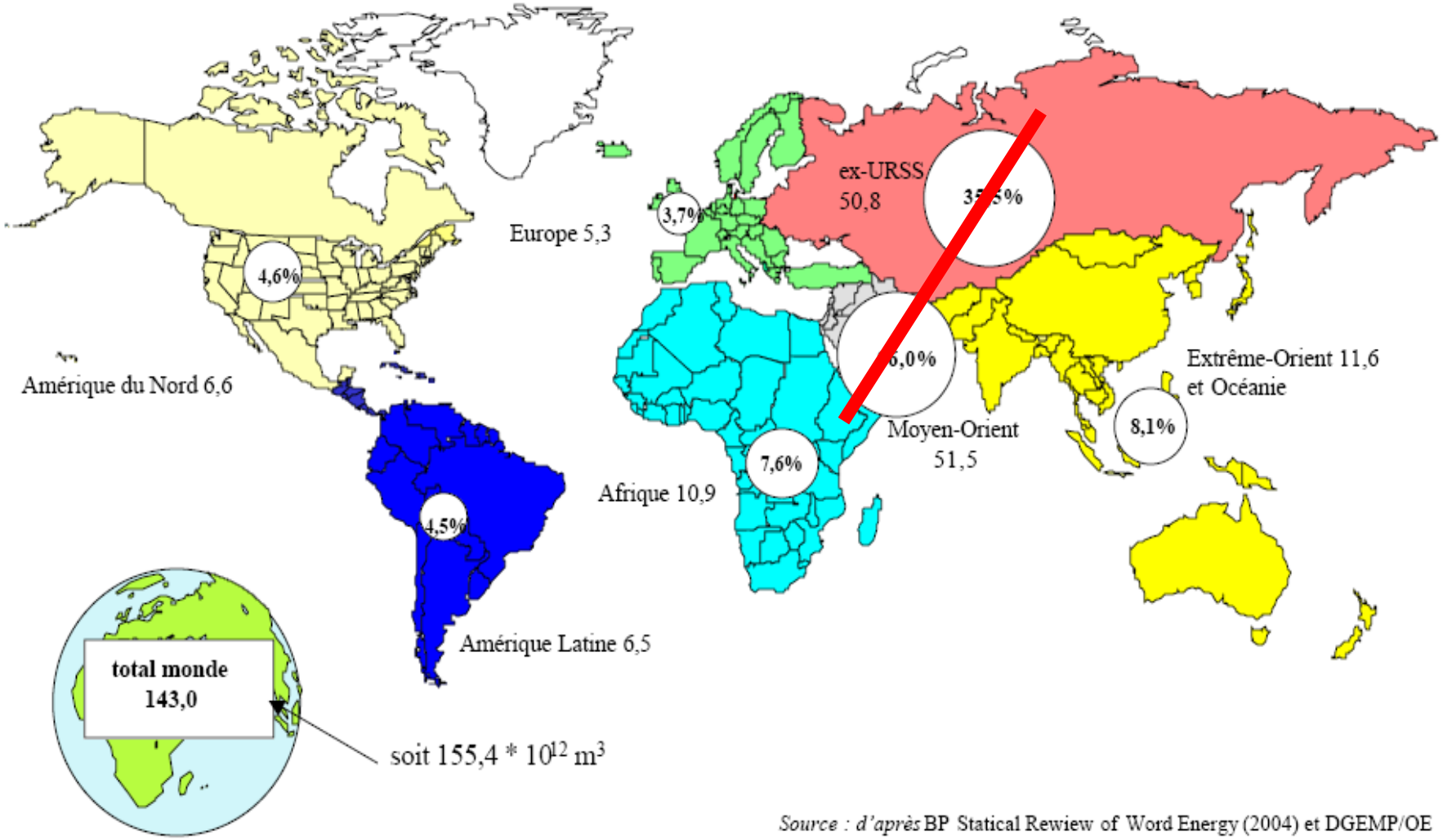
Unité : Milliard de tep



Source : Observatoire de l'énergie d'après DIREM

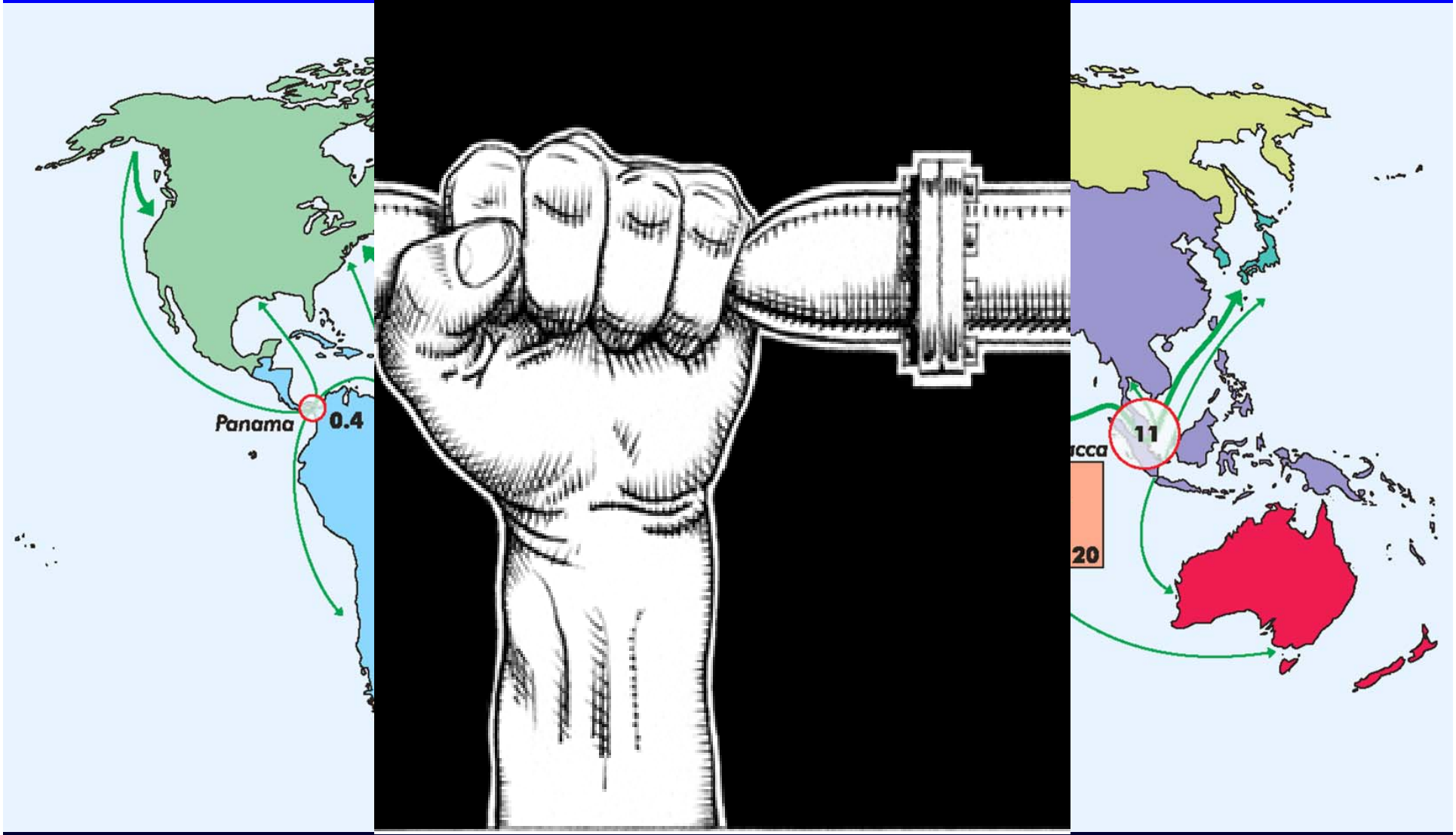
Réserves mondiales prouvées de gaz naturel (1er janvier 2003)

