„NYERSANYAG ÉS ENERGIAKINCS”

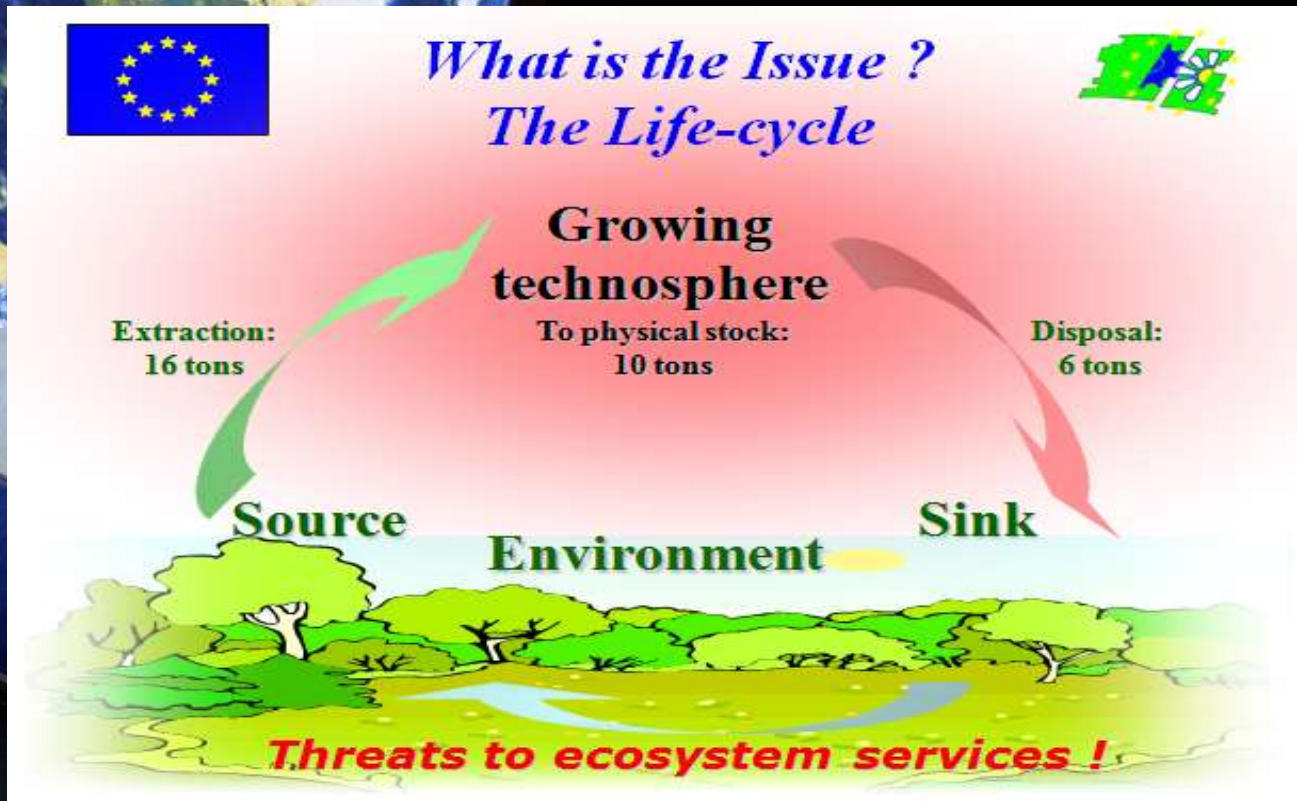
Dr. HÁMOR TAMÁS

Magyar Bányászati és Földtani Hivatal

ELTE TTK TDK előadóestek
Budapest, 2009. november 12.

AZ ALAPVETÉS:

5-5,5 md éves „élhető” égitest, 6,5 md-os emberi társadalommal Meddig elegendők az energia és nyersanyag készletek? (az előadás nem szól biodiverzitásbeli, genetikai, gazdasági, társadalmi fenntarthatóságról és orbitális kataklizmákról SEM)



Natural resources

RAW MATERIALS
Minerals-fuels
Biomass

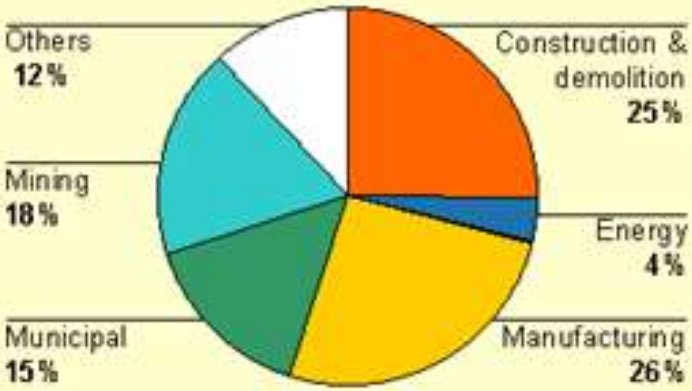
FLOWS
Solar
Wind
Tidal

MEDIA
Air
Soil
Water

Waste management
Production sources

Nearly 10% increase in waste generation, with 6.5 % economic growth (1990 –1995)

Most waste streams expected to increase by 2010



Life Cycle Thinking

Environmental and health impact modelling

Climate change, Acidification, Summer smog, Human toxicity, Ecotoxicity, Eutrophication, Ozone layer depletion, Radioactive releases, ...

Emissions

Life Cycle Inventory

Energy carrier extraction

Extraction of raw material A

Extraction of raw material B

Extraction of raw material C

...

Production of electricity

Production of intermediates

Production of parts

...

Production of final product

Utilisation

Material recycling

Incineration

Land filling

...

Resources

Resource depletion

Material and energy resource consumption, land use

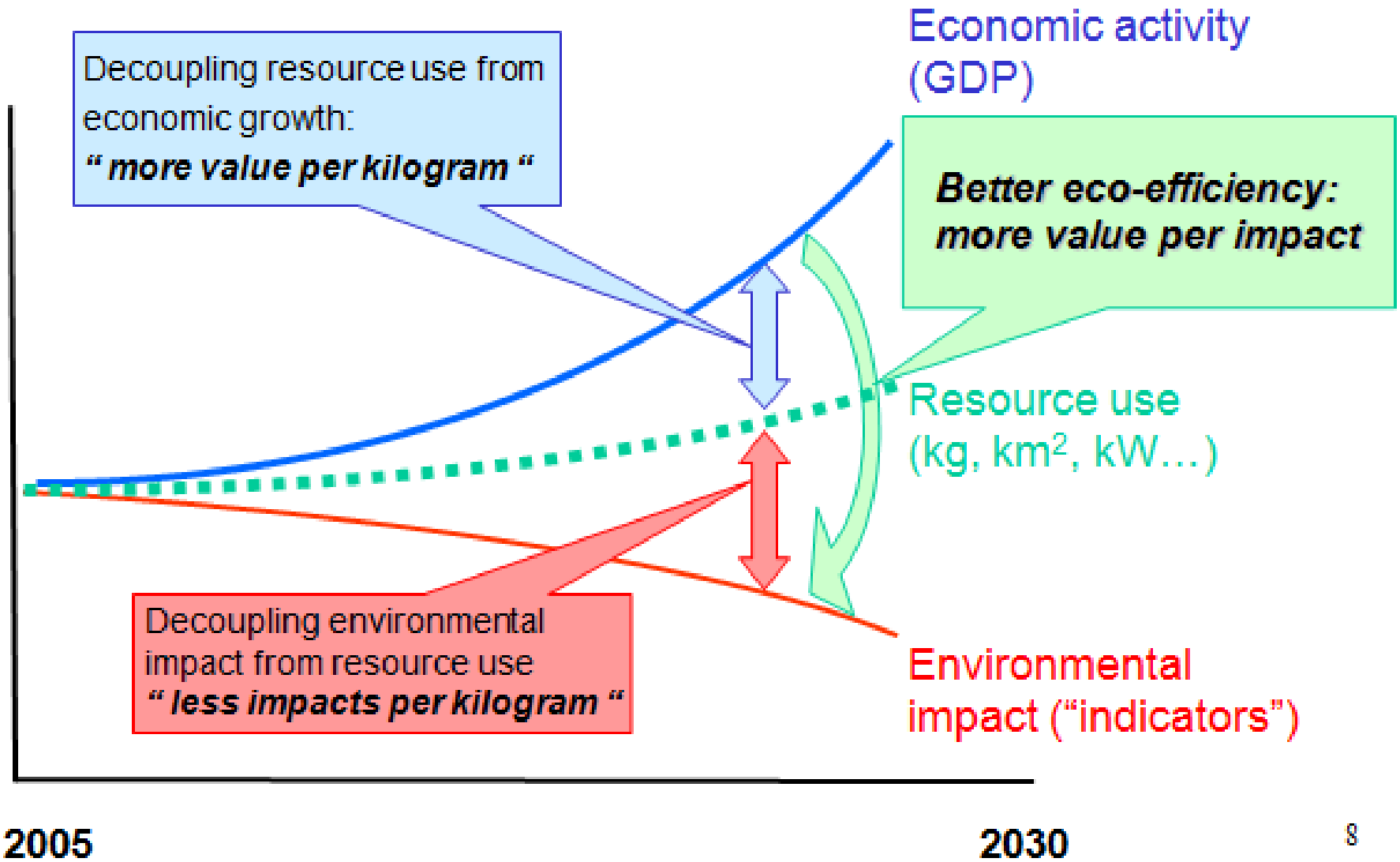
Life Cycle Phases

Production phase

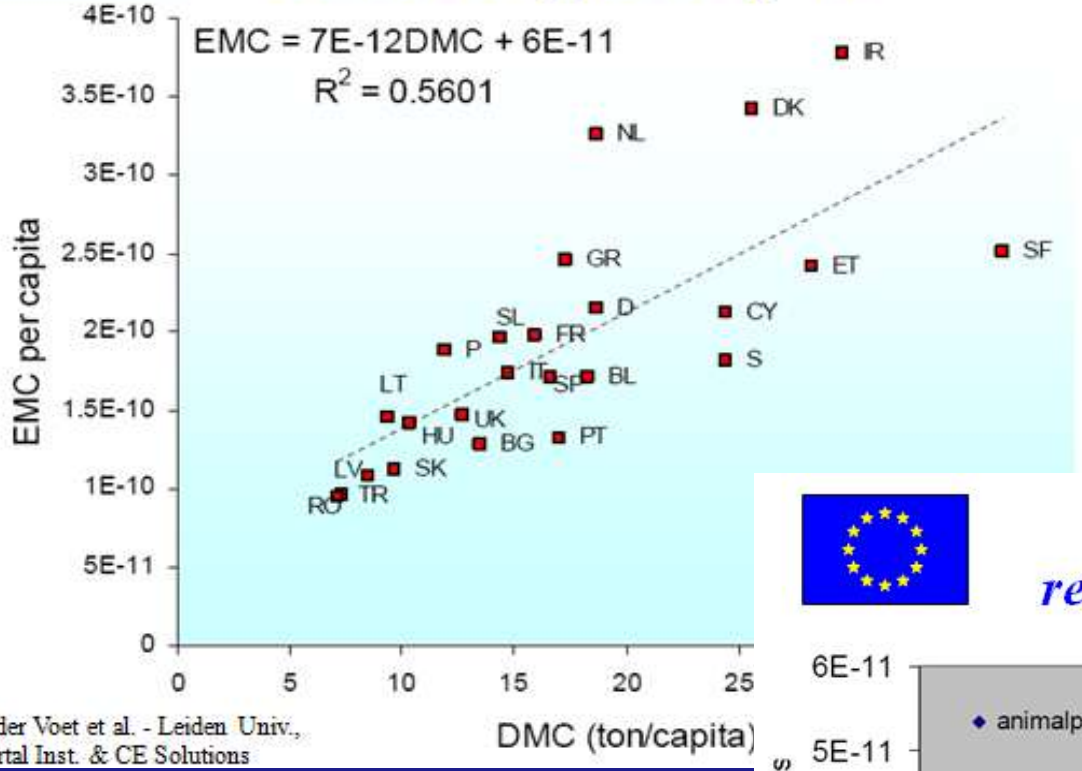
Use phase

End-of-Life phase

Objectives: Decoupling

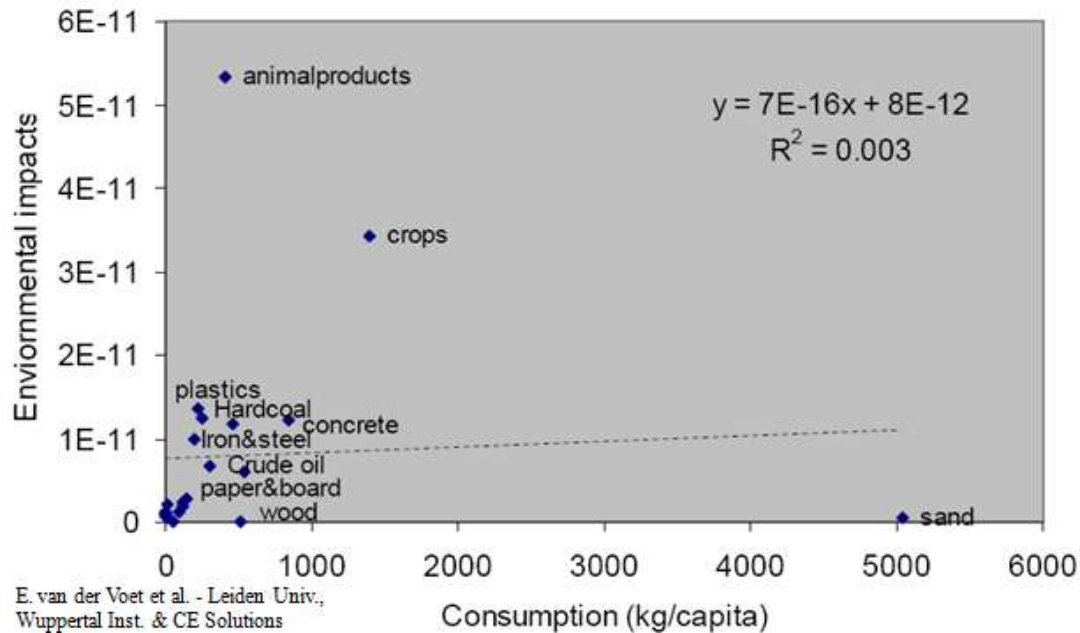


Link impact – resource efficiency (1)



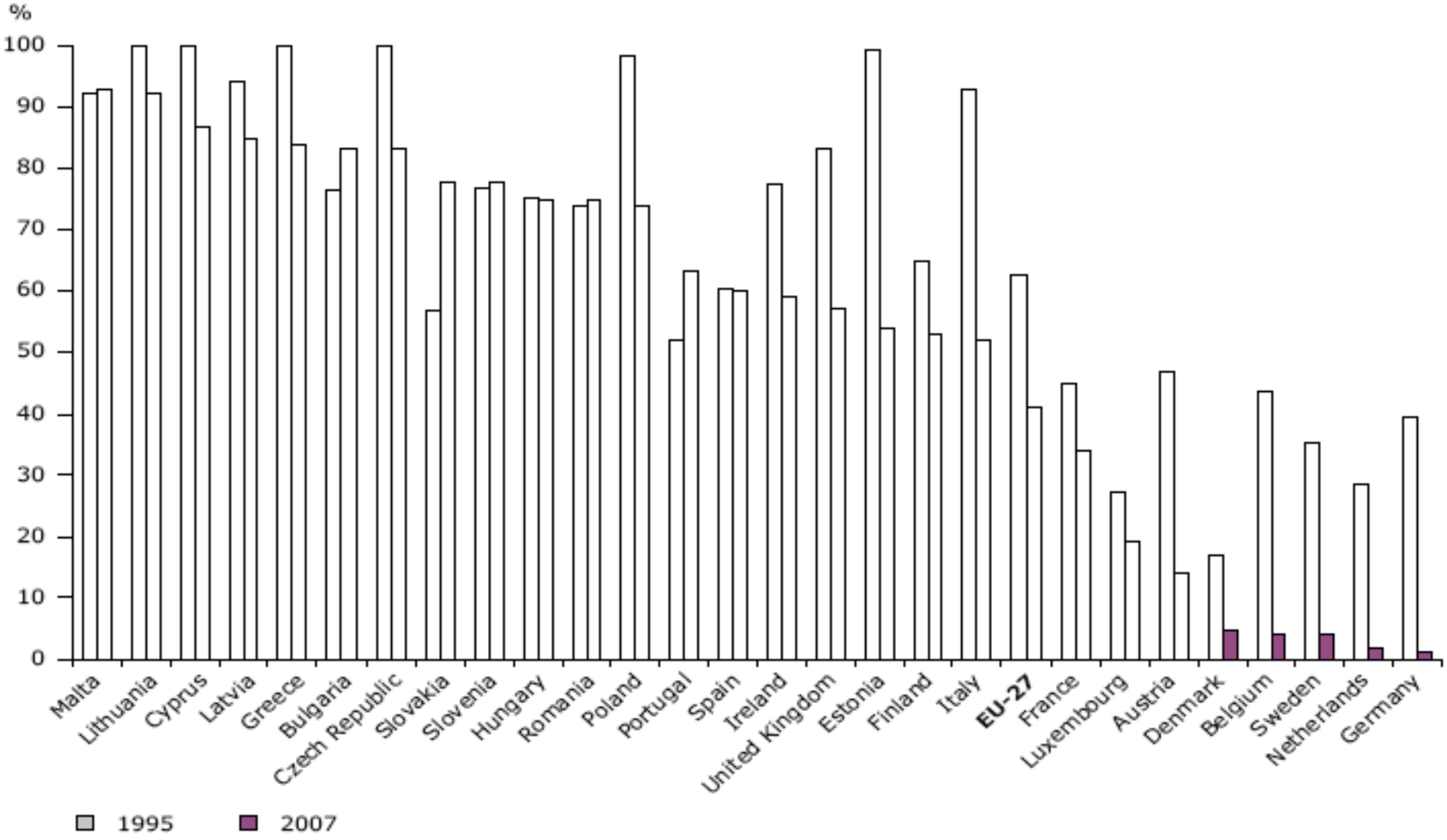
E. van der Voet et al. - Leiden Univ., Wuppertal Inst. & CE Solutions

Link impact – resource efficiency (2)



E. van der Voet et al. - Leiden Univ., Wuppertal Inst. & CE Solutions

Figure 2.2 Percentage of municipal waste that is landfilled in the EU-27, 1995 and 2007



Source: Calculated using Eurostat Structural Indicators.

(2) Alwast *et al.* (2008) used available waste generation data from national statistics according to the European Waste Catalogue (EWC) and the EWC-Stat categorisation.