Unité : Milliard de tep



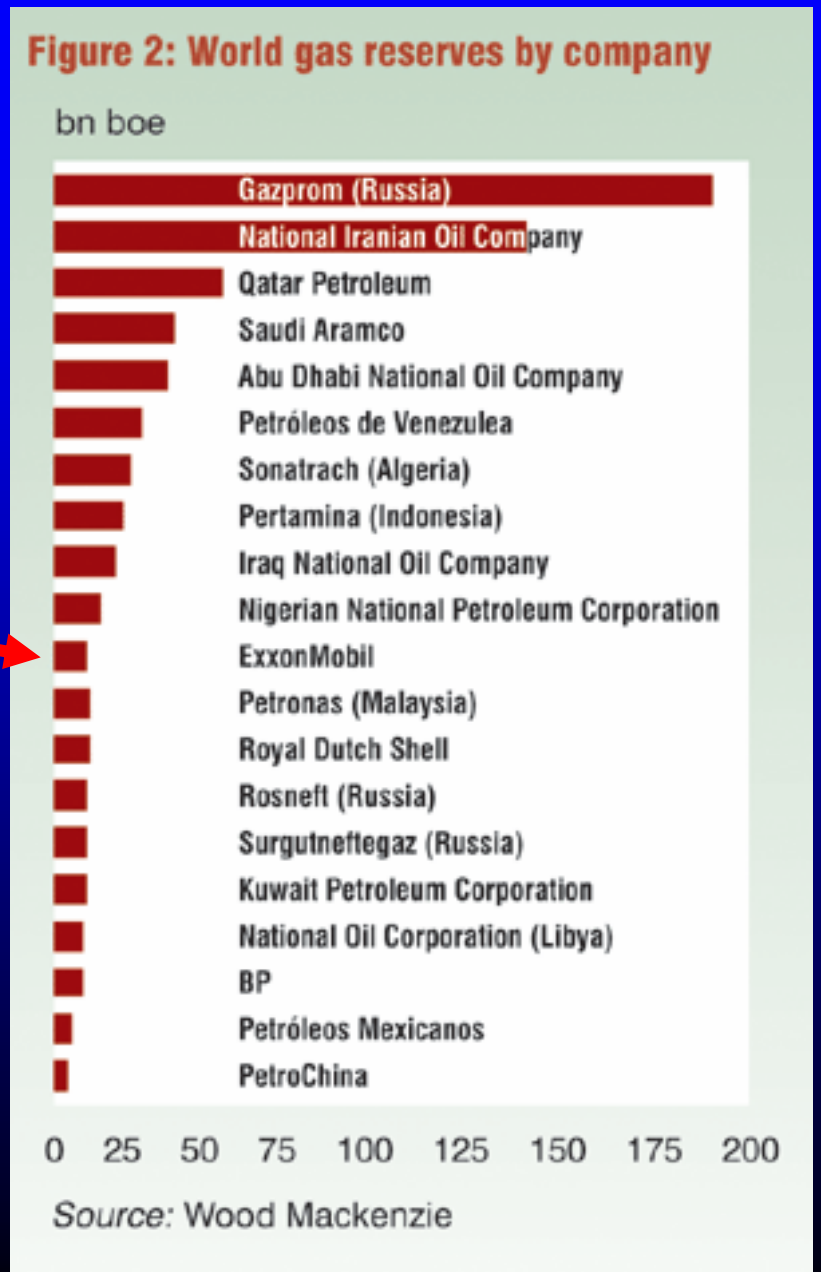
Source : d'après BP Statical Rewiew of Word Energy (2004) et DGEMP/OE

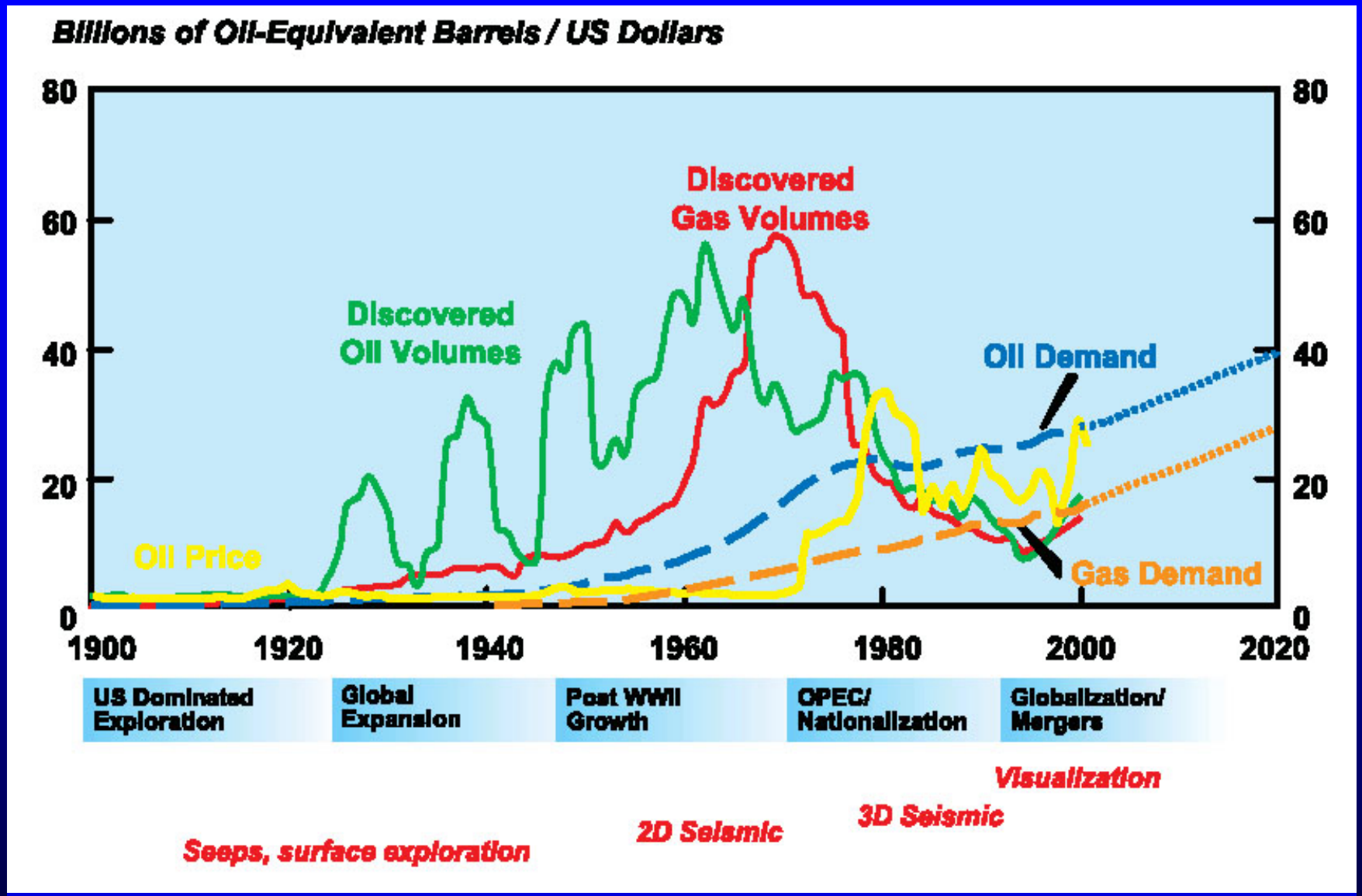
"Choke points"
El talón de Aquiles de Occidente