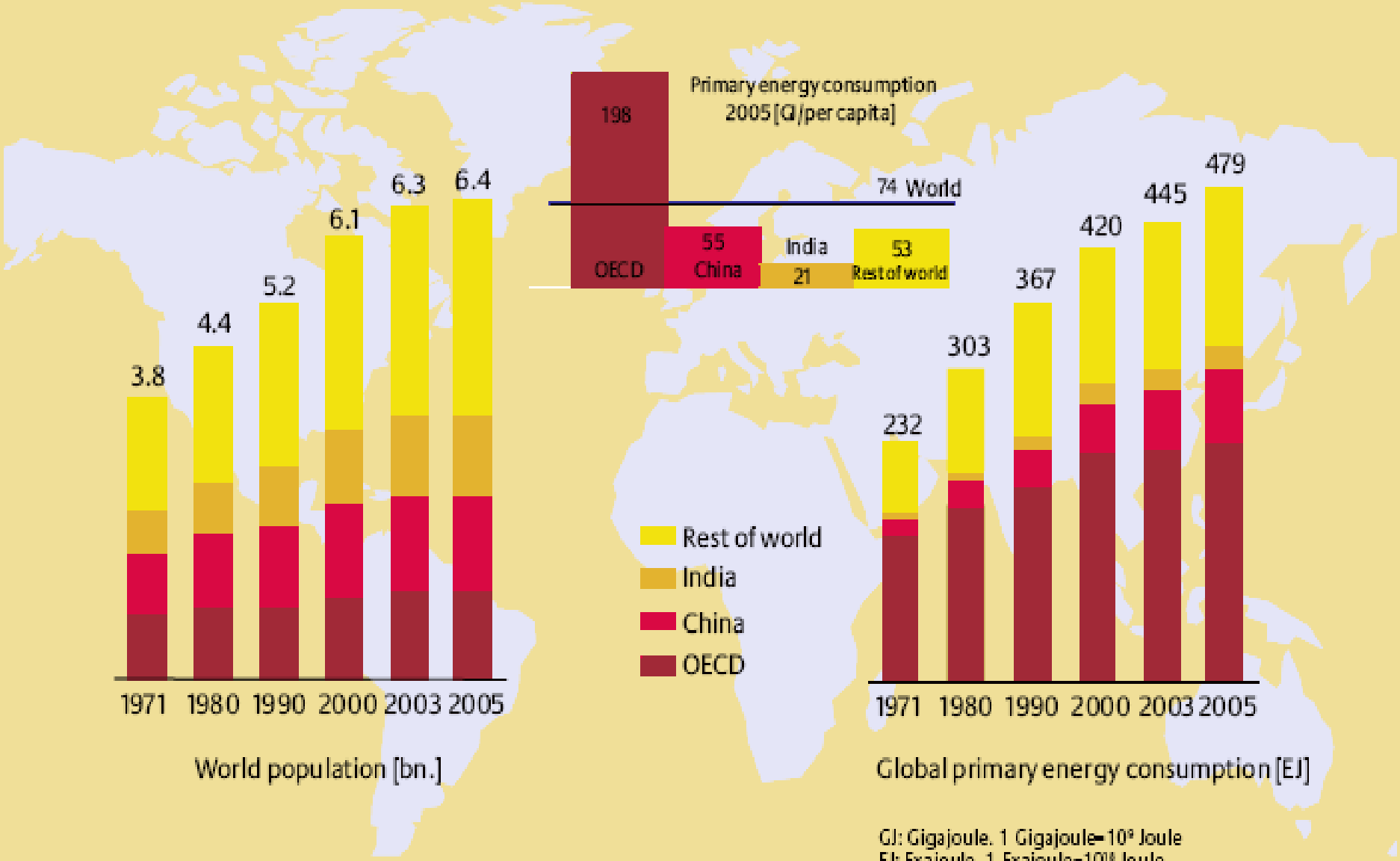
Which resources for the future?

Life cycle →

	Extraction	Production	Product use	End-of-life
Bio-based Economy	☹ ***Biocapacity ?***			
Minerals-based economy	☹ ***Human Health?***			
Flow-based economy	☺ ?			

CO_2 ↗

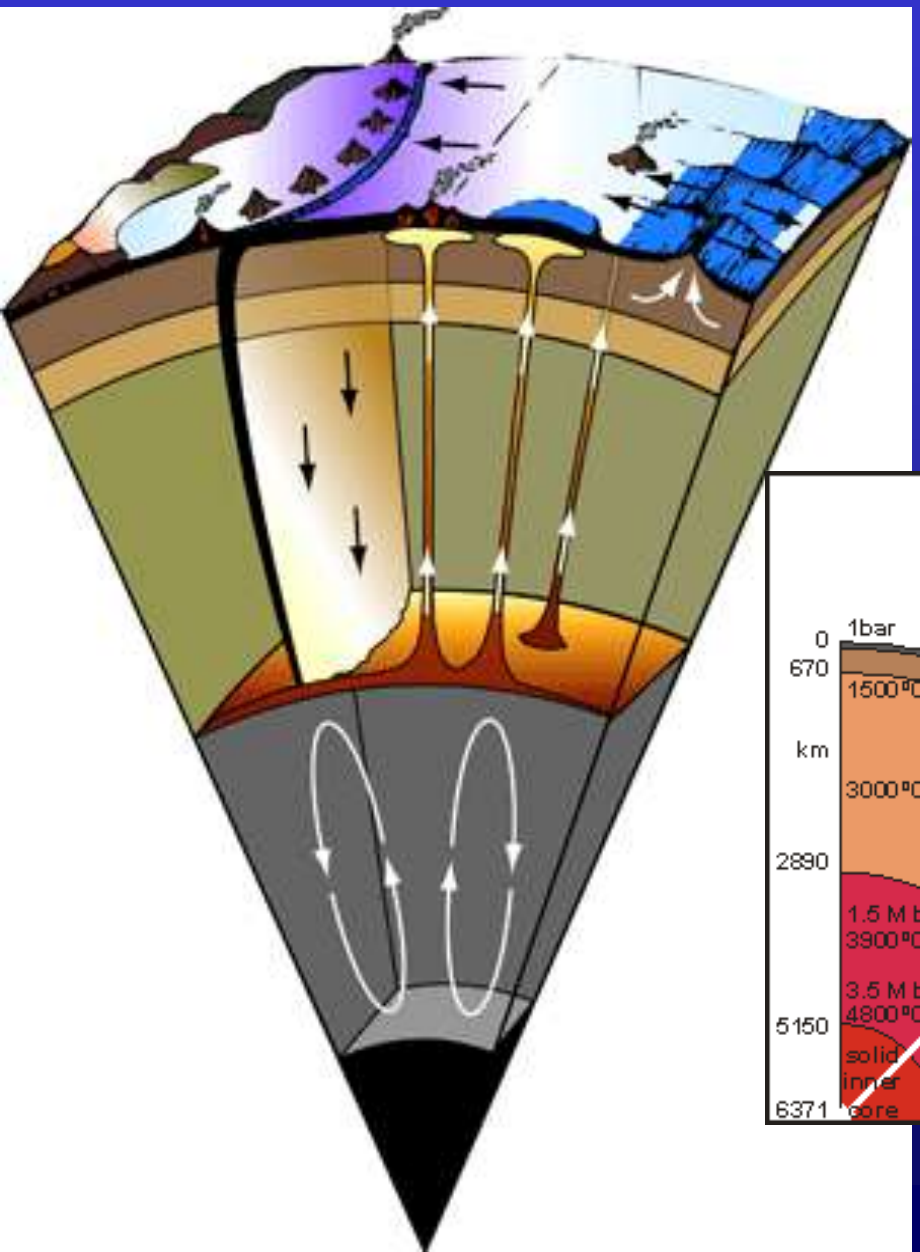
Development of world population and global primary energy consumption



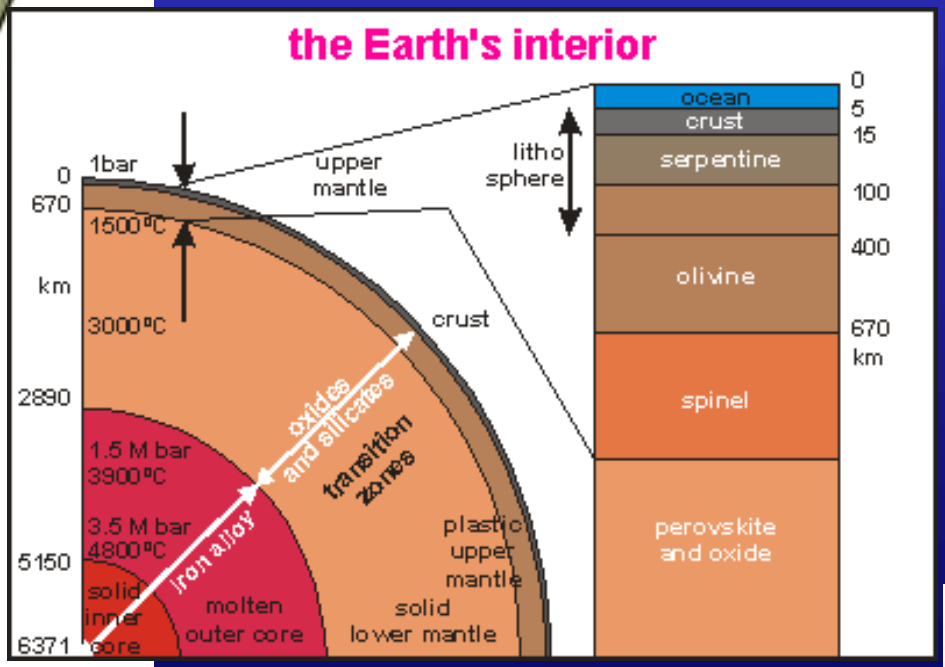
GJ: Gigajoule. 1 Gigajoule=10^9 Joule
EJ: Exajoule. 1 Exajoule=10^{18} Joule

Source: Staiß. F (2007): Jahrbuch Erneuerbare Energien 2007.

PENETRATION INTO GEOSPHERE I



Mapping Earth's interior by seismic waves to the very core



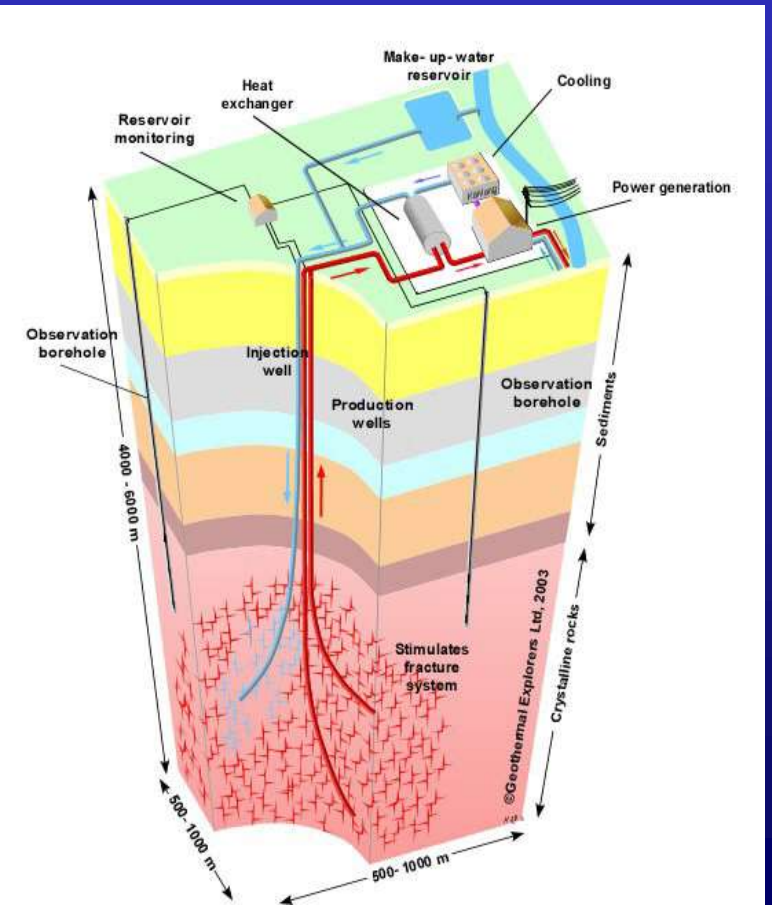
© Max Planck Institut

PENETRATION INTO GEOSPHERE II

Kola SG3 borehole:

12 262 m depth in 1985

© Universitat Bonn



Oil and gas fields (BCGA), enhanced geothermal systems: at 3-6 km depth

© ProbawayWordpress

PENETRATION INTO GEOSPHERE III

Bingham open pit:

1.2 km deep,

2.5 km wide

© Flickr

East Rand mine:

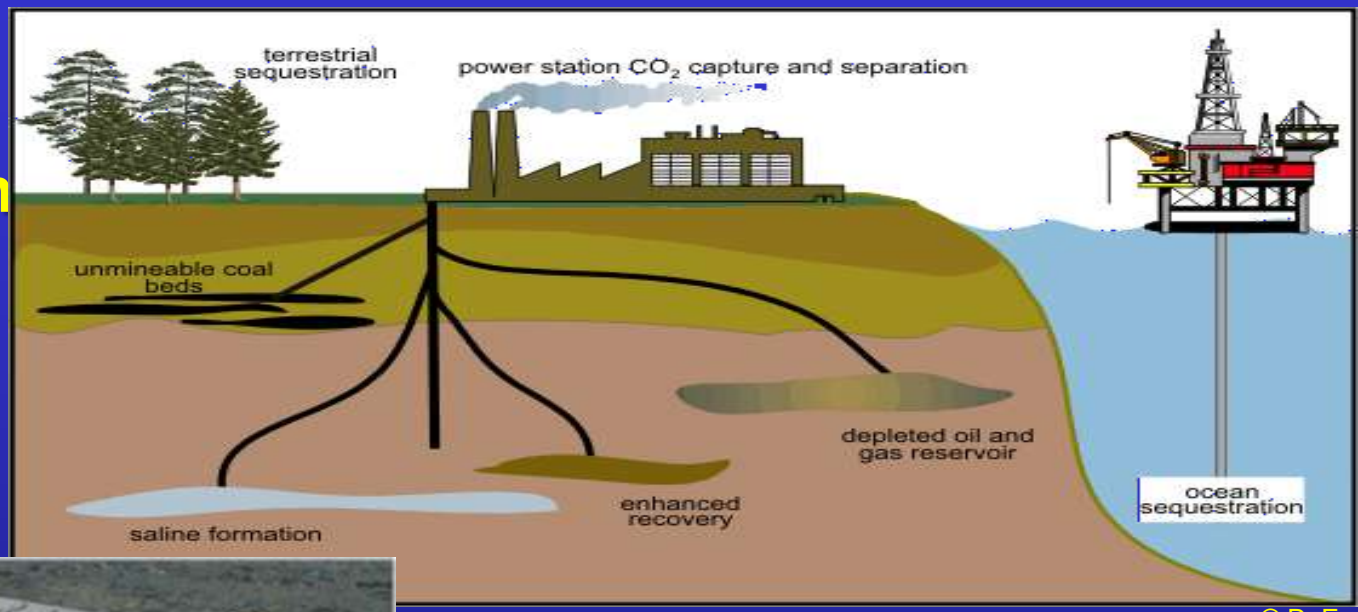
3.6 km deep

© Iran Geoscience Center

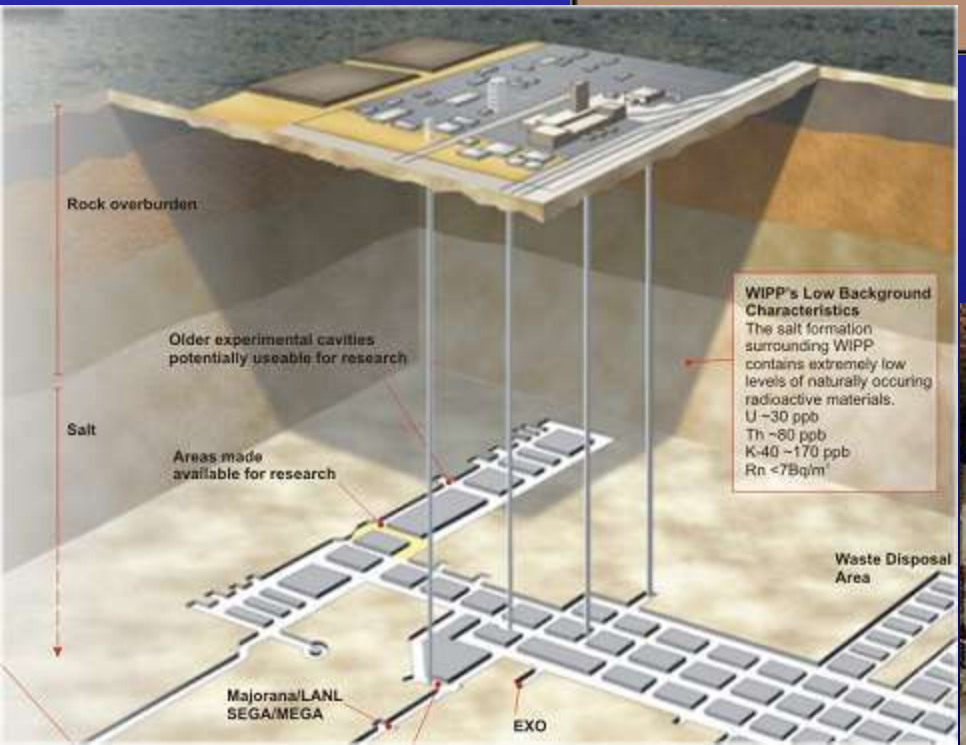
PENETRATION INTO GEOSPHERE IV

CO_2 sequestration

strategic gas storage

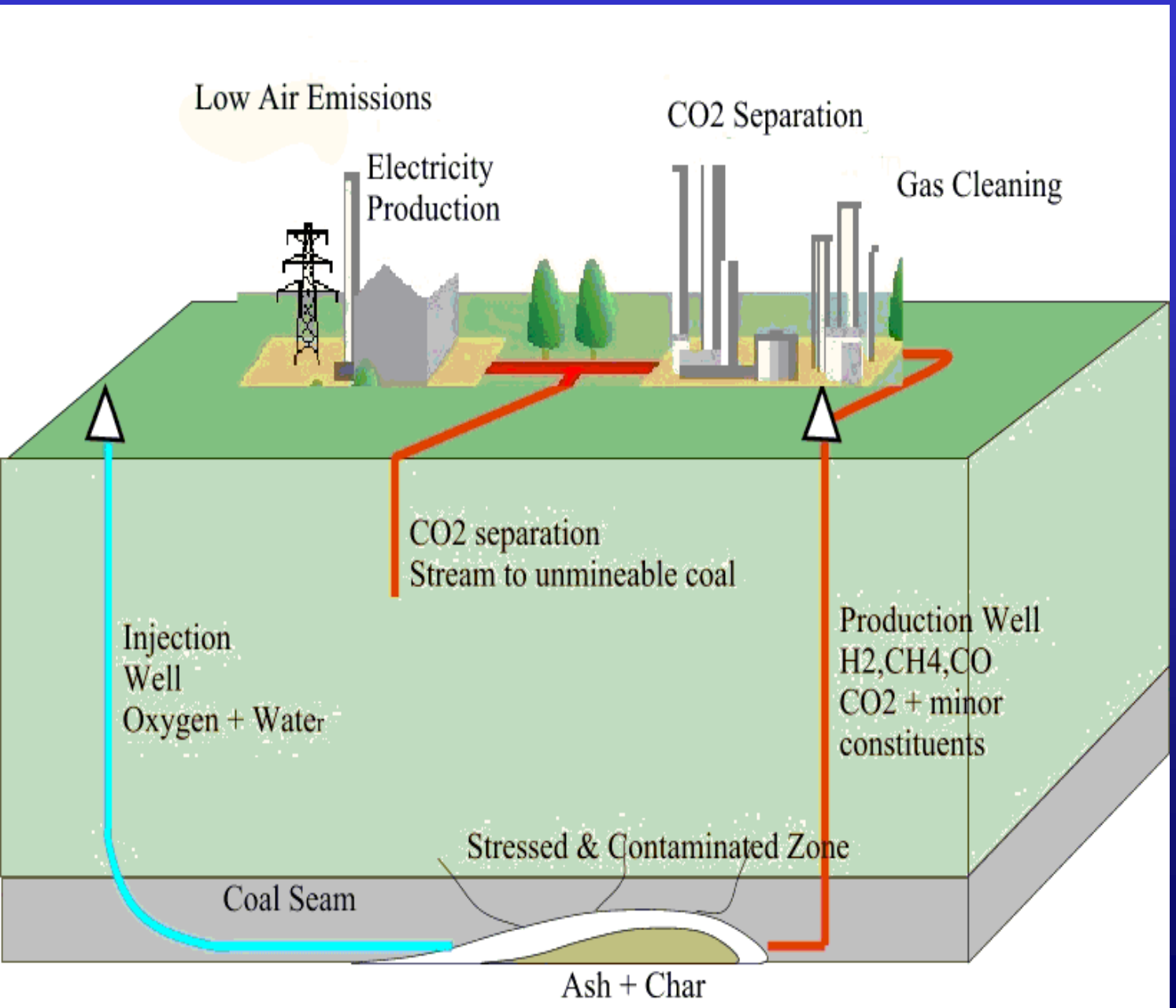


© DoE



radwaste disposal

PENETRATION INTO GEOSPHERE V



underground coal gasification (UCG)