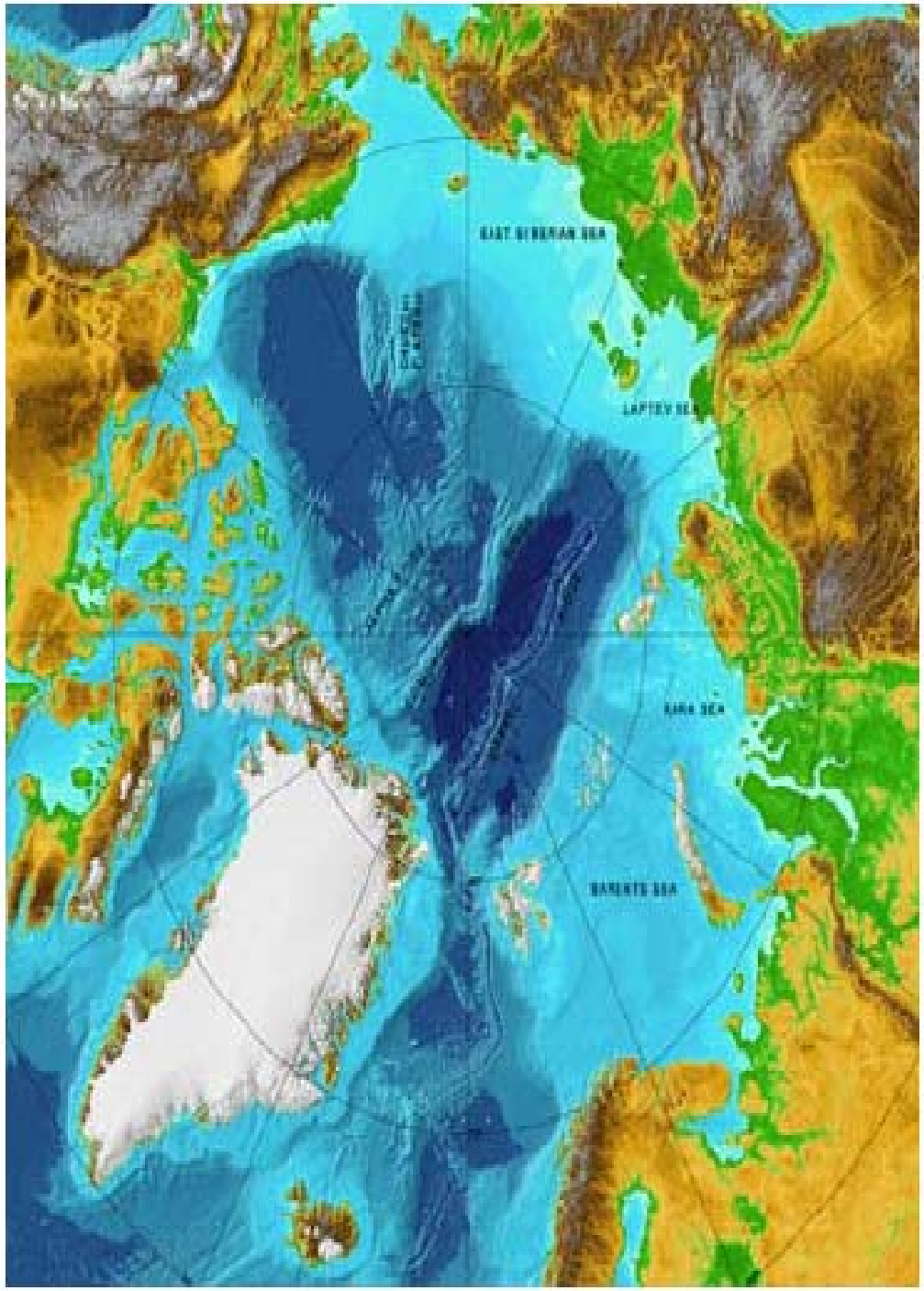
WEO 2004

Reservas: IOC's vs NOC's





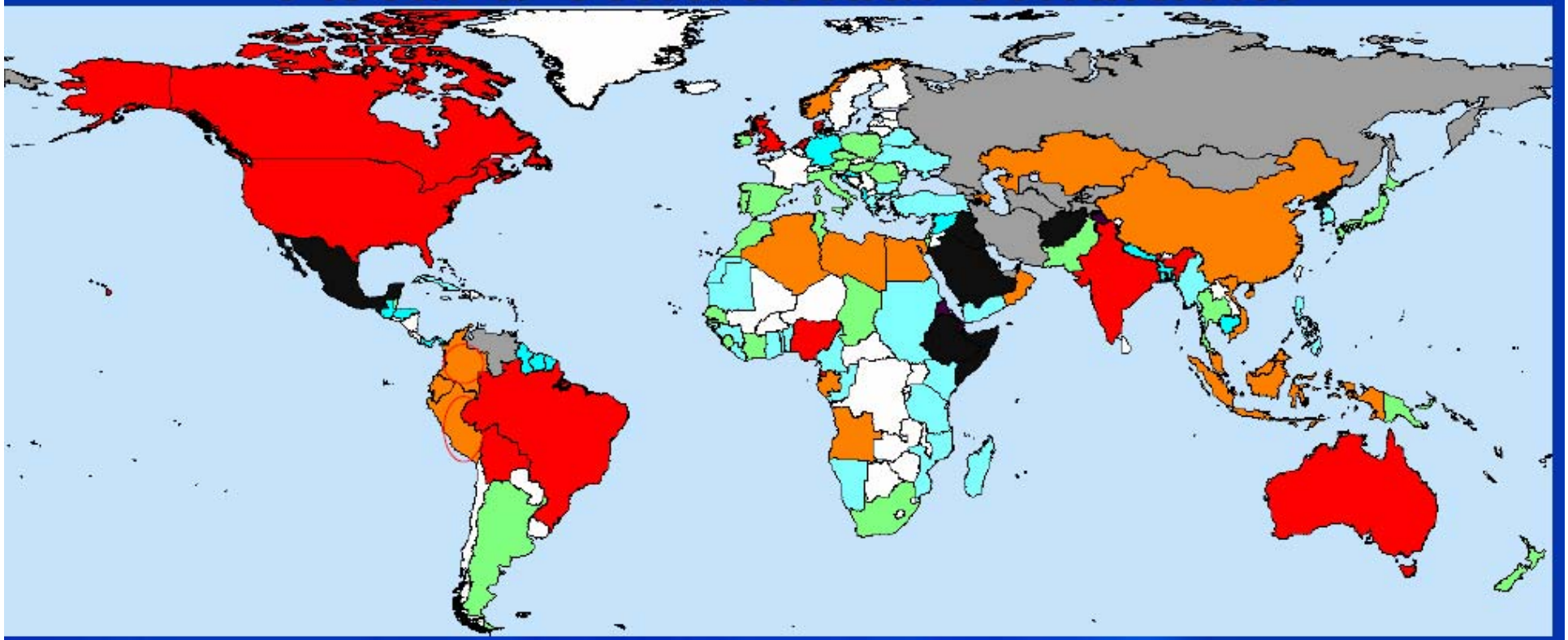
Precios más altos = más descubrimientos?
Longwell,H.J., CEO ExxonMobil, 2002