© UCG Partnerships

PENETRATION INTO GEOSPHERE VI

civil applications: tunnels (54 km longest in Japan), subways, parking lots, underground archives, laboratories, accelerators

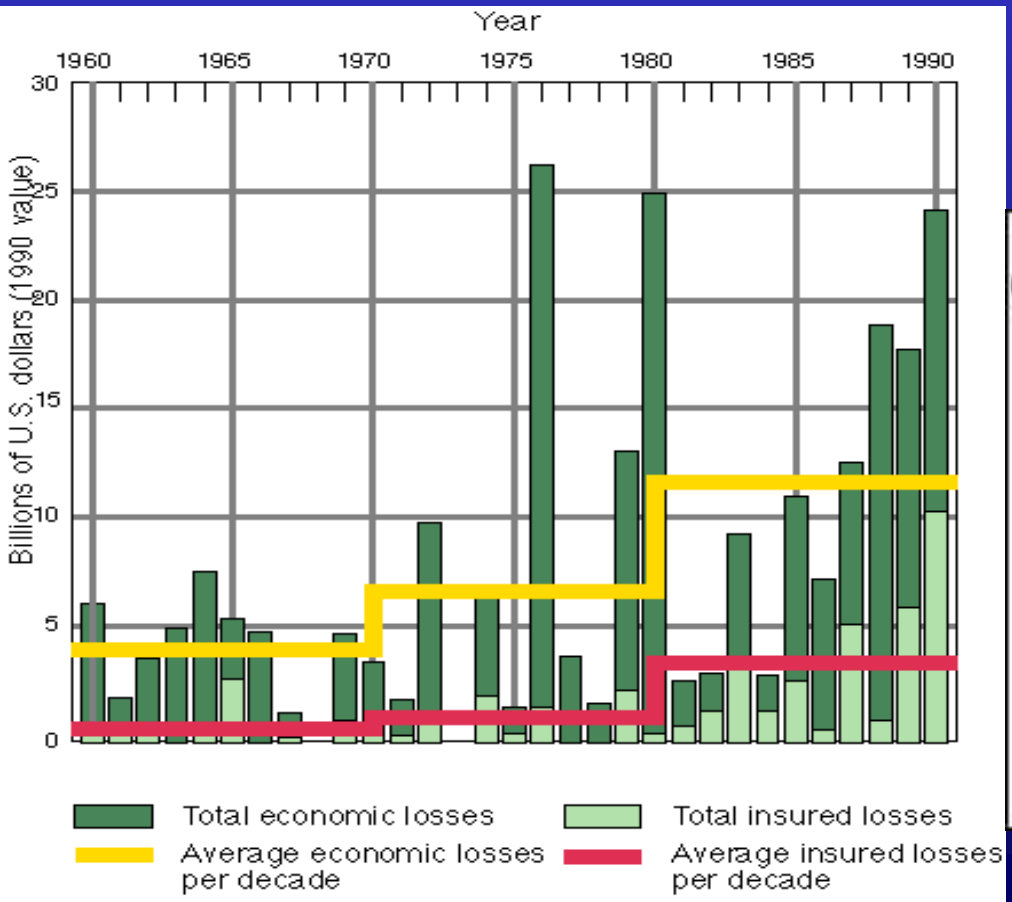
military use (test sites, command centers)

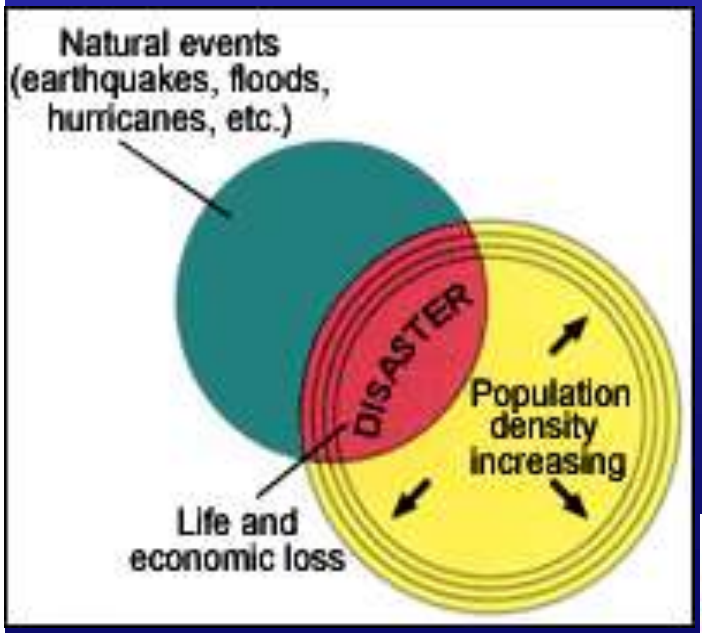
© Greenpeace

MORE „NEW" DRIVERS I

Climate change, environmental aspects

Geohazards (population growth+urbanization+ infrastructures+climate change+forestry)





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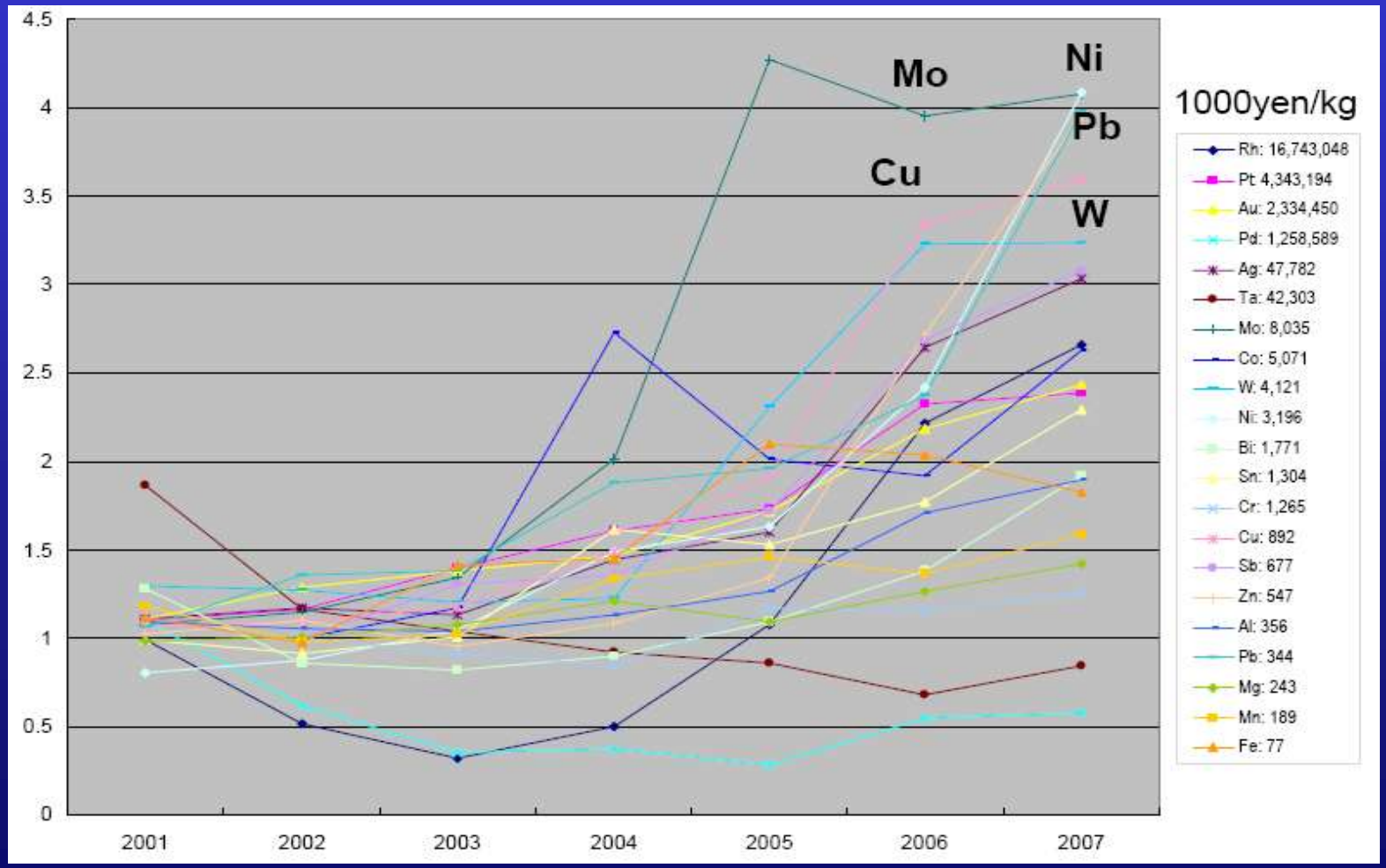
MORE „NEW" DRIVERS II

Minerals boom + Energy crises



K. HALADA, Japan National Institute for Materials Science

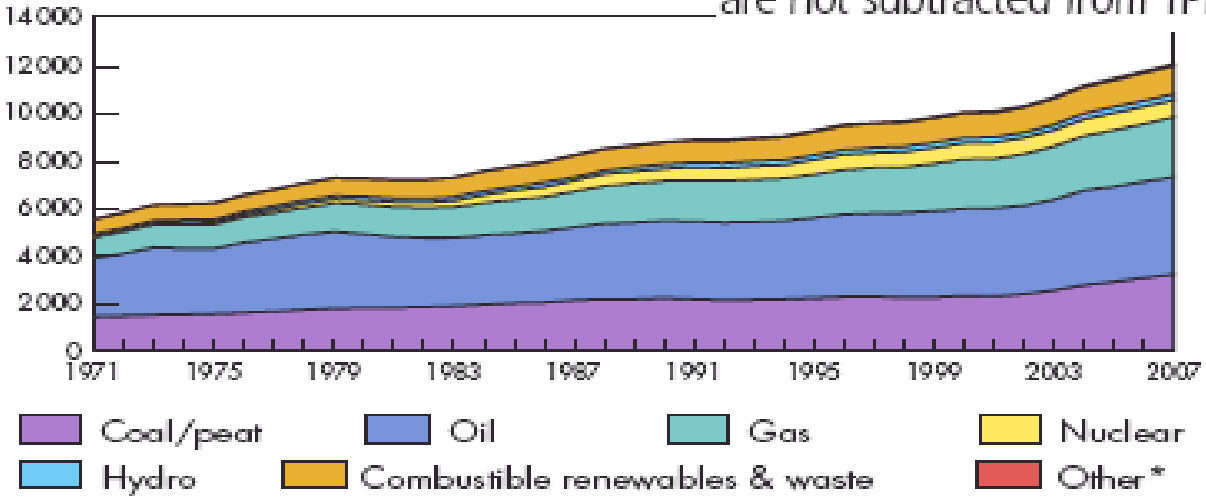
© USGS

TOTAL PRIMARY ENERGY SUPPLY

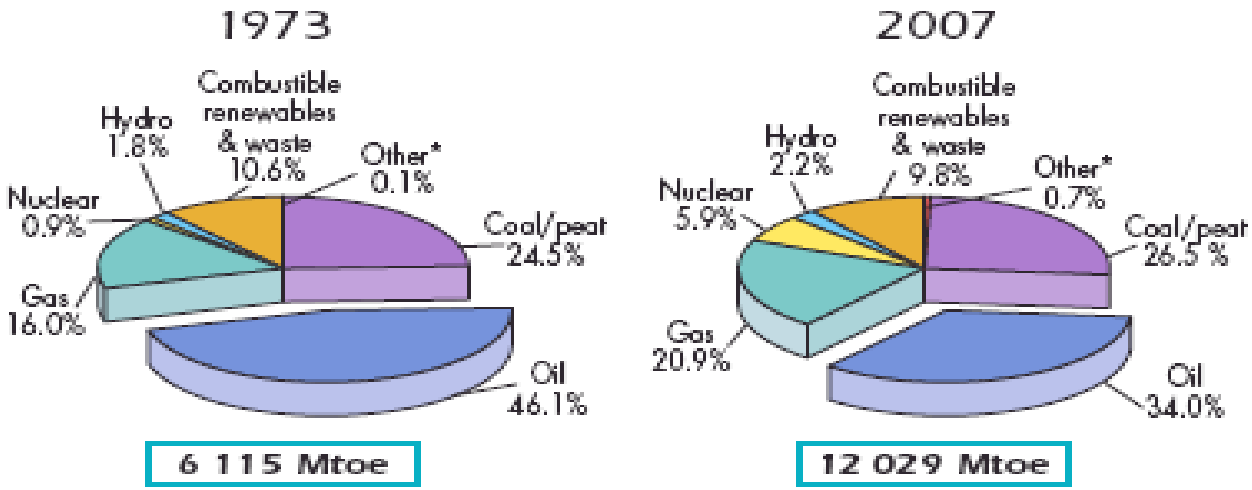
World

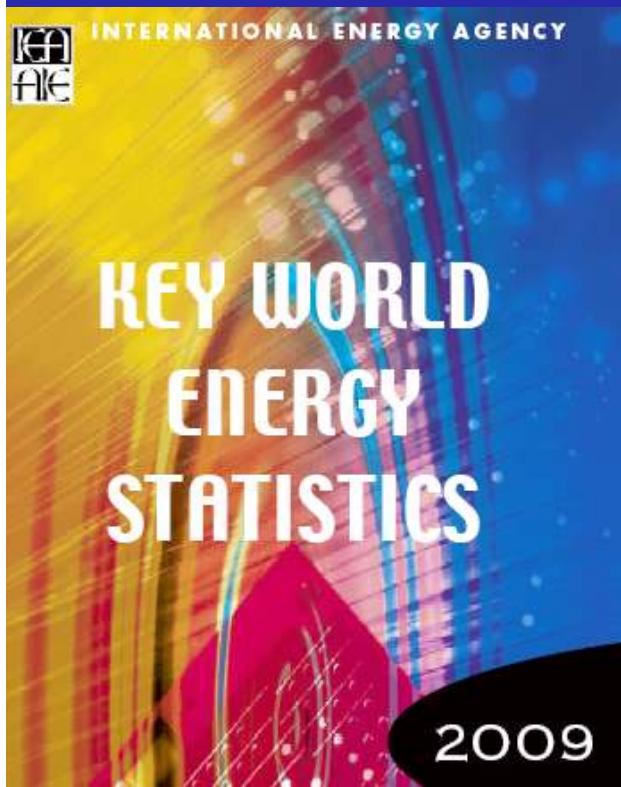
Total primary energy supply (TPES) is made up of production + imports – exports – international marine bunkers – international aviation bunkers ± stock changes. For the world total, international marine bunkers and international aviation bunkers are not subtracted from TPES.

Evolution from 1971 to 2007 of world t by fuel (Mtoe)



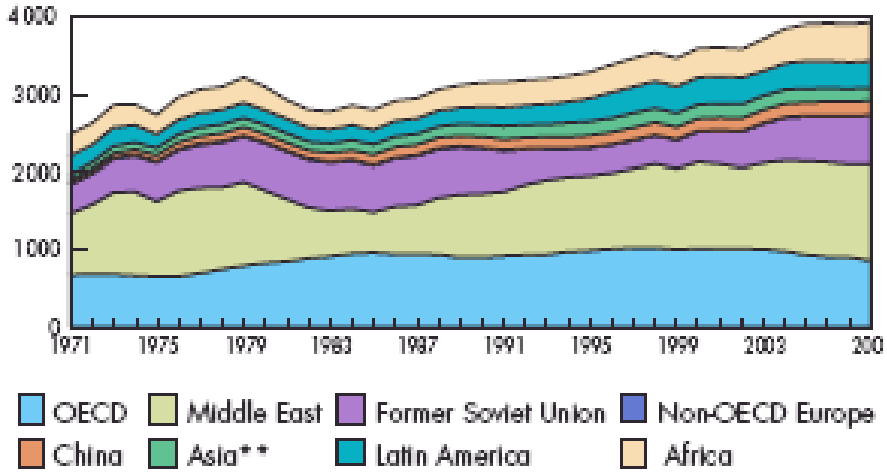
1973 and 2007 fuel shares of TPES





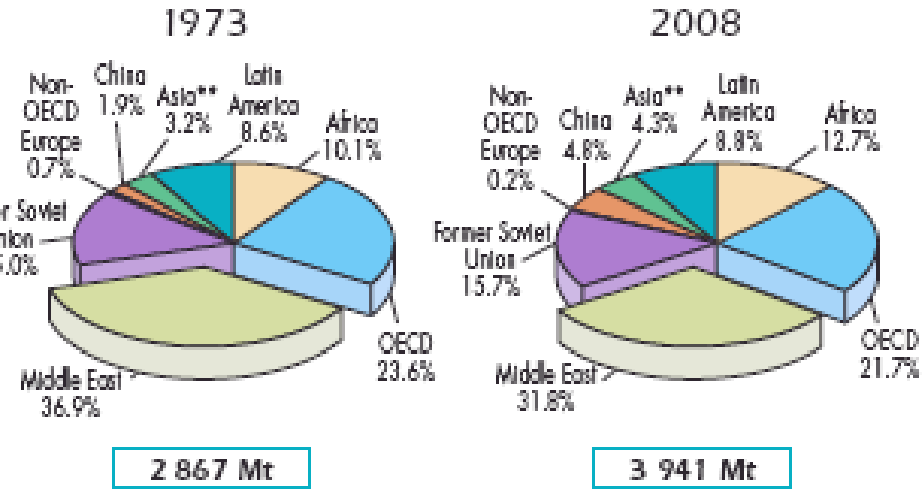
Crude Oil Production

Evolution from 1971 to 2008 of crude oil* production by region (Mt)



bcm	billion cubic metres	**kWh**	kilowatt hour
Gcal	gigacalorie	**MBtu**	million British thermal units
GCV	gross calorific value	**Mt**	million tonnes
GW	gigawatt	**Mtoe**	million tonnes of oil equivalent
GWh	gigawatt hour	**PPP**	purchasing power parity
kb/cd	thousand barrels per calendar day	**t**	metric ton = tonne = 1000 kg
kcal	kilocalorie	**TJ**	terajoule
kg	kilogramme	**toe**	tonne of oil equivalent = 10^7 kcal
kJ	kilojoule	**TWh**	terawatt hour

1973 and 2008 regional shares of crude oil* production



2 867 Mt

3 941 Mt

*Includes crude oil, NGL, feedstocks, additives and other hydrocarbons.
**Asia excludes China.