USGS: 25% of the world's undiscovered resources to be found in the Arctic

Source: USGS, Statoil

Fiscal & Contractual Conditions

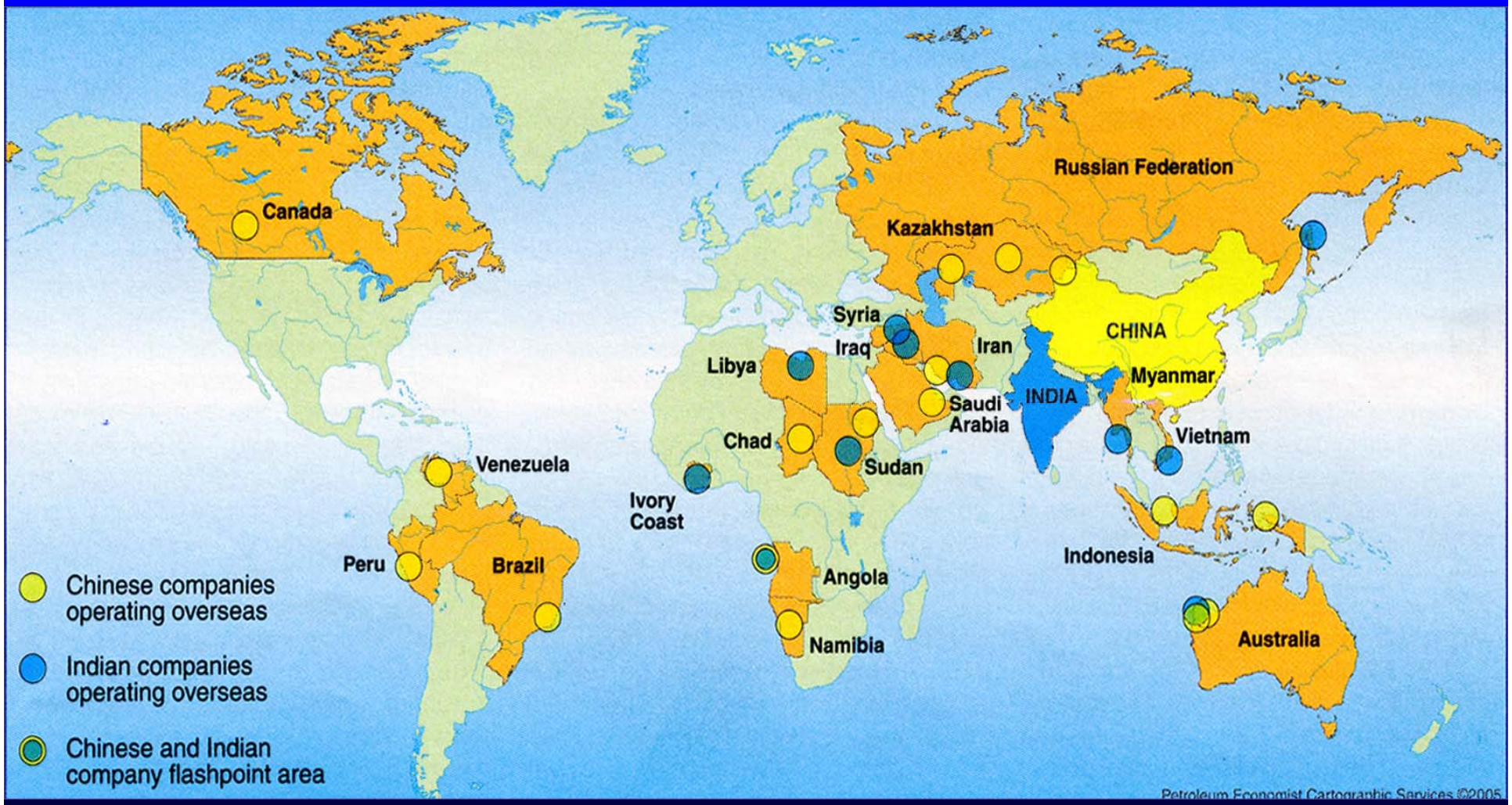


- Prospective, actively seeking investment with low tax rates
- Prospective, seeking investment but with high tax rates and regulation
- Low Prospectivity, but actively seeking investment with low tax rates
- Low Prospectivity, and non-competitive fiscal terms, or unfavourable contract environmen
- Very Low Prospectivity, no significant opportunity
- Fiscal/Legal instability, or policies which deter investment
- Closed to foreign investors

All content © 2004 IHS Energy

IHS ENERGY

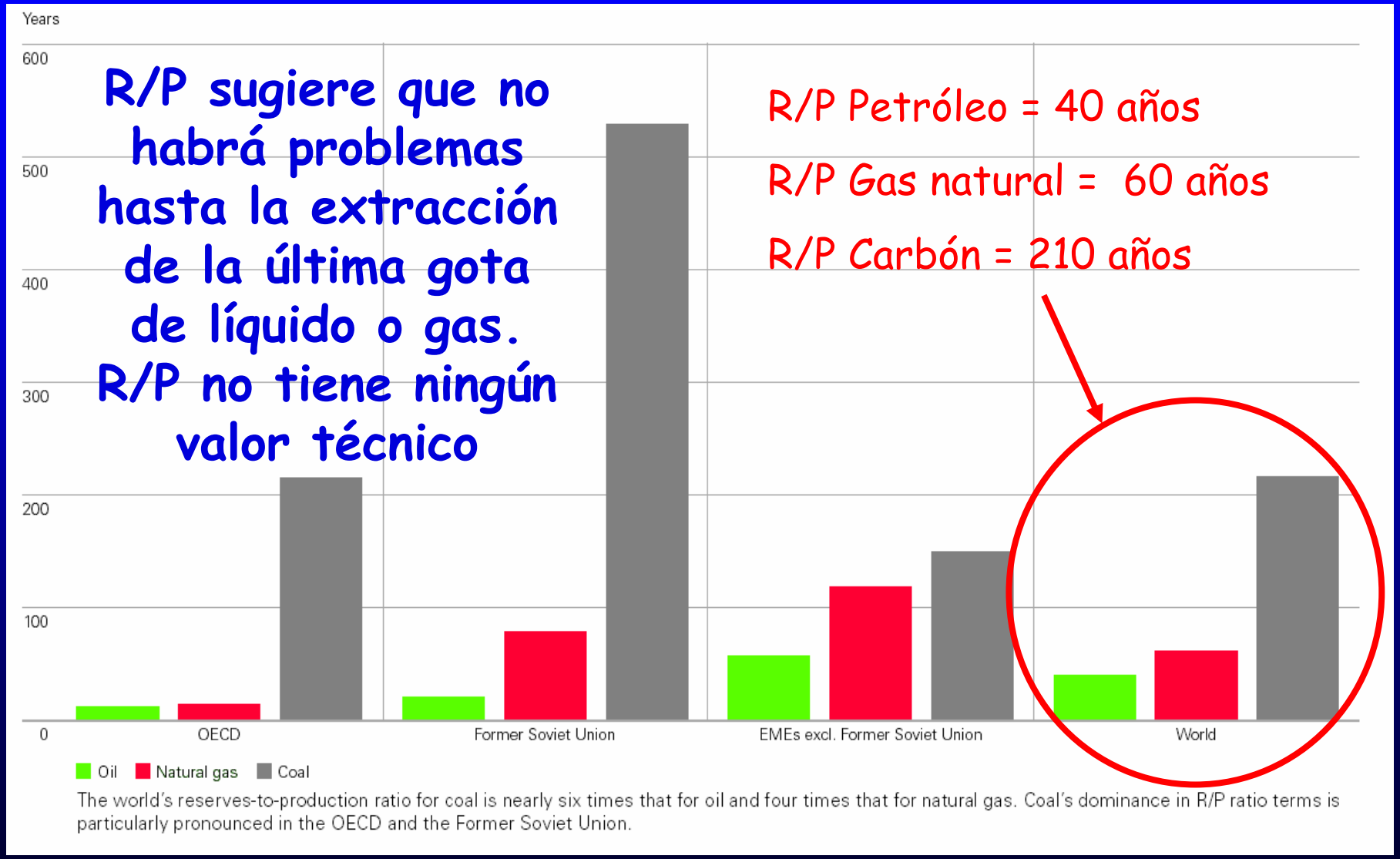
Chinese and Indian NOC's



Y por si todo esto fuera poco todavía nos queda por considerar la parte sumergida del iceberg

Recuerden estas dos palabras: "peak oil"

Disponibilidad de reservas y recursos
Cociente ente reservas y "producción" (R/P)



The world's reserves-to-production ratio for coal is nearly six times that for oil and four times that for natural gas. Coal's dominance in R/P ratio terms is particularly pronounced in the OECD and the Former Soviet Union.

BP SRWE 2002

Extraer el petróleo es como extraer el café que impregna un terrón de azúcar

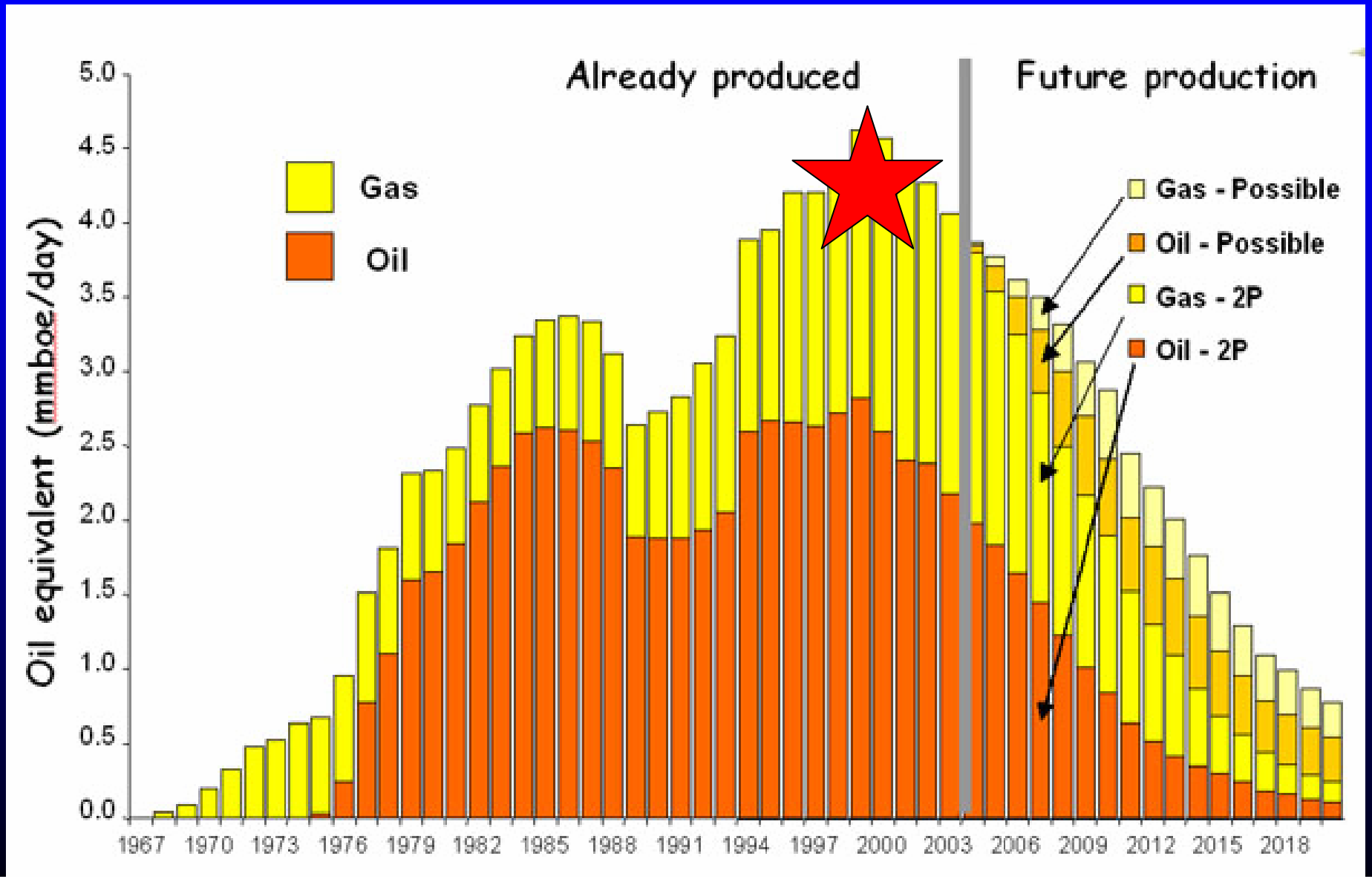
primero se extrae lo fracción que fluye más fácilmente (crudos menos viscosos y de buena calidad)…

para el final va quedando lo peor (mayor viscosidad)

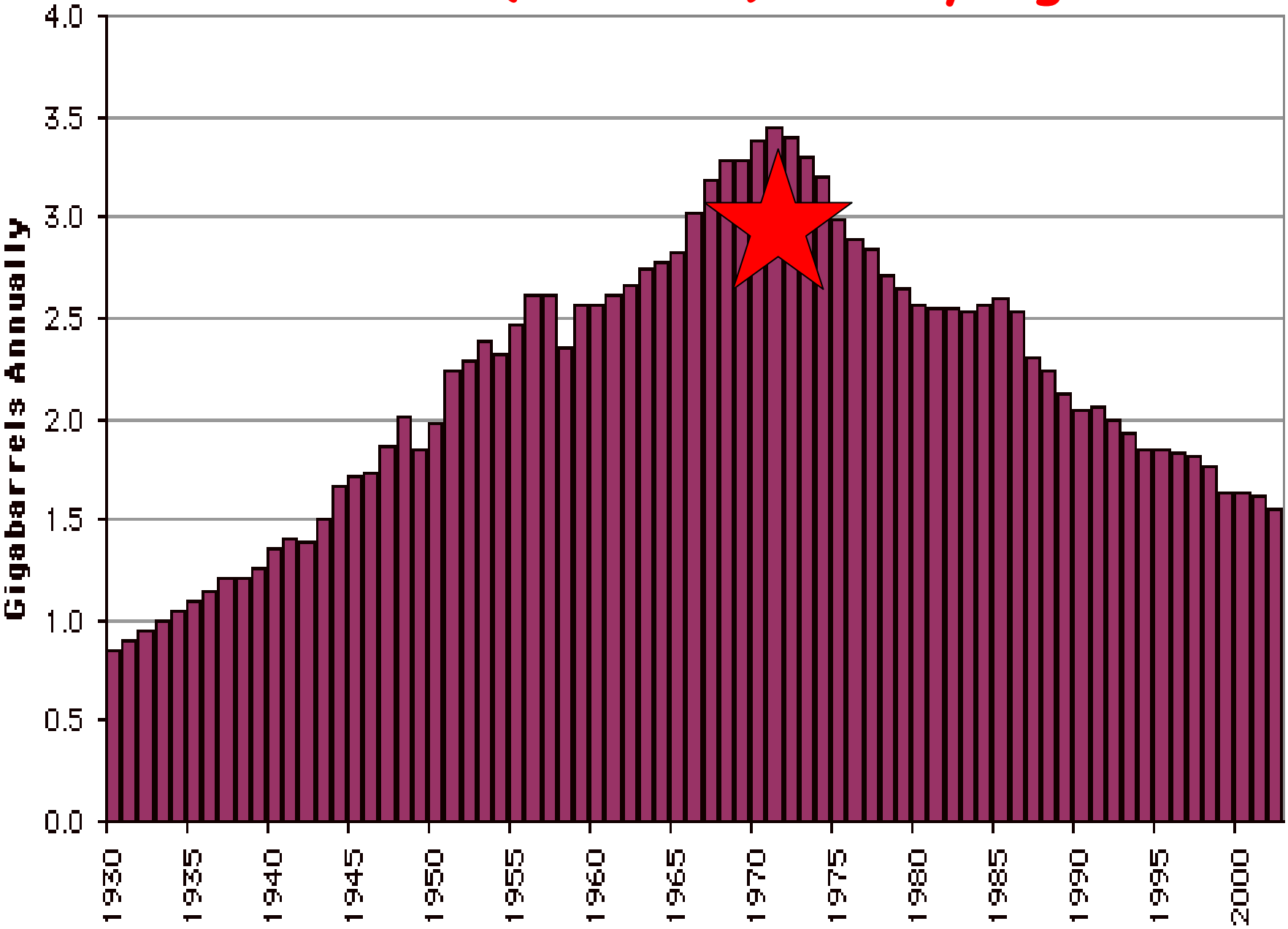
¿evolución extracción con el tiempo?

La curva de Hubbert.