Producers	Mt	% of world total
Saudi Arabia	509	12.9
Russian Federation	485	12.3
United States	300	7.6
Islamic Rep. of Iran	214	5.4
People's Rep. of China	190	4.8
Mexico	159	4.0
Canada	155	3.9
Kuwait	145	3.7
Venezuela	137	3.5
United Arab Emirates	136	3.5
Rest of the world	1 511	38.4
World	3 941	100.0

2008 data

Net exporters	Mt
Saudi Arabia	339
Russian Federation	256
Islamic Rep. of Iran	130
Nigeria	112
United Arab Emirates	105
Norway	97
Mexico	89
Angola	83
Kuwait	82
Iraq	81
Others	583
Total	1 957

2007 data

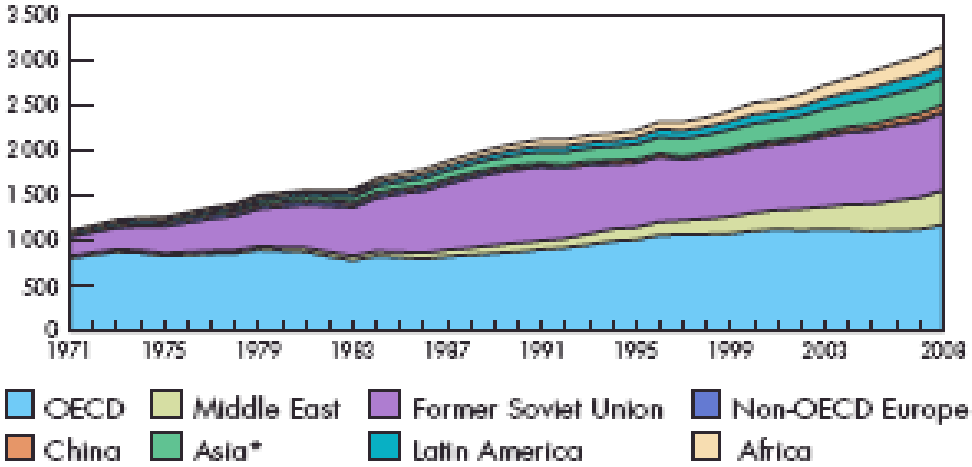
Net importers	Mt
United States	573
Japan	206
People's Rep. of China	159
India	122
Korea	118
Germany	106
Italy	94
France	81
Spain	59
Netherlands	58
Others	515
Total	2 091

2007 data

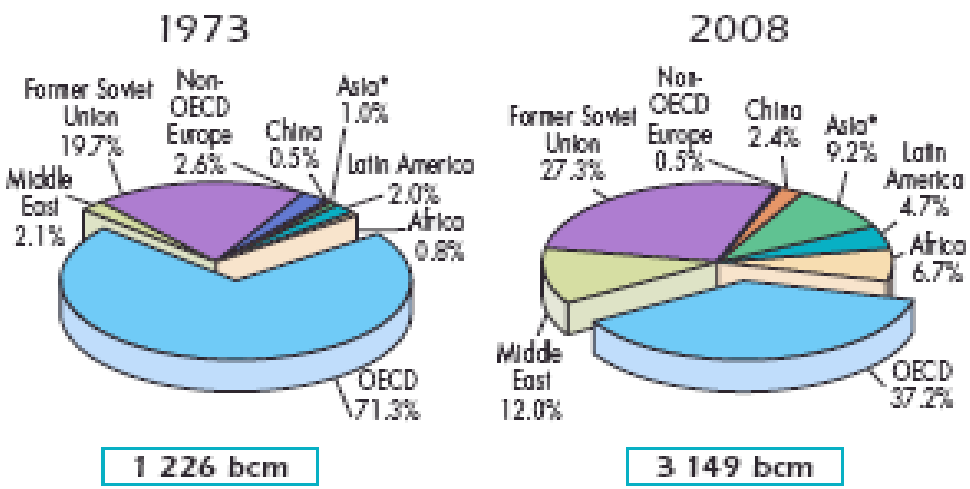
*Includes crude oil, NGL, feedstocks, additives and other hydrocarbons.

Natural Gas Production

Evolution from 1971 to 2008 of natural gas production by region (billion cubic metres)



1973 and 2008 regional shares of natural gas production



*Asia excludes China.

Producers	bcm	% of world total
Russian Federation	657	20.9
United States	583	18.5
Canada	175	5.6
Islamic Rep. of Iran	121	3.8
Norway	103	3.3
Netherlands	85	2.7
Algeria	82	2.6
Qatar	79	2.5
Indonesia	77	2.4
People's Rep. of China	76	2.4
Rest of the world	1 111	35.3
World	3 149	100.0

2008 data

Net exporters	bcm
Russian Federation	187
Norway	96
Canada	88
Qatar	58
Algeria	58
Turkmenistan	51
Netherlands	36
Indonesia	34
Malaysia	22
Nigeria	21
Others	149
Total	800

2008 data

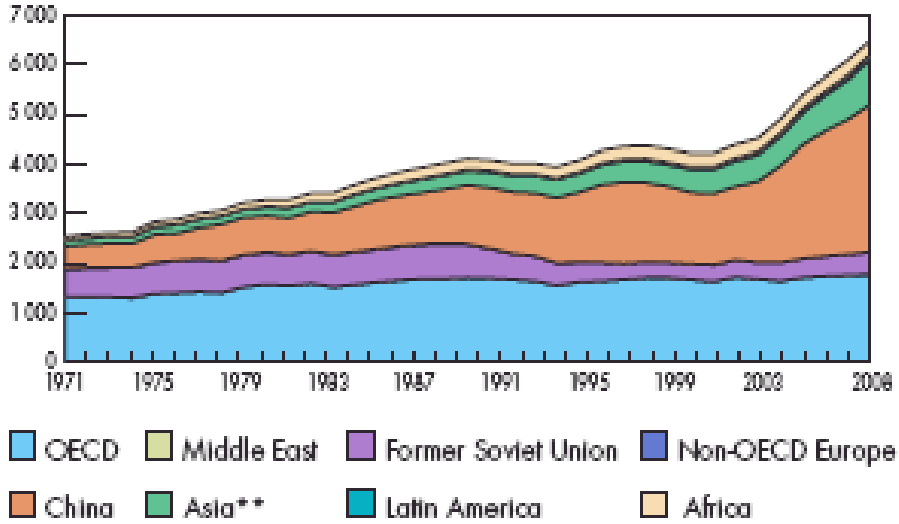
Net importers	bcm
Japan	95
United States	84
Germany	79
Italy	77
Ukraine	53
France	44
Spain	39
Turkey	36
Korea	36
United Kingdom	26
Others	214
Total	783

2008 data

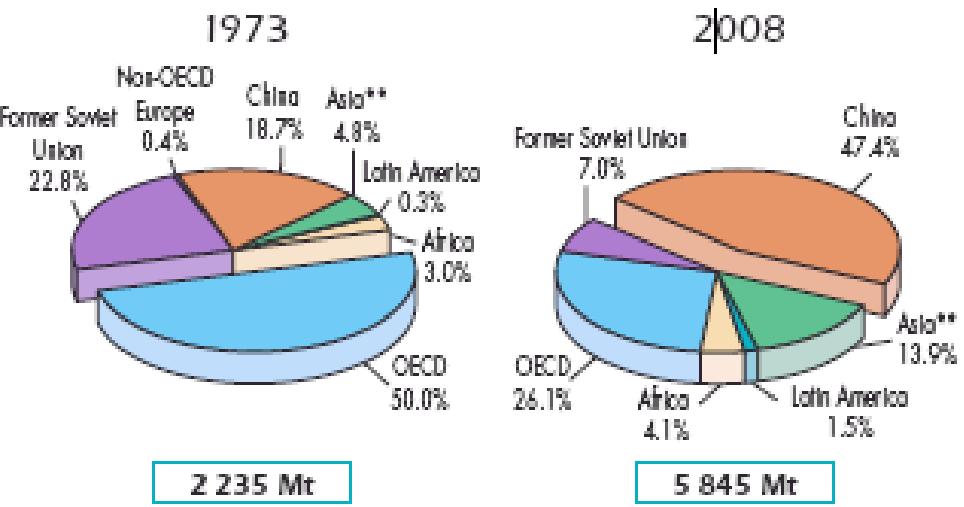
*Net exports and net imports include pipeline gas and LNG.

Hard Coal Production

Evolution from 1971 to 2008 of hard coal* production by region (Mt)



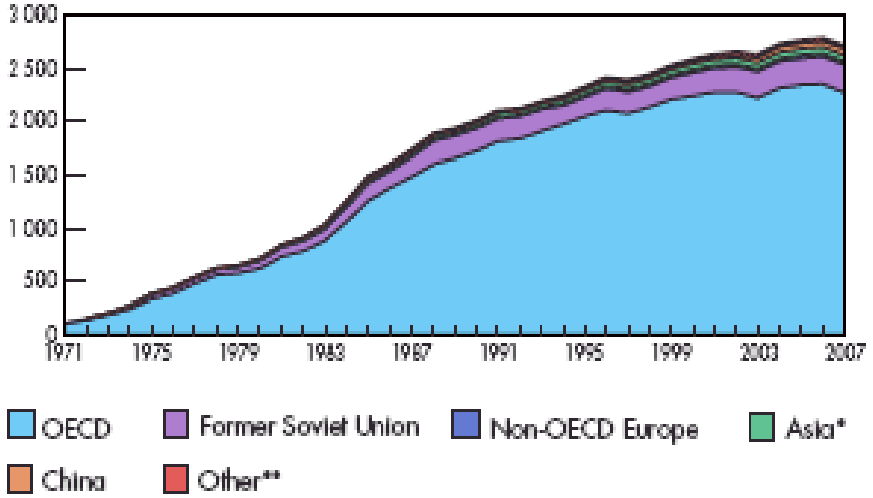
1973 and 2008 regional shares of hard coal* production



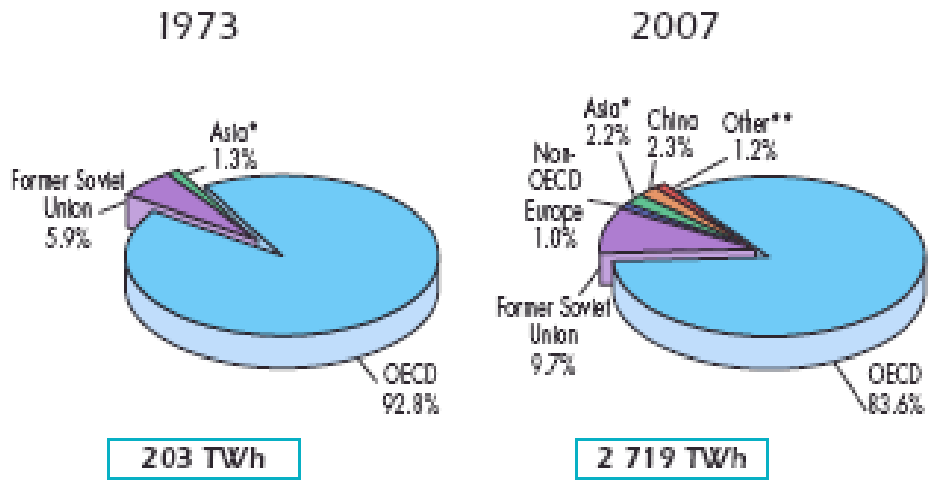
*Includes recovered coal.
**Asia excludes China.

Nuclear Production

Evolution from 1971 to 2007 of nuclear production by region (TWh)



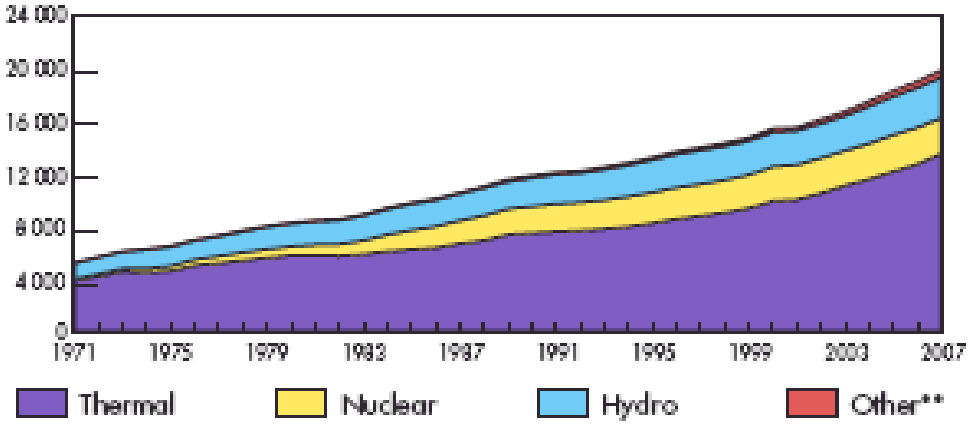
1973 and 2007 regional shares of nuclear production



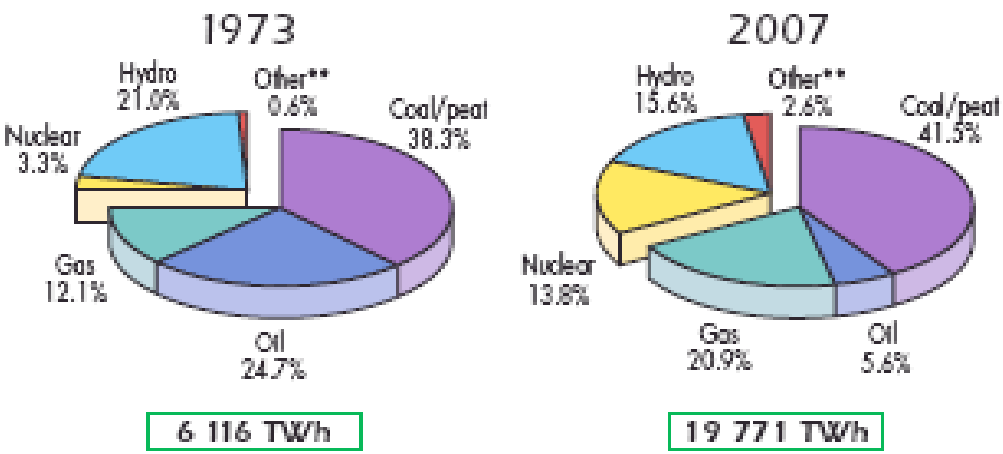
*Asia excludes China.
**Other includes Africa, Latin America and the Middle East.

Electricity Generation* by Fuel

Evolution from 1971 to 2007 of world electricity generation* by fuel (TWh)



1973 and 2007 fuel shares of electricity generation*



*Excludes pumped storage.
**Other includes geothermal, solar, wind, combustible renewables & waste, and heat.

Electricity production from fossil fuels

Coal/peat	TWh
People's Rep. of China	2 656
United States	2 118
India	549
Japan	311
Germany	311
South Africa	247
Australia	194
Korea	171
Russian Federation	170
Poland	148
Rest of the world	1 353
World	8 228

2007 data

Oil	TWh
Japan	156
Saudi Arabia	104
United States	78
Mexico	52
Indonesia	38
Italy	35
Kuwait	35
People's Rep. of China	34
India	33
Iraq	33
Rest of the world	516
World	1 114

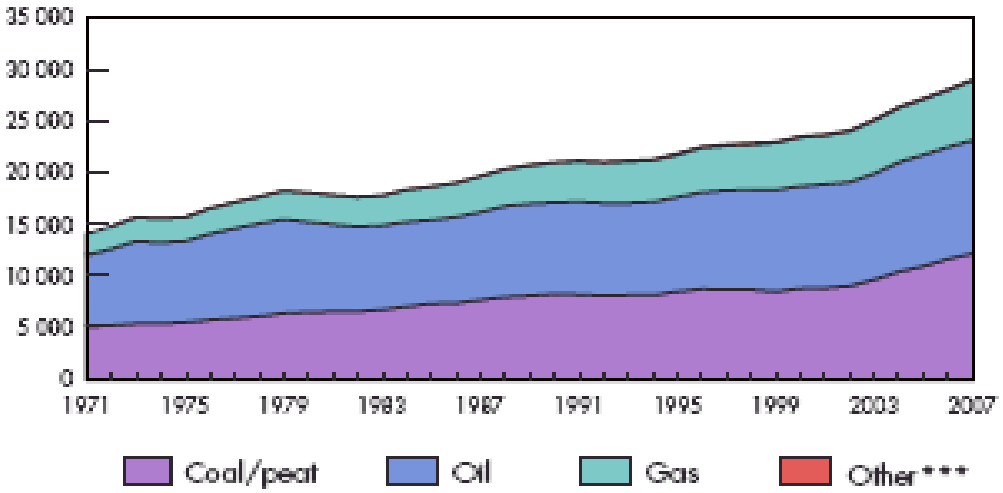
2007 data

Gas	TWh
United States	915
Russian Federation	487
Japan	290
Italy	173
United Kingdom	164
Islamic Rep. of Iran	160
Mexico	126
Thailand	97
Turkey	95
Spain	93
Rest of the world	1 527
World	4 127

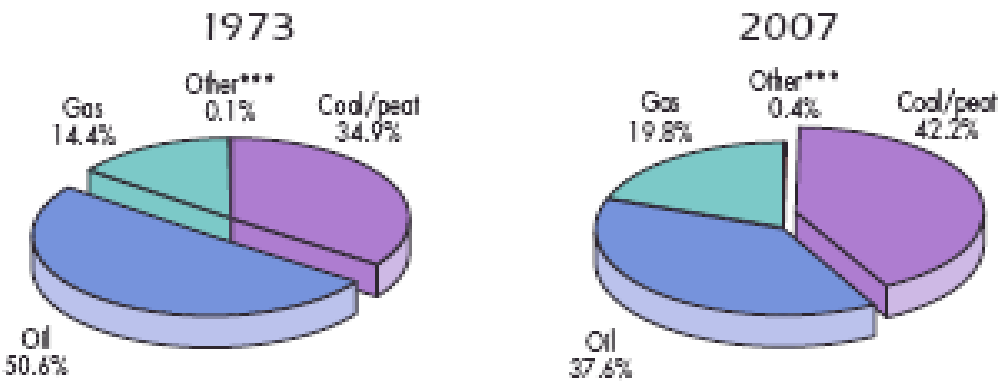
2007 data

CO_2 Emissions by Fuel

Evolution from 1971 to 2007 of world* CO_2 emissions** by fuel (Mt of CO_2)