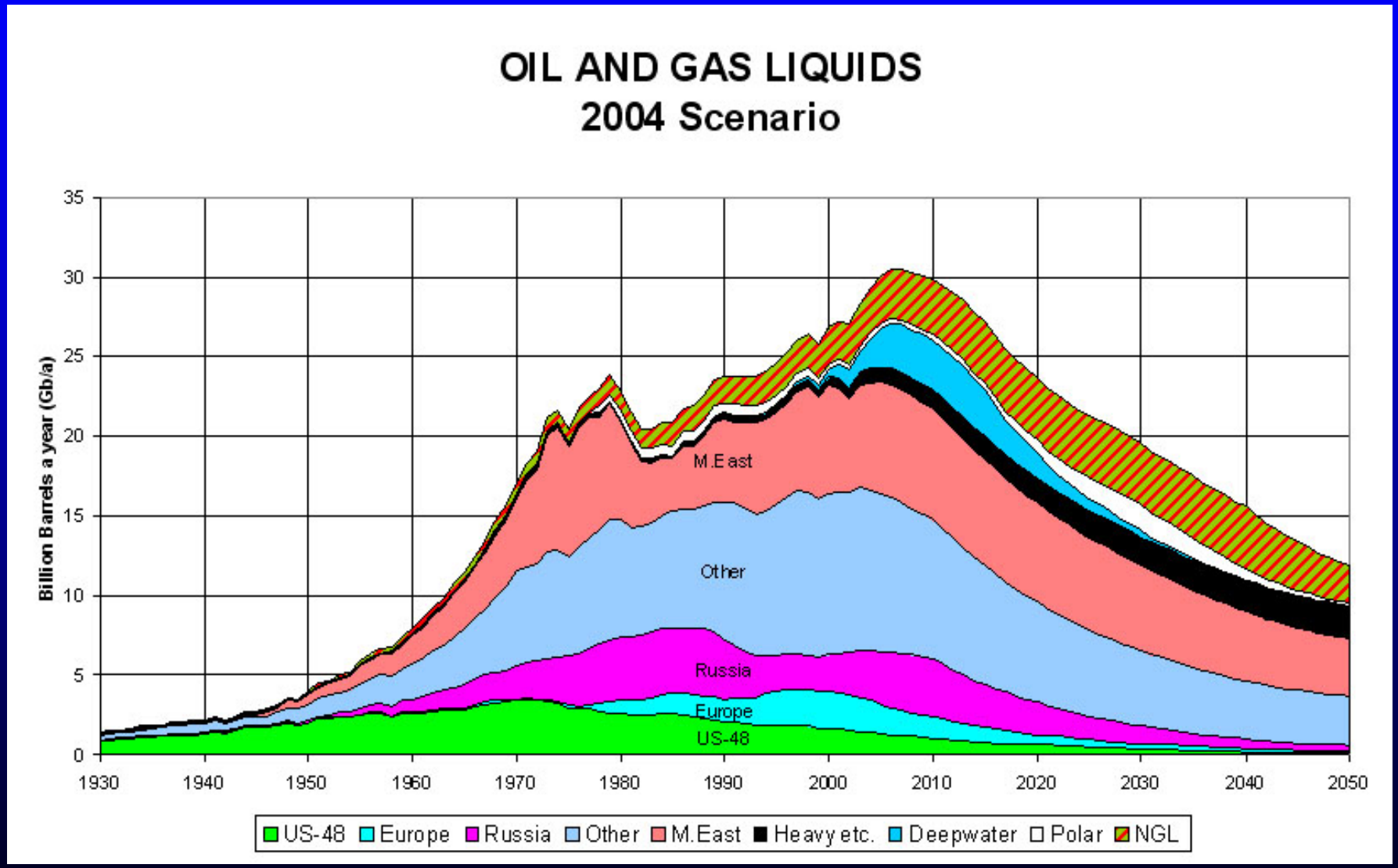
El cenit de la extracción marca un antes y un después



El caso de los EUA (lower 48) es muy significativo



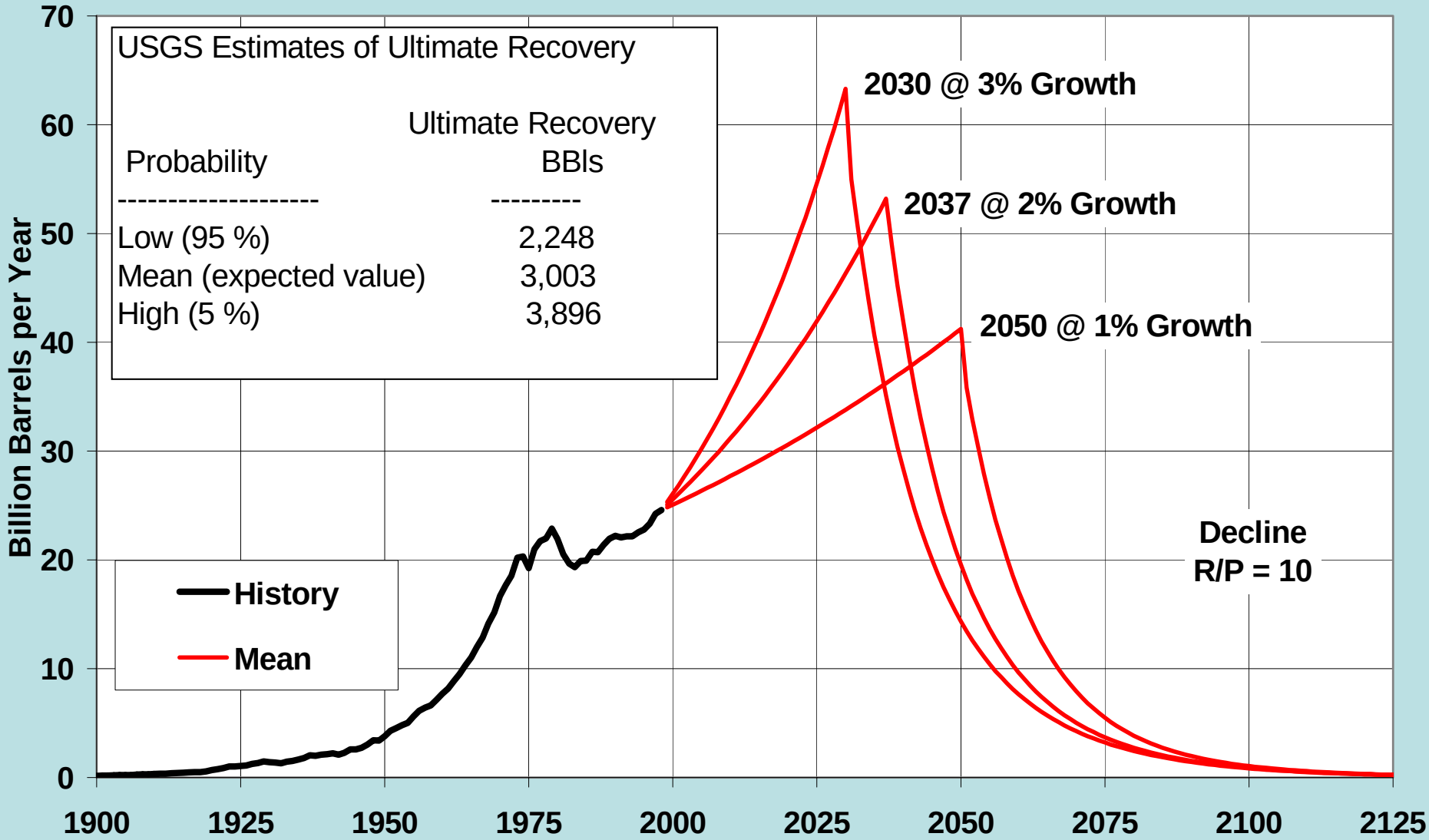
Para algunos el cenit de la extracción mundial está a la vuelta de la esquina…