1973 and 2007 fuel shares of CO_2 emissions**



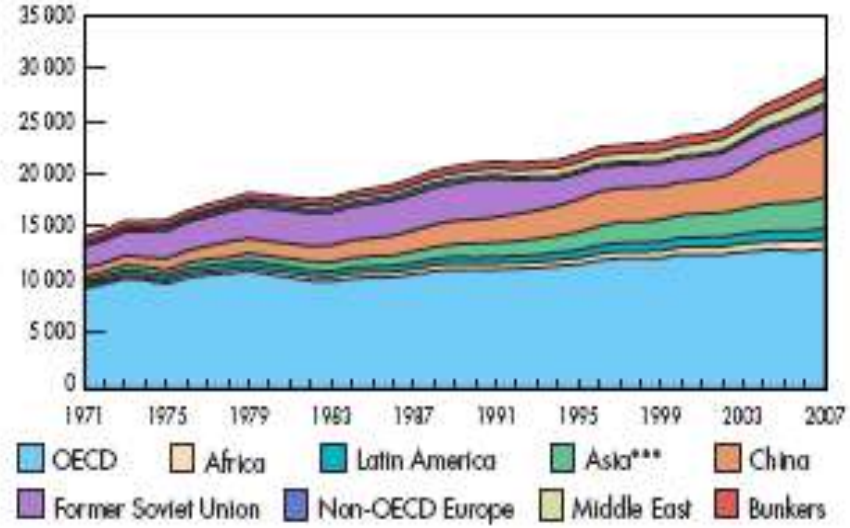
15 640 Mt of CO_2

28 962 Mt of CO_2

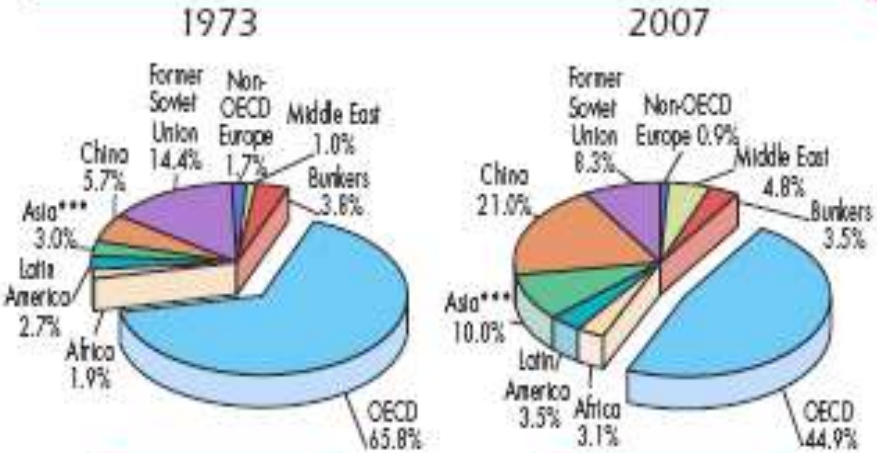
*World includes international aviation and international marine bunkers. **Calculated using the IEA's energy balances and the Revised 1996 IPCC Guidelines. CO_2 emissions are from fuel combustion only. ***Other includes industrial waste and non-renewable municipal waste.

CO_2 Emissions by Region

Evolution from 1971 to 2007 of world* CO_2 emissions** by region (Mt of CO_2)



1973 and 2007 regional shares of CO_2 emissions**



15 640 Mt of CO_2

28 962 Mt of CO_2

*World includes international aviation and international marine bunkers, which are shown together as Bunkers. **Calculated using the IEA's energy balances and the Revised 1996 IPCC Guidelines. CO_2 emissions are from fuel combustion only. ***Asia excludes China.

Figure 1. Shares of anthropogenic greenhouse-gas emissions in Annex I countries, 2006*

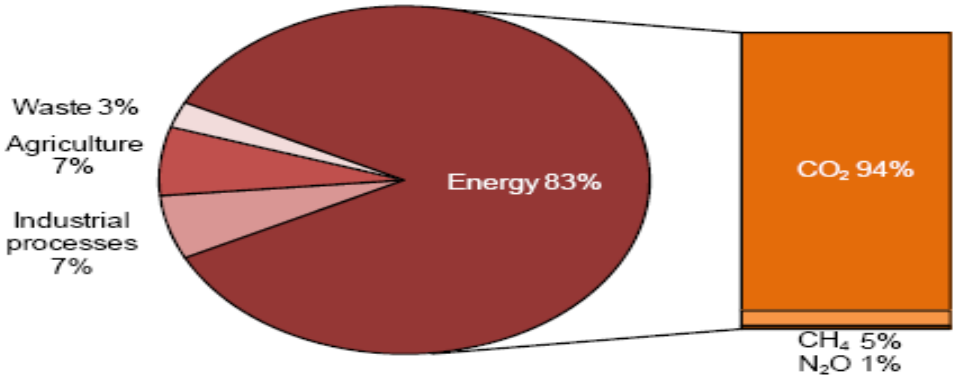
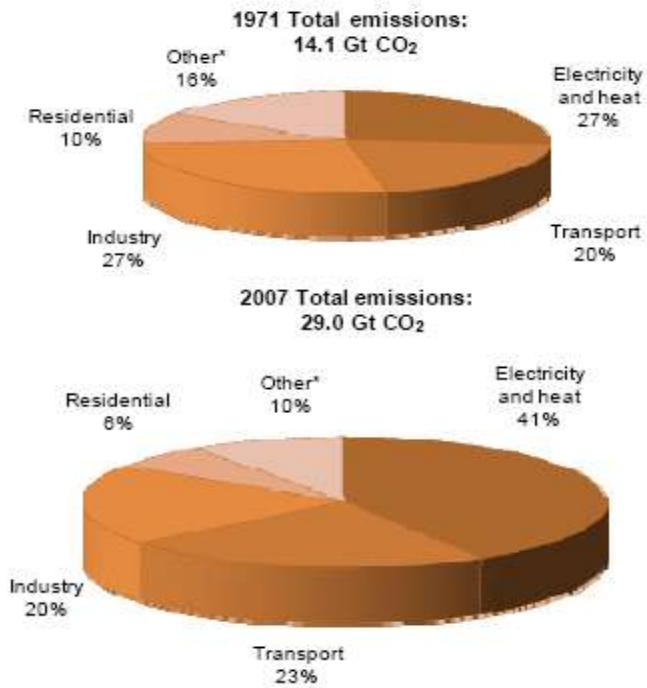
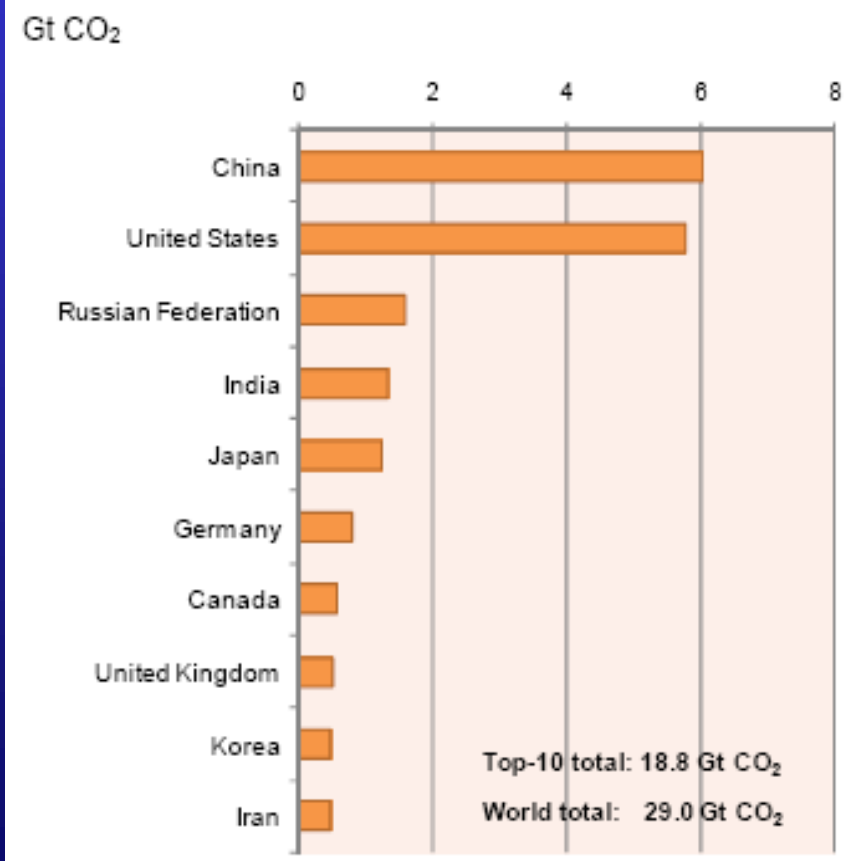


Figure 11. World CO_2 emissions by sector

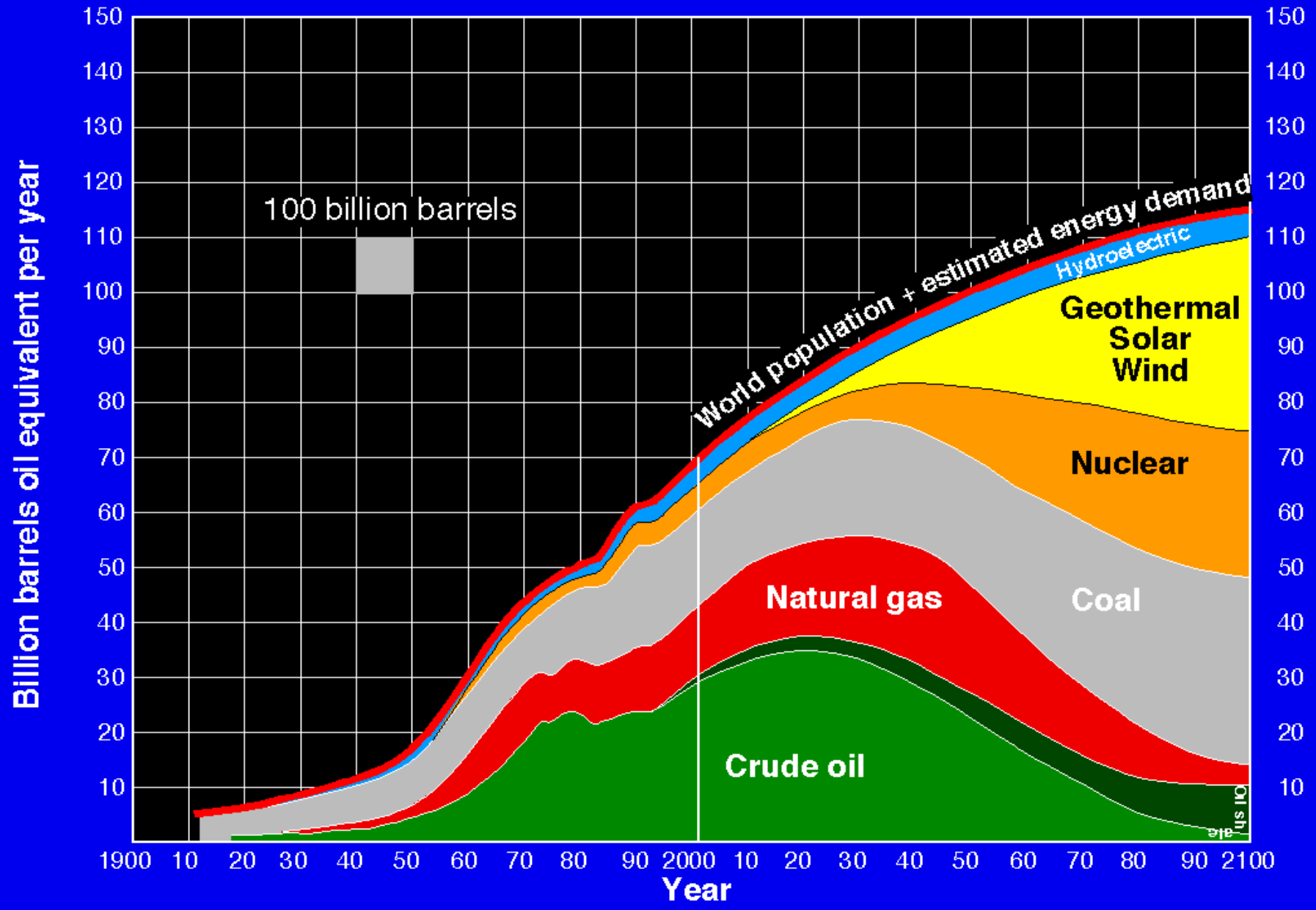


* Other includes commercial/public services, agriculture/forestry, fishing, energy industries other than electricity and heat generation, and other emissions not specified elsewhere.

Figure 7. Top 10 emitting countries in 2007

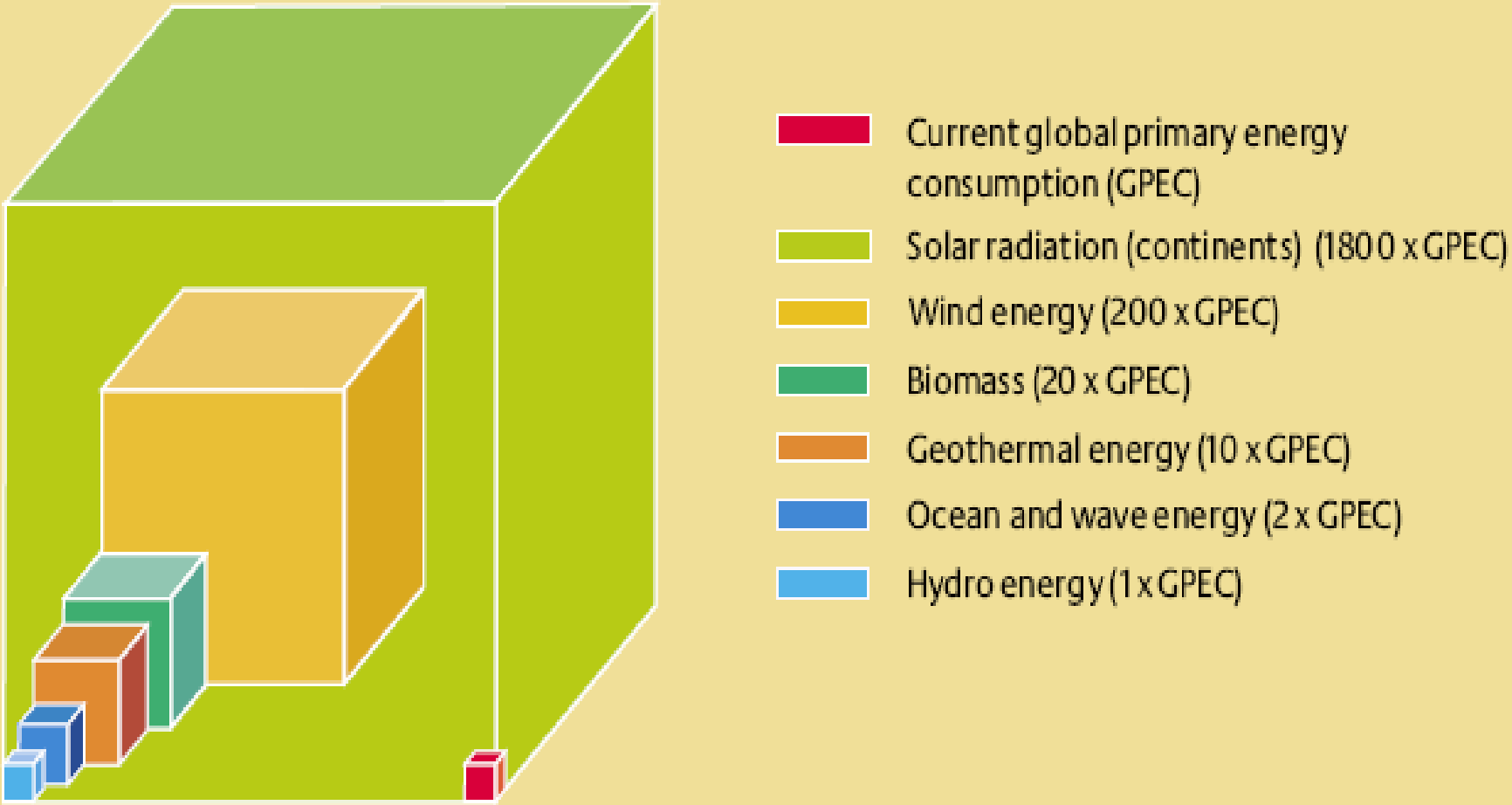


Key point: The Top 10 emitting countries account for about two-thirds of the world CO_2 emissions.