ASPO 2004

Otros (USGS) lo sitúan entre el 2030-2050

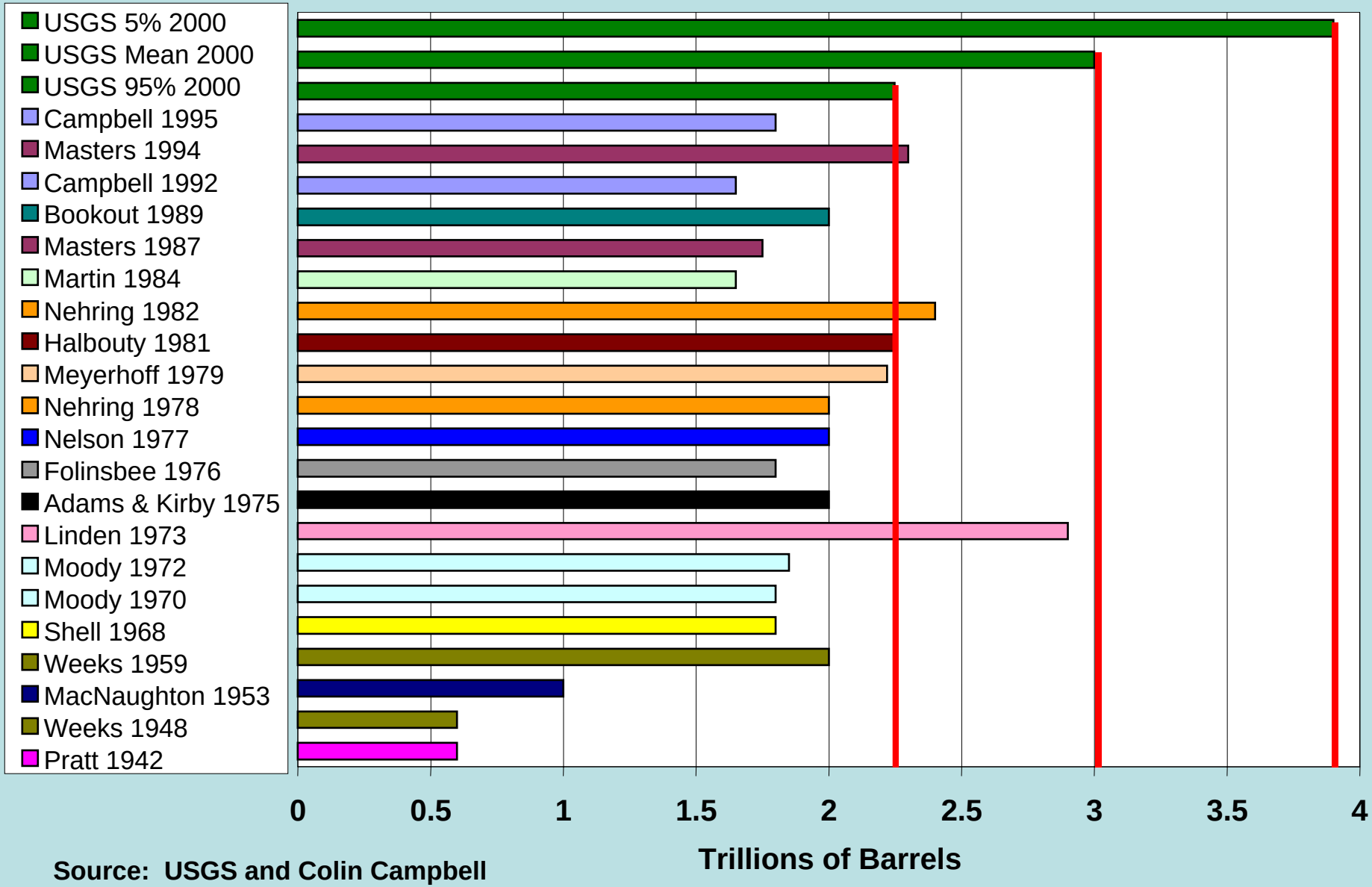
Annual Production Scenarios for the Mean Resource Estimate and Different Growth Rates (Decline R/P = 10)