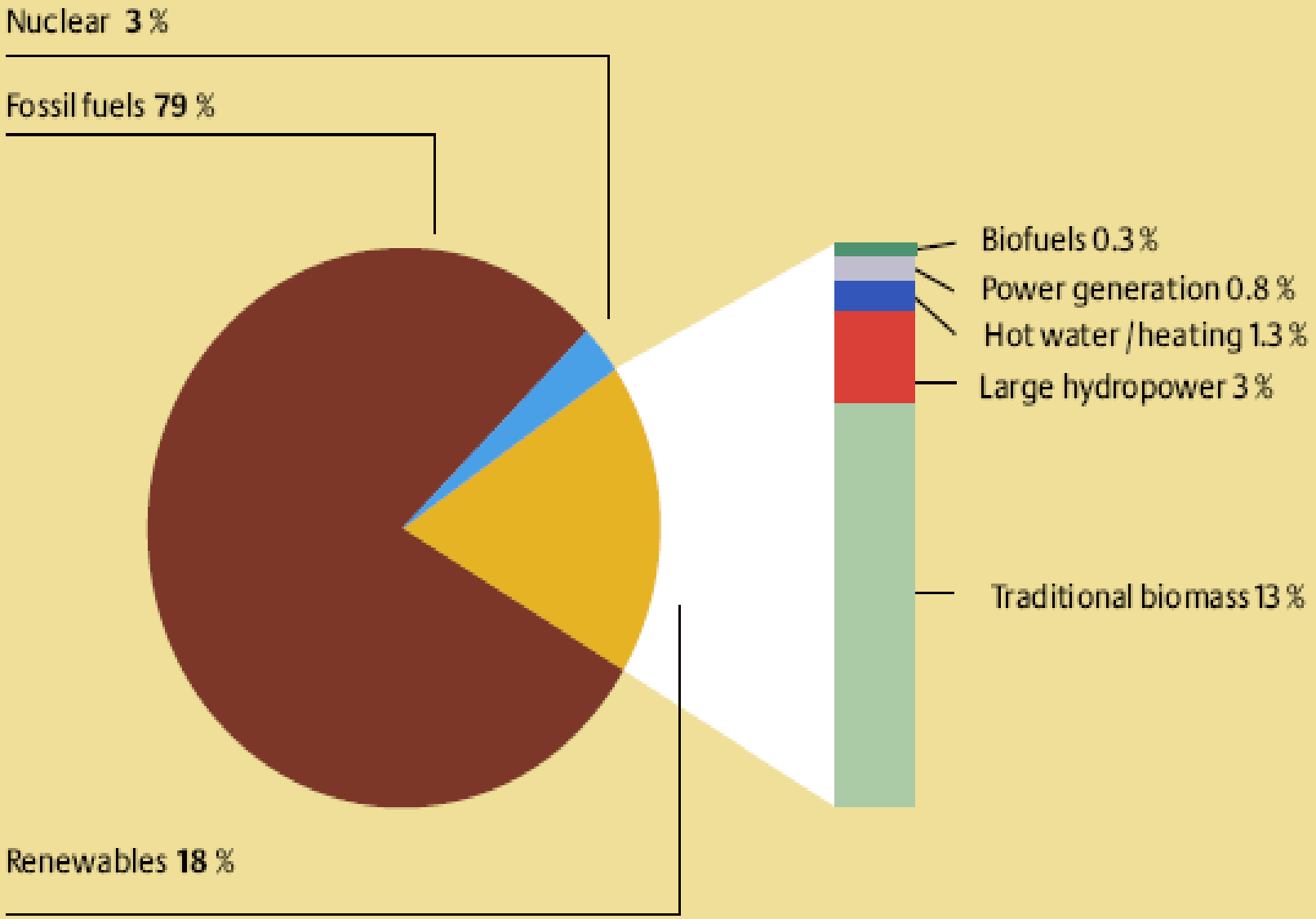
Quelle: Edwards, AAPG 8.97

The physical potential of renewable energies



Source: Nitsch, F. (2007): Technologische und energiewirtschaftliche Perspektiven erneuerbarer Energien. Deutsches Zentrum für Luft- und Raumfahrt.

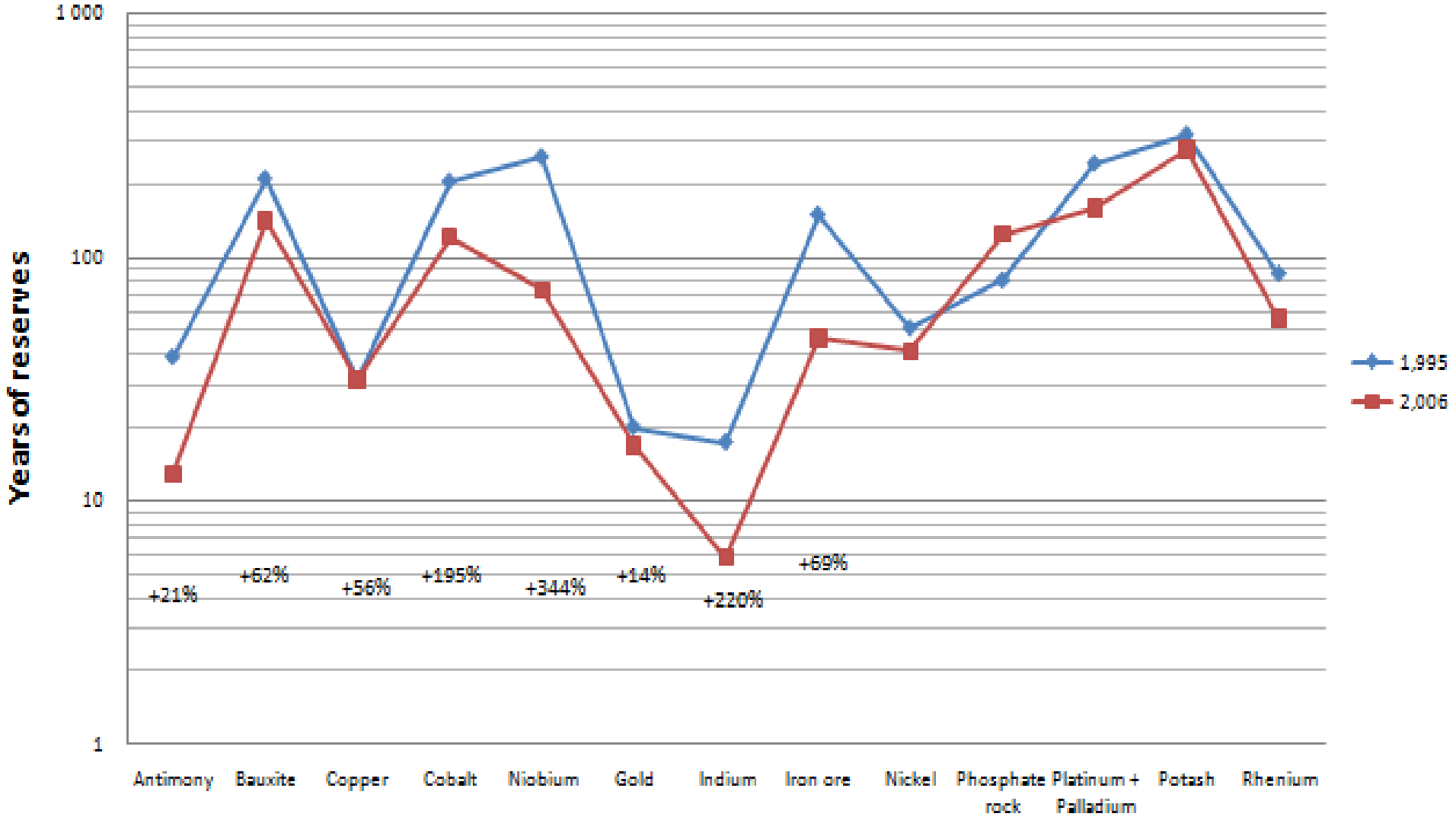
Renewable Energy Share of Global Final Energy Consumption, 2006



Source: REN21 (2008): Renewables 2007 Global Status Report.

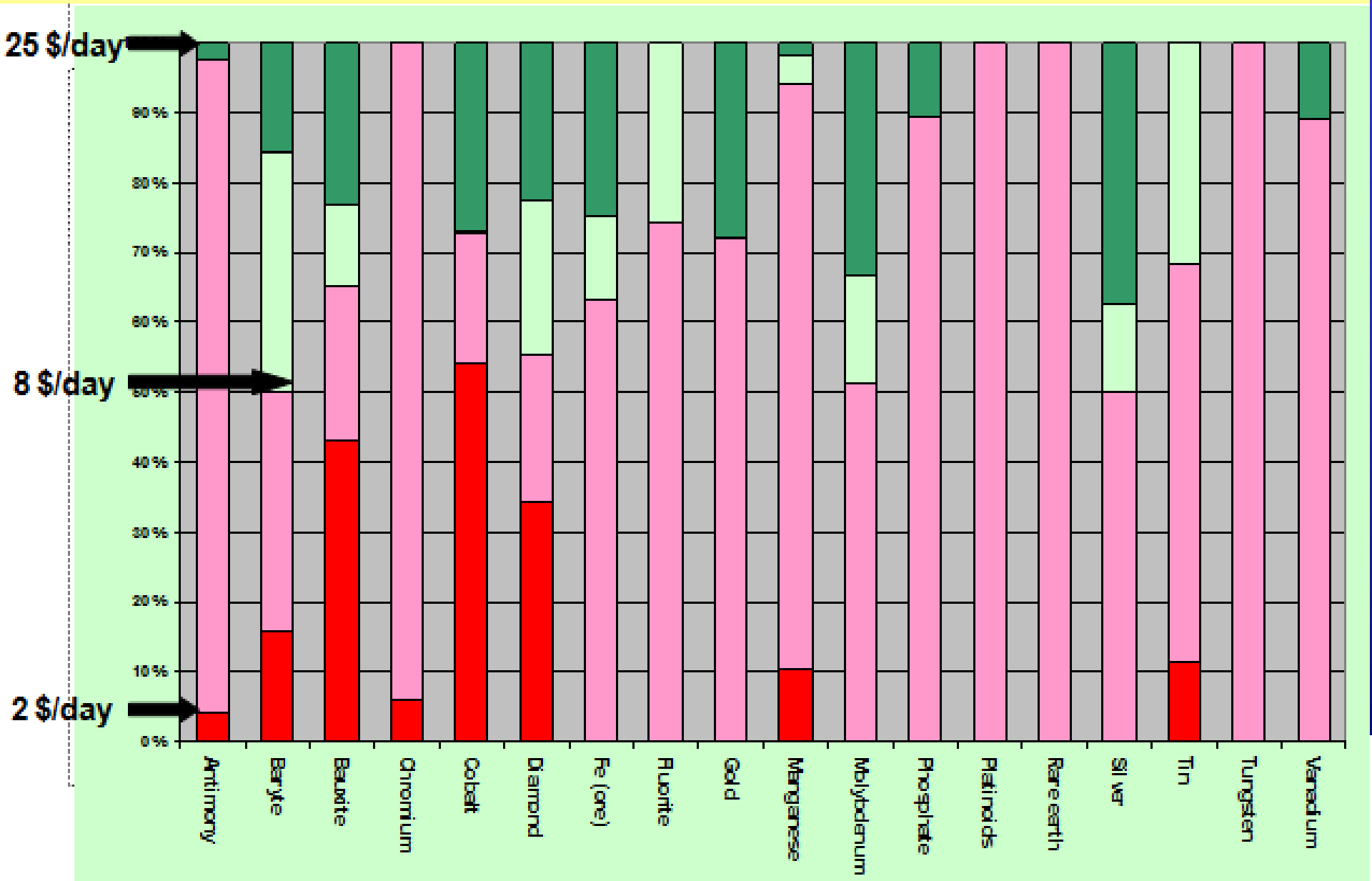
Security of supplies: is scarcity of minerals an issue?
Changes of reserves of selected economically important minerals 1995-2006

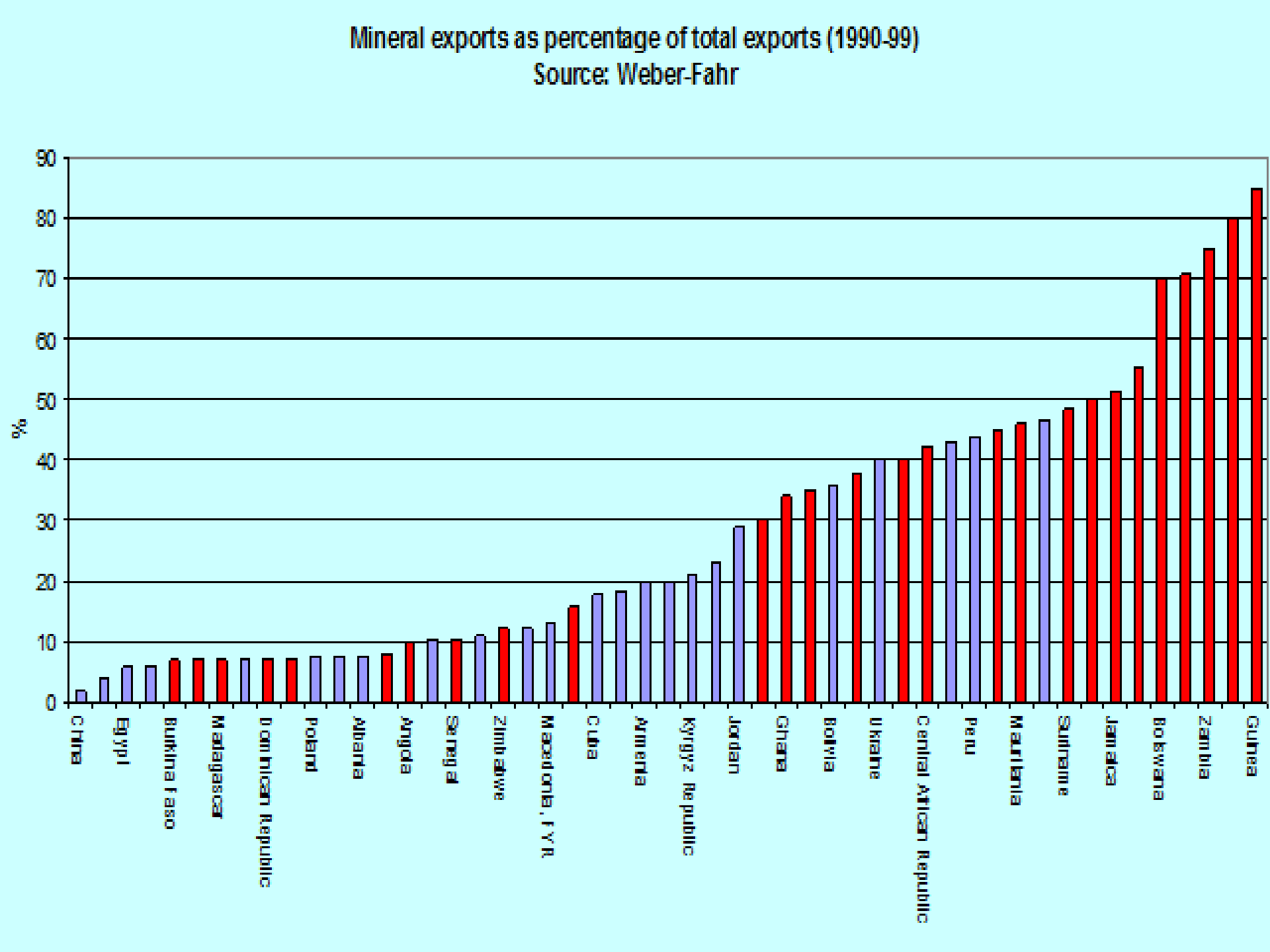
Data source: USGS Mineral commodity prioces

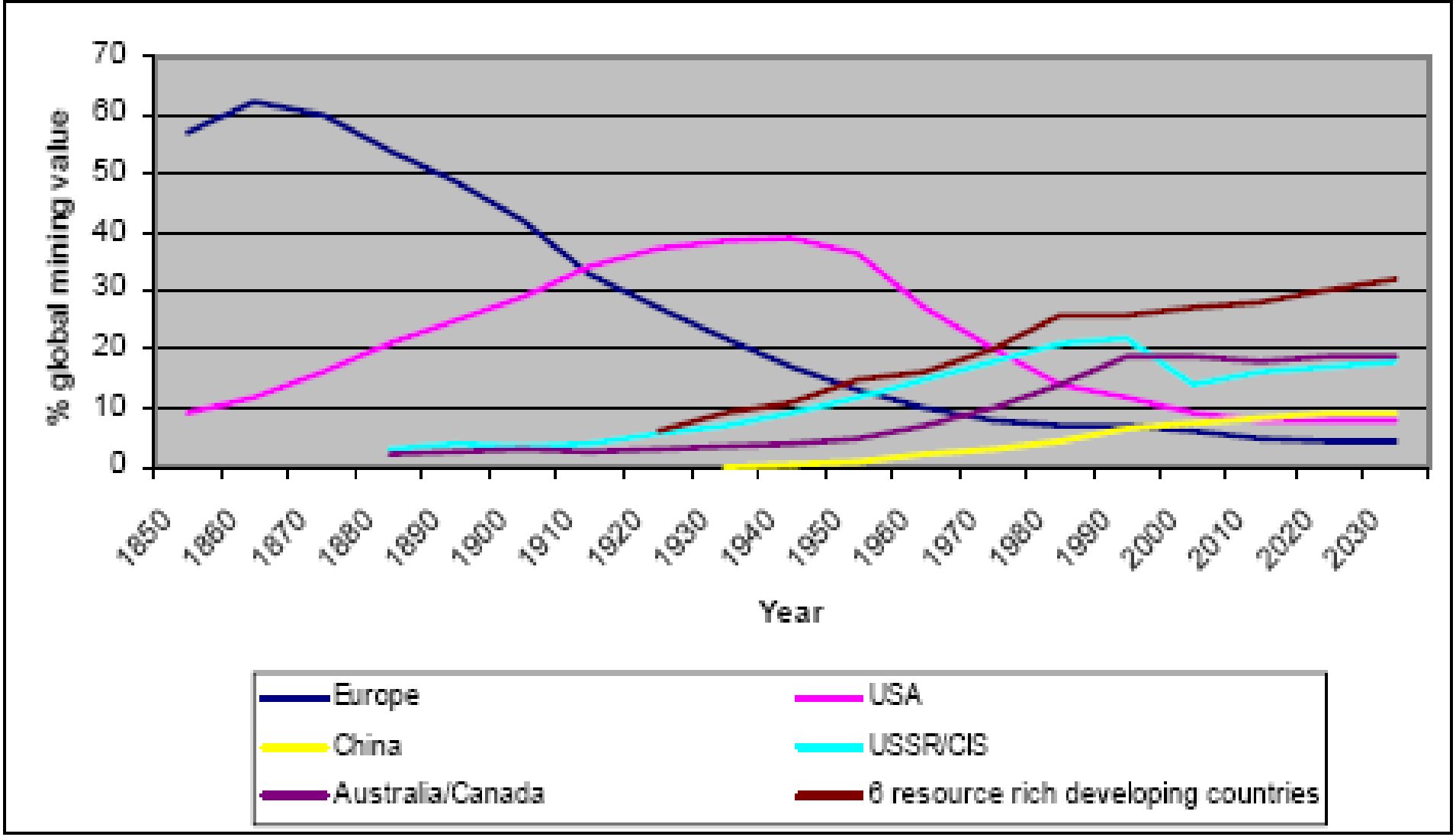


Security of supplies: More than 50% of the known reserves of many minerals essential to industry are in countries with less than 8 €/day/capita gross national income,

Data sources: U.S. Geological Survey and World Bank (2002-2003)




Mineral exports as percentage of total exports (1990-99)
Source: Weber-Fahr
%
0
10
20
30
40
50
60
70
80
90
China
Egypt
Burkina Faso
Madagascar
Dominican Republic
Poland
Albania
Angola
Senegal
Zimbabwe
Macedonia, F.Y.R.
Cuba
Armenia
Kyrgyz Republic
Jordan
Ghana
Bolivia
Ukraine
Central African Republic
Peru
Mauritania
Suriname
Jamaica
Botswana
Zambia
Guinea

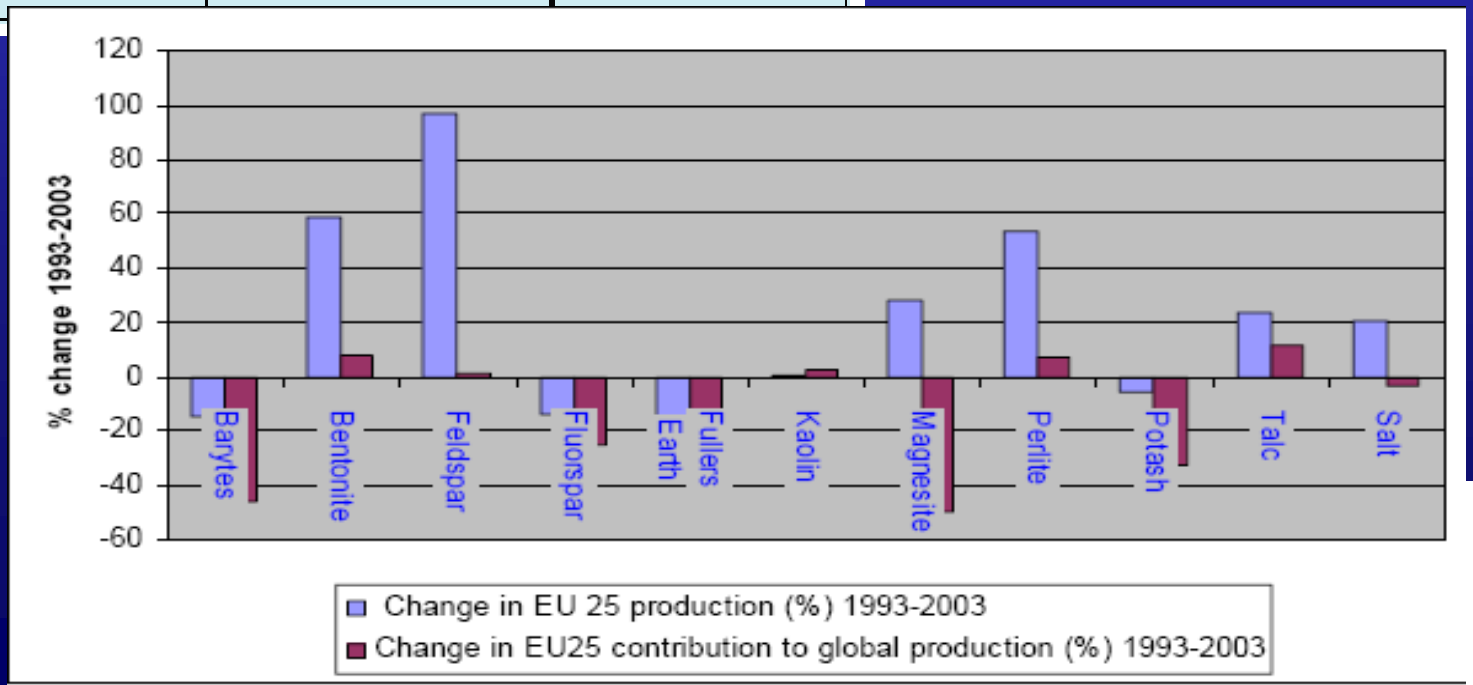


Data source: W. Sames (to 1975) and Raw Materials Group (to 2000 and forecast to 2030).

Table 1: EU 25: European minerals Production as a Proportion of Total World Production (Source: World Mining Data 2002)

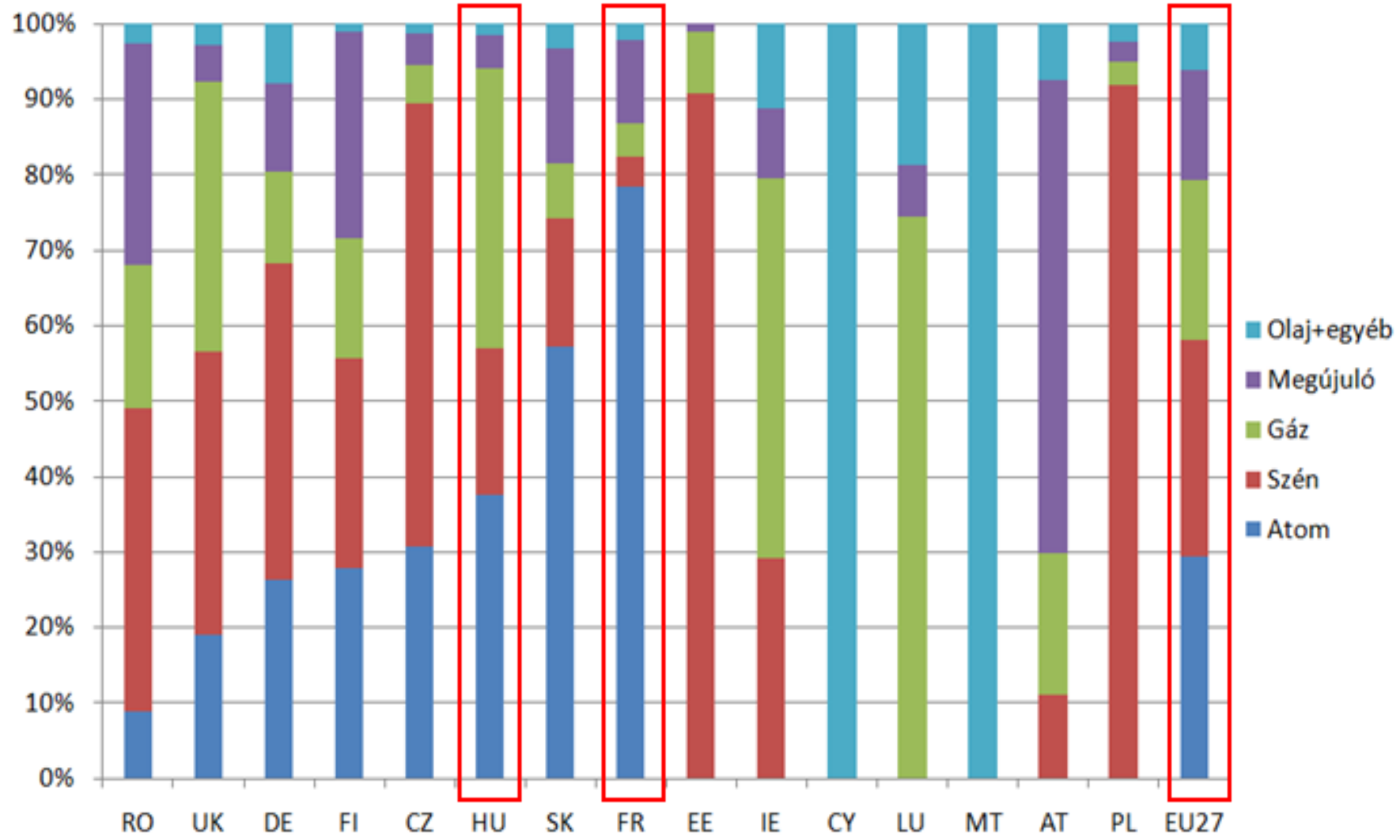
Ores	t(Metal)	% Proportion World
Bauxite (Aluminum)	2,467,255	1.8
Copper	715,689	5.2
Lead	271,190	8.8
Zinc	843,810	9.5
Chrome	288,343	5.6
Nickel	22,201	1.9
Iron Ore	11,878,949	1.6
Industrial Minerals	**Production (t metal)**	**% Proportion World**
Baryte	398,936	5.8
Bentonite	2,586,585	24.7
Diatomite	128,387	12
Feldspar	4,684,413	52.1
Fluorspar	314,381	7.1
Graphite	21,479	3.6
Magnesite	2,649,830	19
Perlite	1,014,165	46.1
Salt	44,878,991	21.9
Talk	1,274,770	17.2
Agricultural Minerals	**Production (t K_2O)**	**% Proportion World**
Potash	4,936,875	19.9

EU mineral imports dependence in 1995, after data from the European Minerals Yearbook (BRGM, 1997) TREND: WORSENING			
Antimony ore	100%	Vanadium ore	100%
Beryllium ore	100%	Uranium ore	94%
Boron	100%	Phosphate rock	93%
Cobalt	100%	Bauxite	82%
Molybdenum	**100%**	Iron ore	82%
Niobium ore	100%	Zinc ore	82%
PGM ores	100%	Copper ore	78%
Rare earth ores	100%	Nickel	78%
Rhenium ore	100%	Lead ore	56%
Tantalum ore	100%	Chromium ore	50%
Ilmenite	100%	Tungsten ore	48%
Rutile	100%	Asbestos	43%



Európai sokszínűség

A villamosenergia-termelés tüzelőanyag-összetétele az EU tagországaiban (2006)



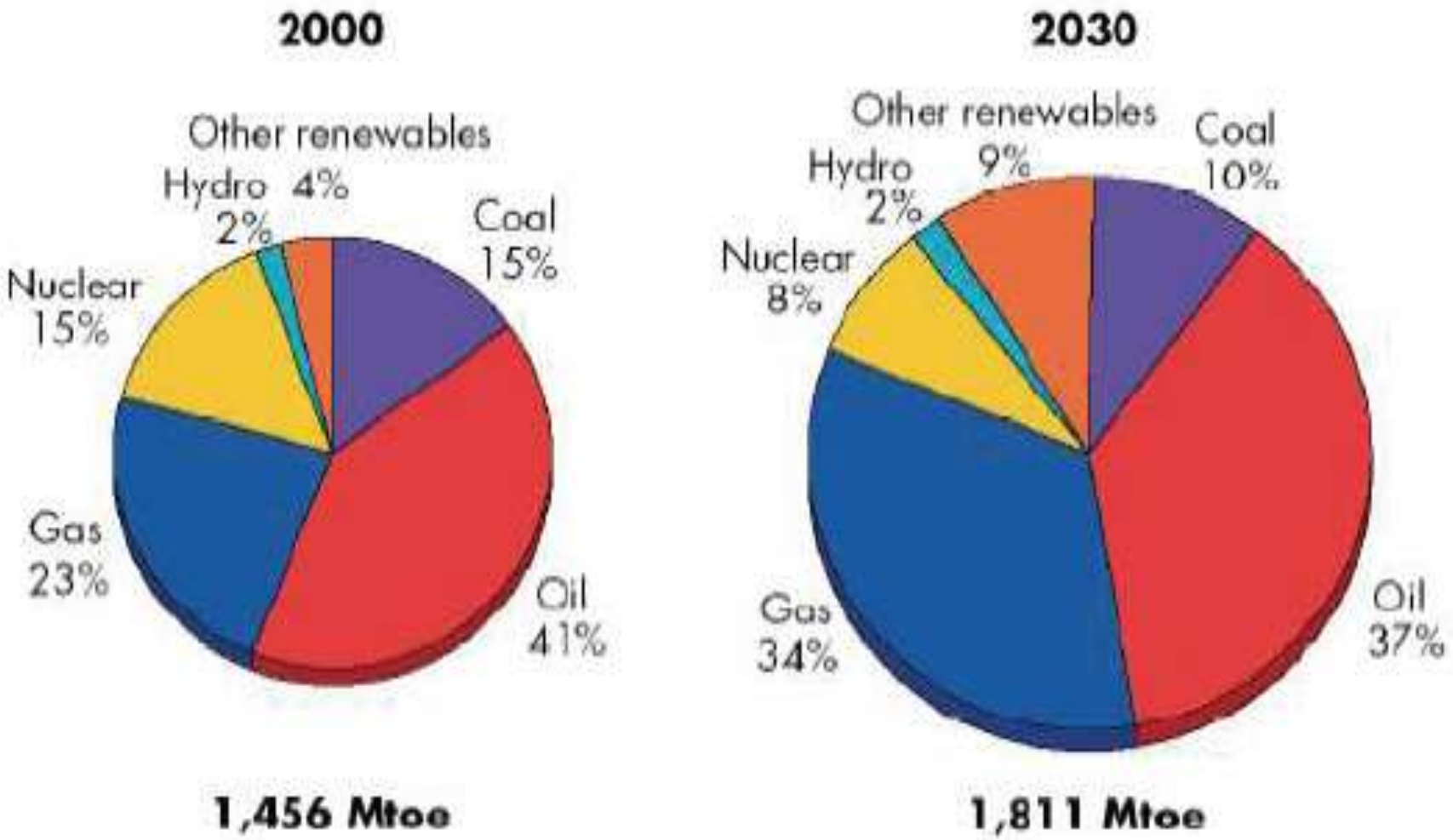
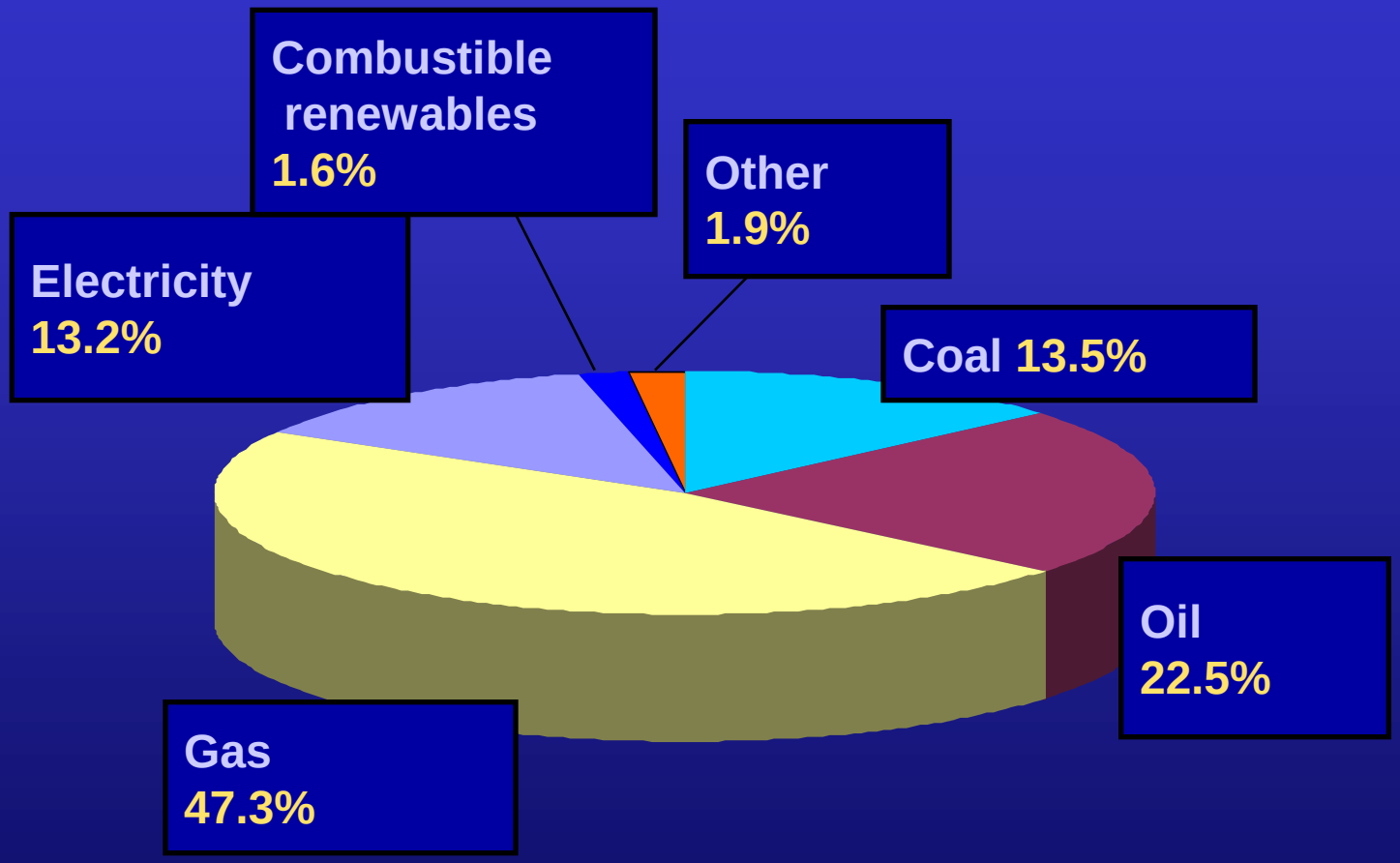
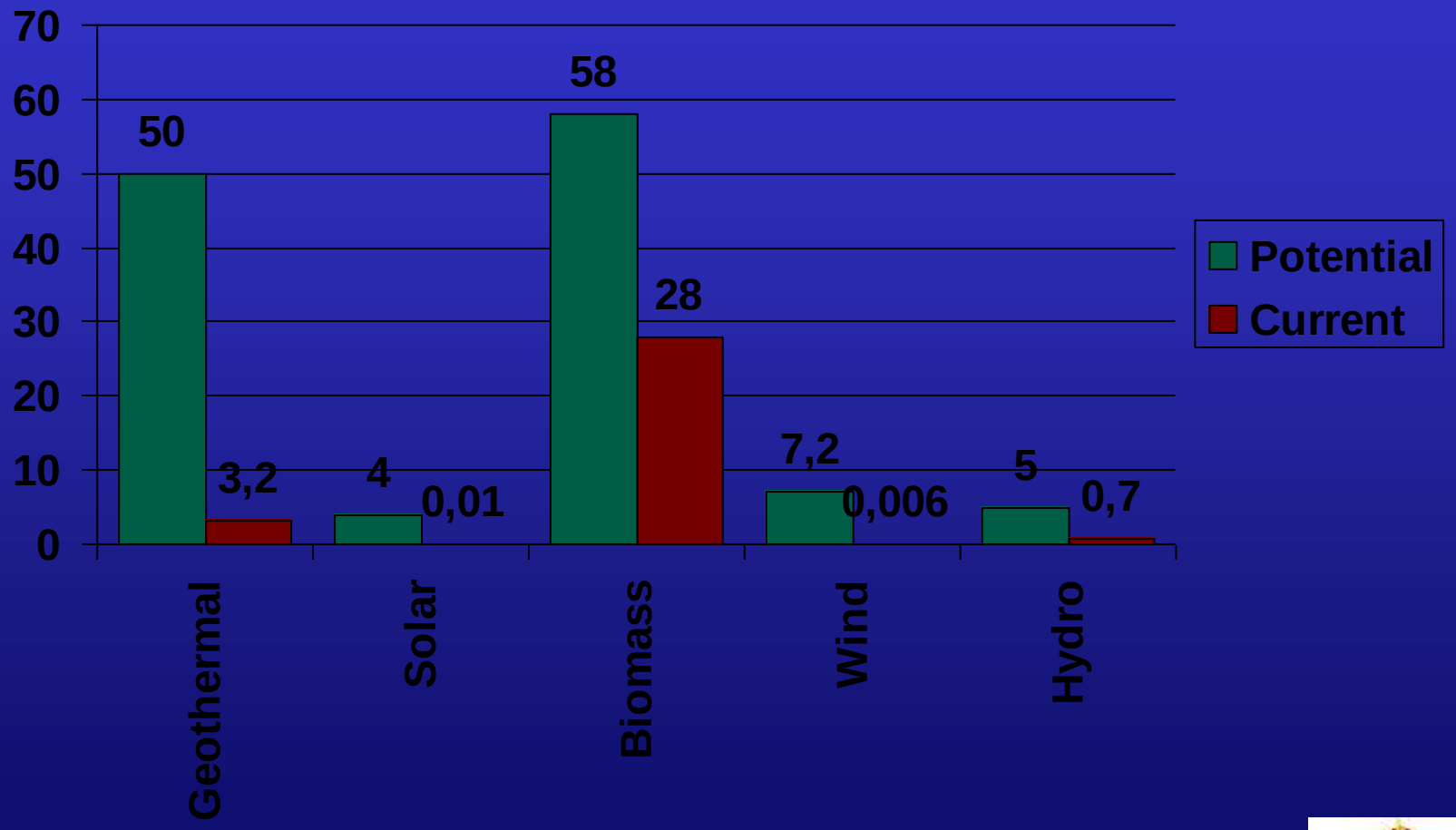