Note: U.S. volumes were added to the USGS foreign volumes to obtain world totals

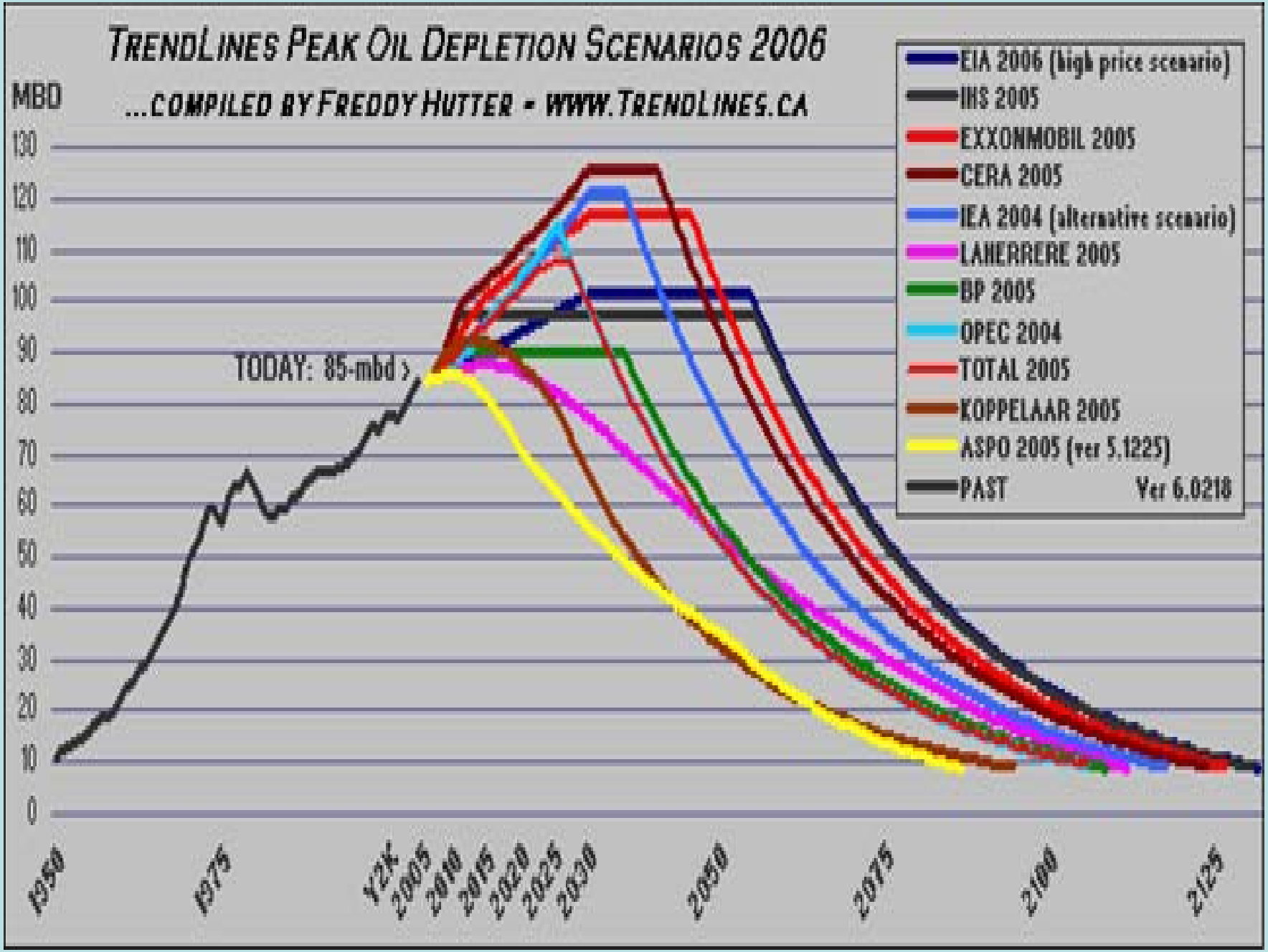
USGS (95%, 50% y 5%) contra casi todos…

Published Estimates of World Oil Ultimate Recovery

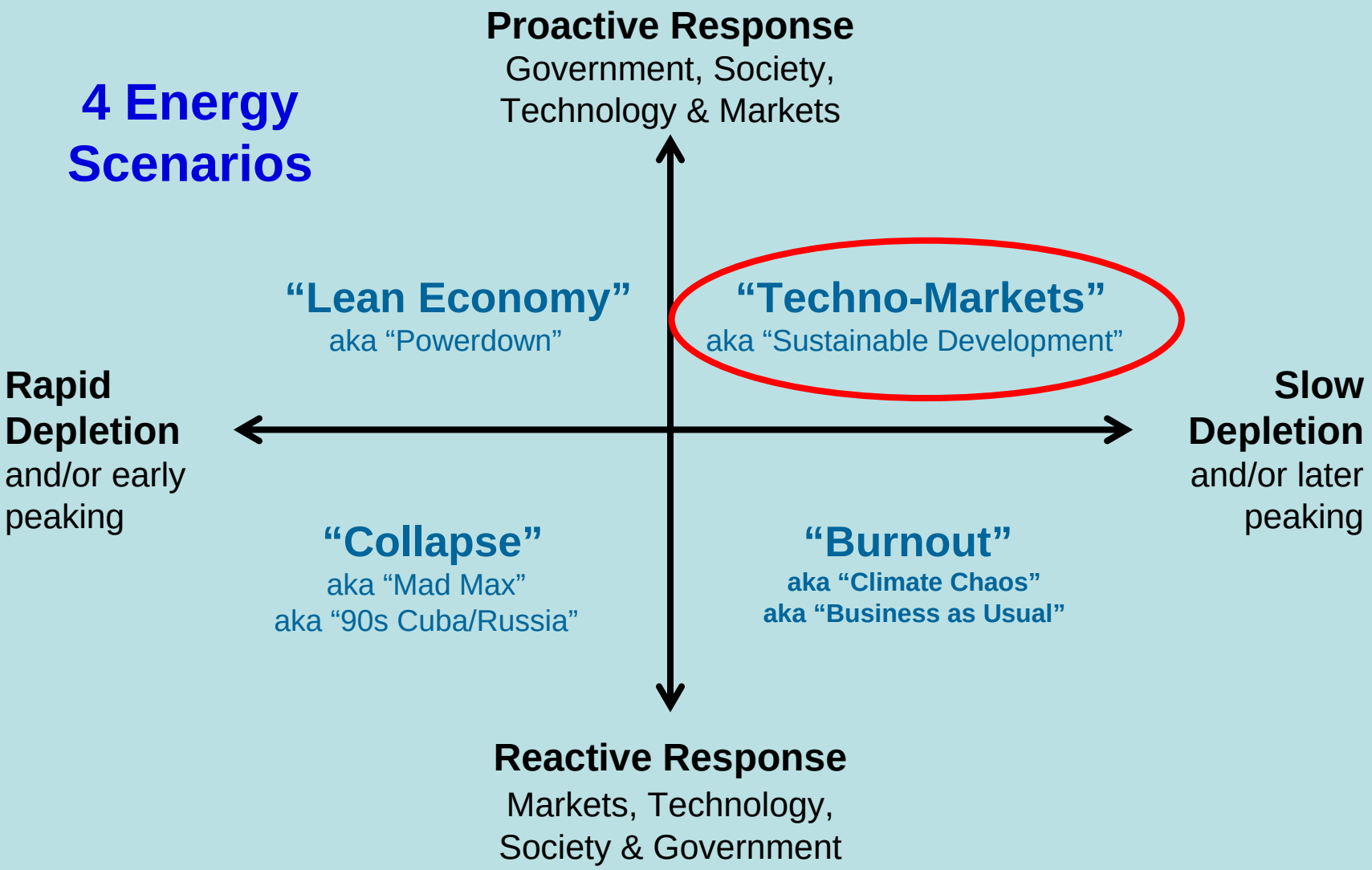


Source: USGS and Colin Campbell

EIA 2004

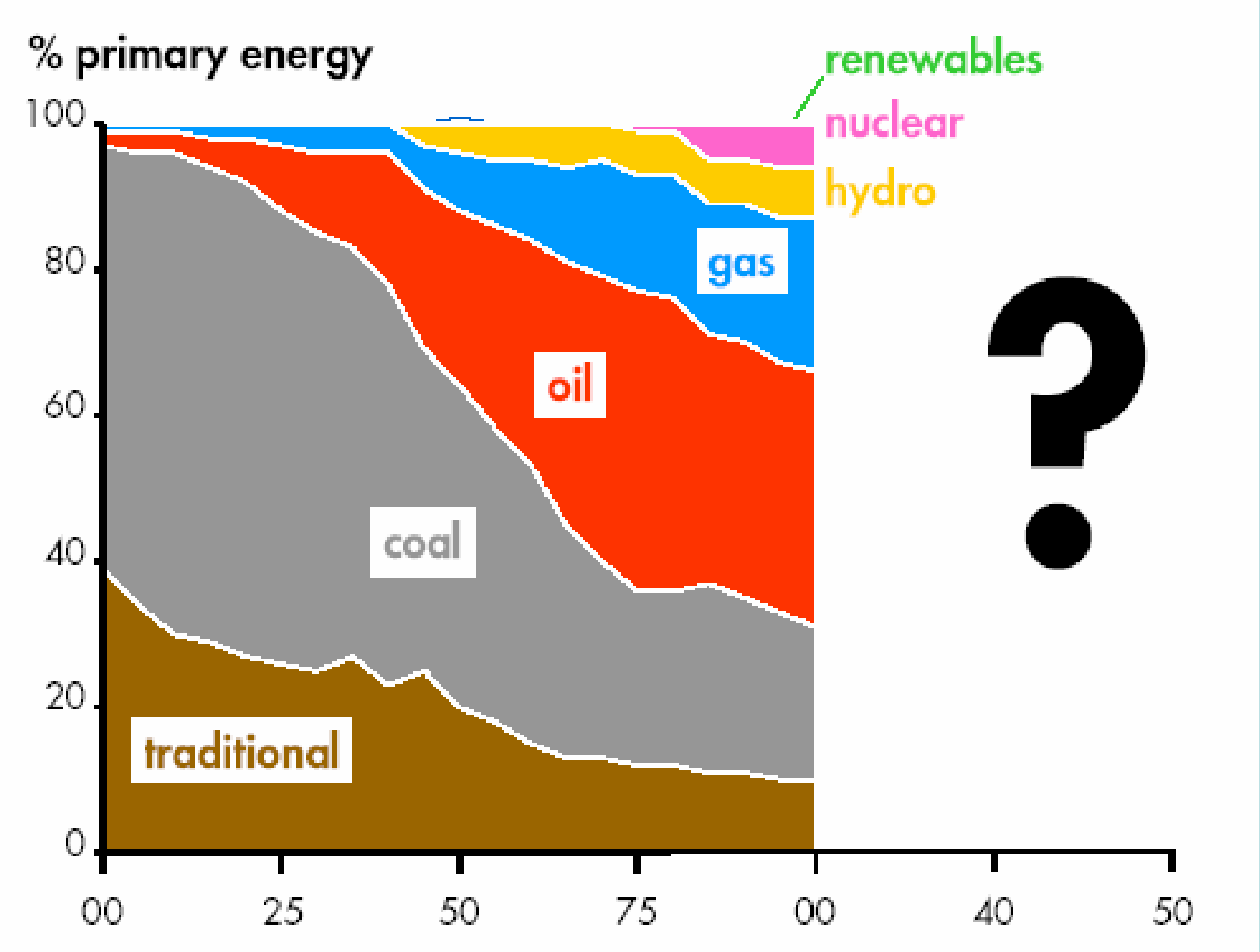

TrendLines Peak Oil Depletion Scenarios 2006
...compiled by Freddy Hutter • www.TrendLines.ca
MBD
130
120
110
100
90
80
70
60
50
40
30
20
10
0
TODAY: 85-mbd >
1950
1975
Y2K
2005
2010
2015
2020
2025
2030
2050
2075
2100
2125
EIA 2006 (high price scenario)
IHS 2005
EXXONMOBIL 2005
CERA 2005
IEA 2004 (alternative scenario)
LAHERRERE 2005
BP 2005
OPEC 2004
TOTAL 2005
KOPPELAAR 2005
ASPO 2005 (ver 5.1225)
PAST
Ver 6.0218

4 Energy Scenarios



* per David Fleming

Hay que afrontar una nueva transición energética



La regla de las 3 "es"

Eliminar la "e" del electoralismo

Investigación y Desarrollo

HC no convencionales (gas hidratos incluidos), GTL, CTL…

Secuestro del CO_2: uso "limpio" de combustibles fósiles.

Una nueva generación de reactores nucleares de fisión y/o de nuevas tecnologías en el campo de las renovables que pudieran liberarnos de nuestra dependencia de los combustibles fósiles.

Fusión nuclear

Es improbable que esto suceda antes del 2030.

Para que estas tecnologías sean competitivas, los consumidores deben estar dispuestos a pagar los costes íntegros de la energía, incluyendo la I+D y los costes ambientales.

Los Gobiernos deben decidir hoy

Muchas gracias