Fig. 12 – Total primary energy demand in the European Union 2000-2030 (World Energy Outlook 2002, taken from Van der Linde, 2003)

TOTAL PRIMARY ENERGY SUPPLY IN 2003, Hungary
25.8 Mtoe (1213.5 PJ)



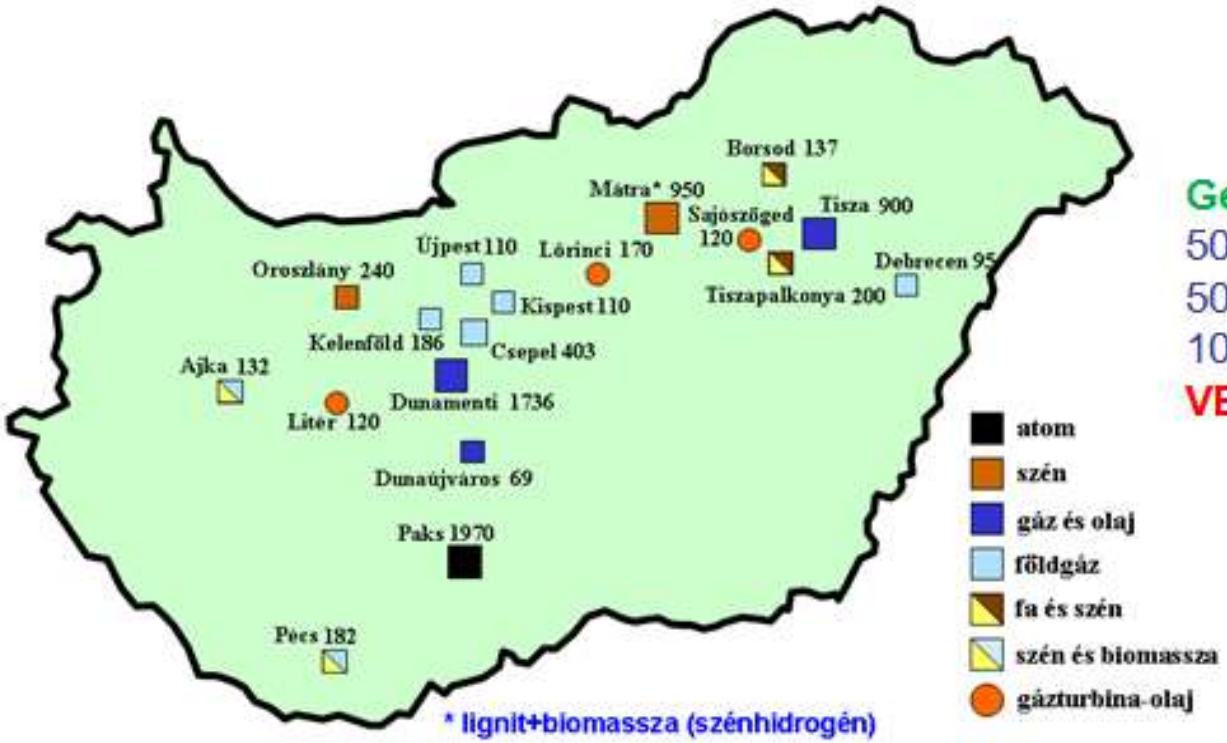
RENEWABLE ENERGY RESOURCES IN HUNGARY (PJ/year)



A primer energiaimport-függőség alakulása Magyarországon 1990 és 2005 között

	1990	1998	2005
	%	%	%
Szén	16,4	28,6	39,6
Olaj	75,9	80,9	86,1
Földgáz	58	72,7	81,8
Villamos energia (primer)	21,1	1,7	12,9
Egyéb (koksz, brikett, tűzifa és egyéb megújuló)	43,4	-16	8,5

A magyar VER főbb erőművei 2008. december 31-én

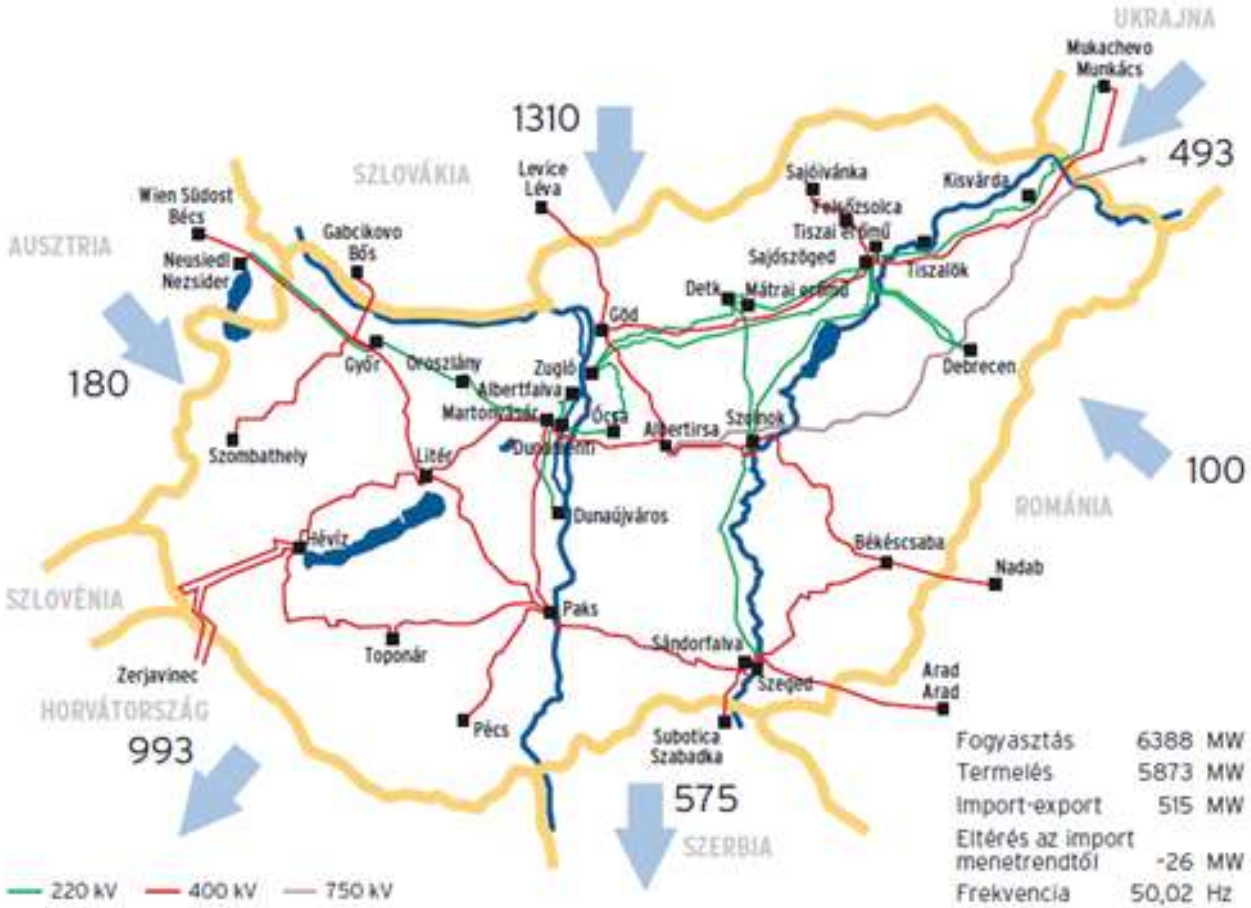


Gépnagyság	Darab	MW
50 MW alatt	529	2087,8
50-100 MW között	15	1033,0
100 MW felett	30	6019,0
VER összesen	**574**	**9139,8**

Nagyerőművek:	7812,9 MW
Kiserőművek:	1326,9 MW
Összes erőmű:	**9139,8 MW**

Az erőmű neve mellett a beépített, névleges villamos teljesítőképesség (BT) MW-ban

A VER rendszerterhelése az éves csúcsterhelés időpontjában (2008.01.09., 17.00 óra)



Csúcsterhelés

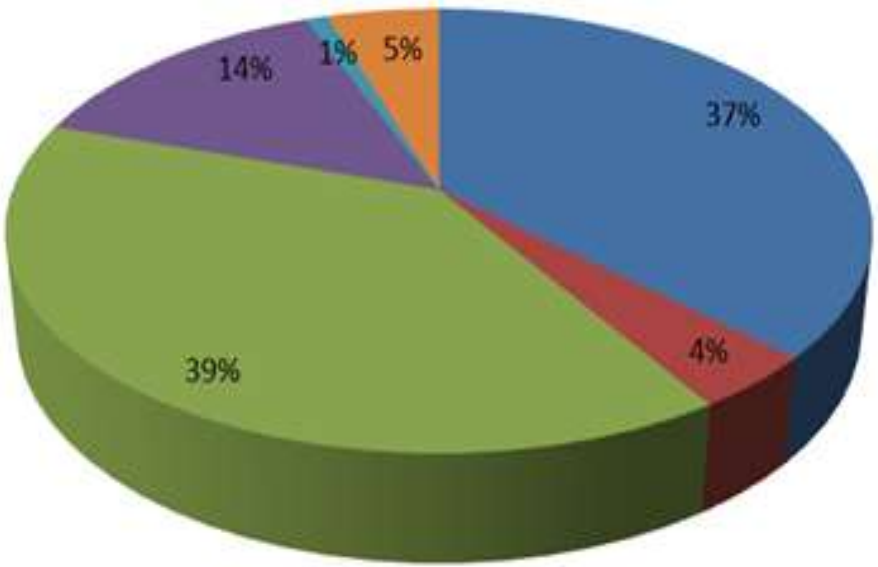
2006-ban **6432** MW (2006.12.13)

2007-ben **6602** MW (2007.11.29)

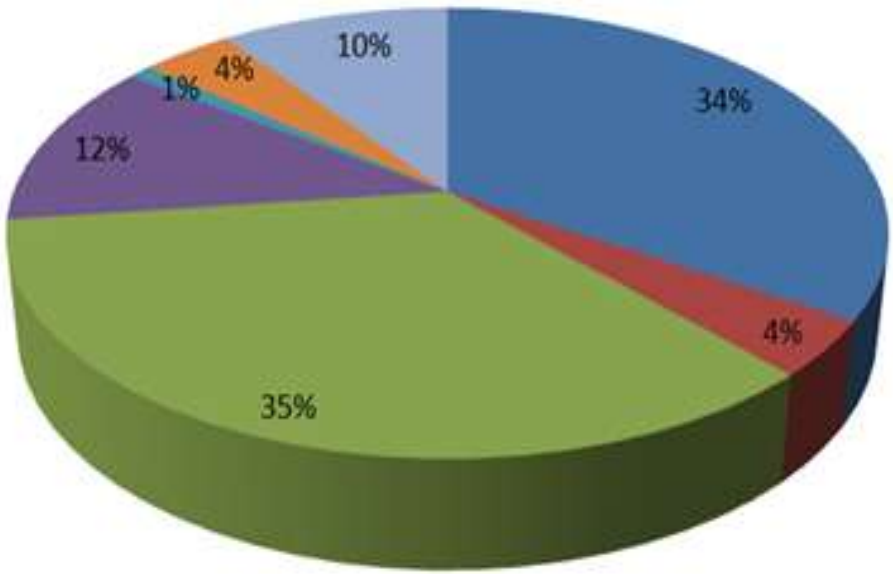
2008-ban 6388 MW

A fogyasztás és termelés megoszlása 2008-ban

A termelt hazai villamos energia megoszlása

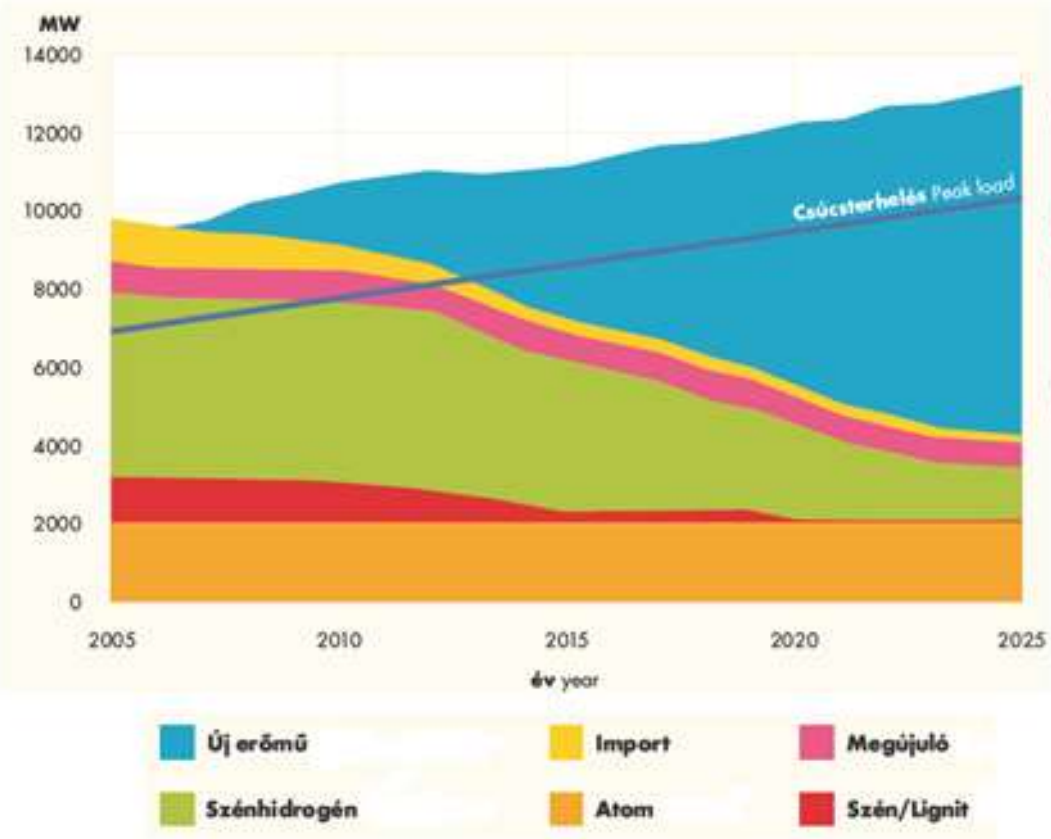


A bruttó villamosenergia-fogyasztás forrásmegoszlása



Atom Szén Földgáz Lignit Olaj Megújuló Import

A jövő nagy kihívása…



szükséges új kapacitás

növekvő energiaigény…

avuló erőműpark…

csökkenő import…

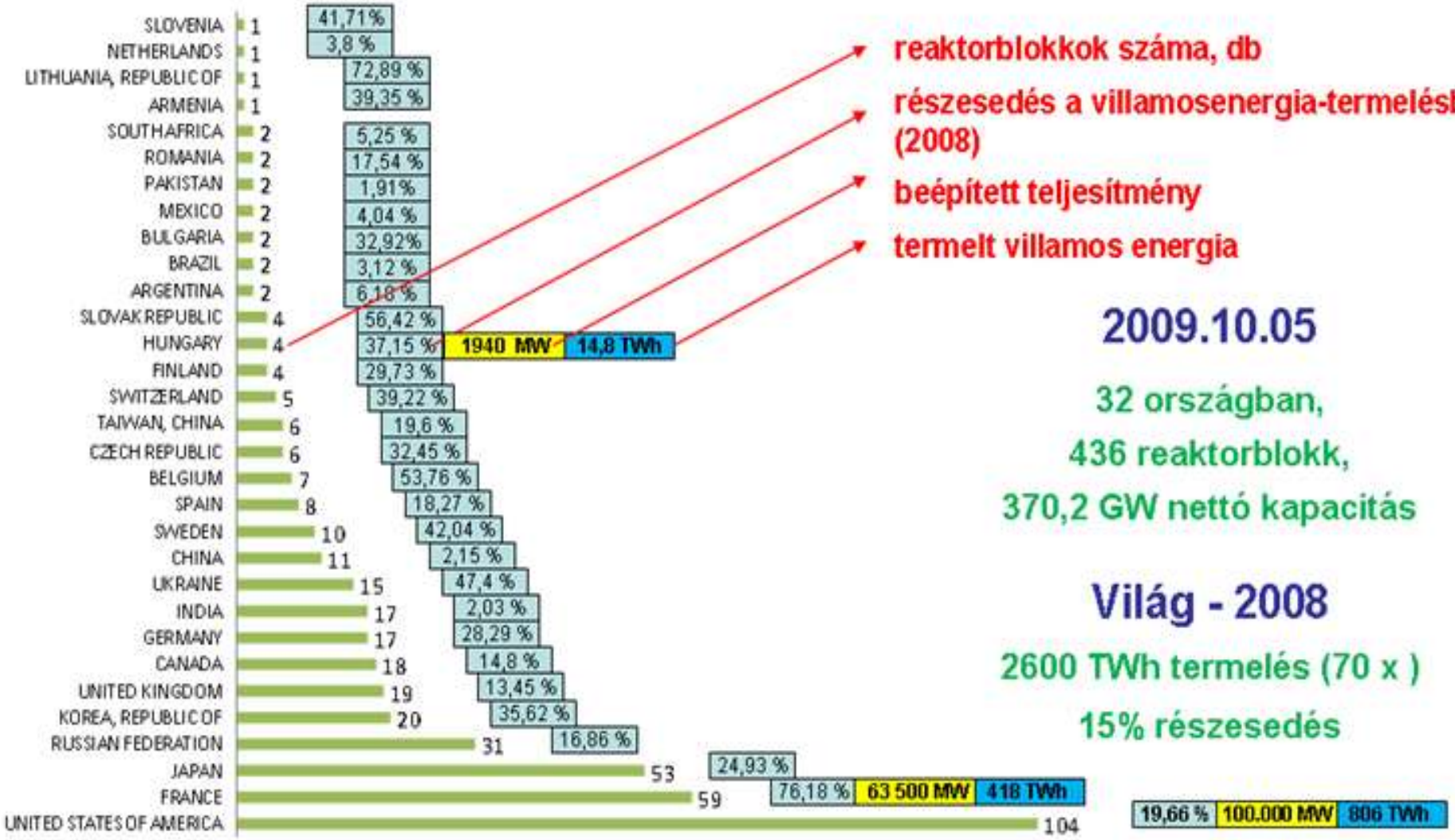
Terhelésnövekedésből (~100 MW/a)
+ 1500 MW

Erőmű-leállításokból (9000 → 5000 MW)
+ 4000 MW

Import-csökkenésből (500 → 0 MW)
+ 500 MW

Összes újonnan létesítendő erőmű 2025-ig: + 6000 MW

Az atomenergia nemzetközi jelene, jövője – működő blokkok



2009.10.05

32 országban,

436 reaktorblokk,

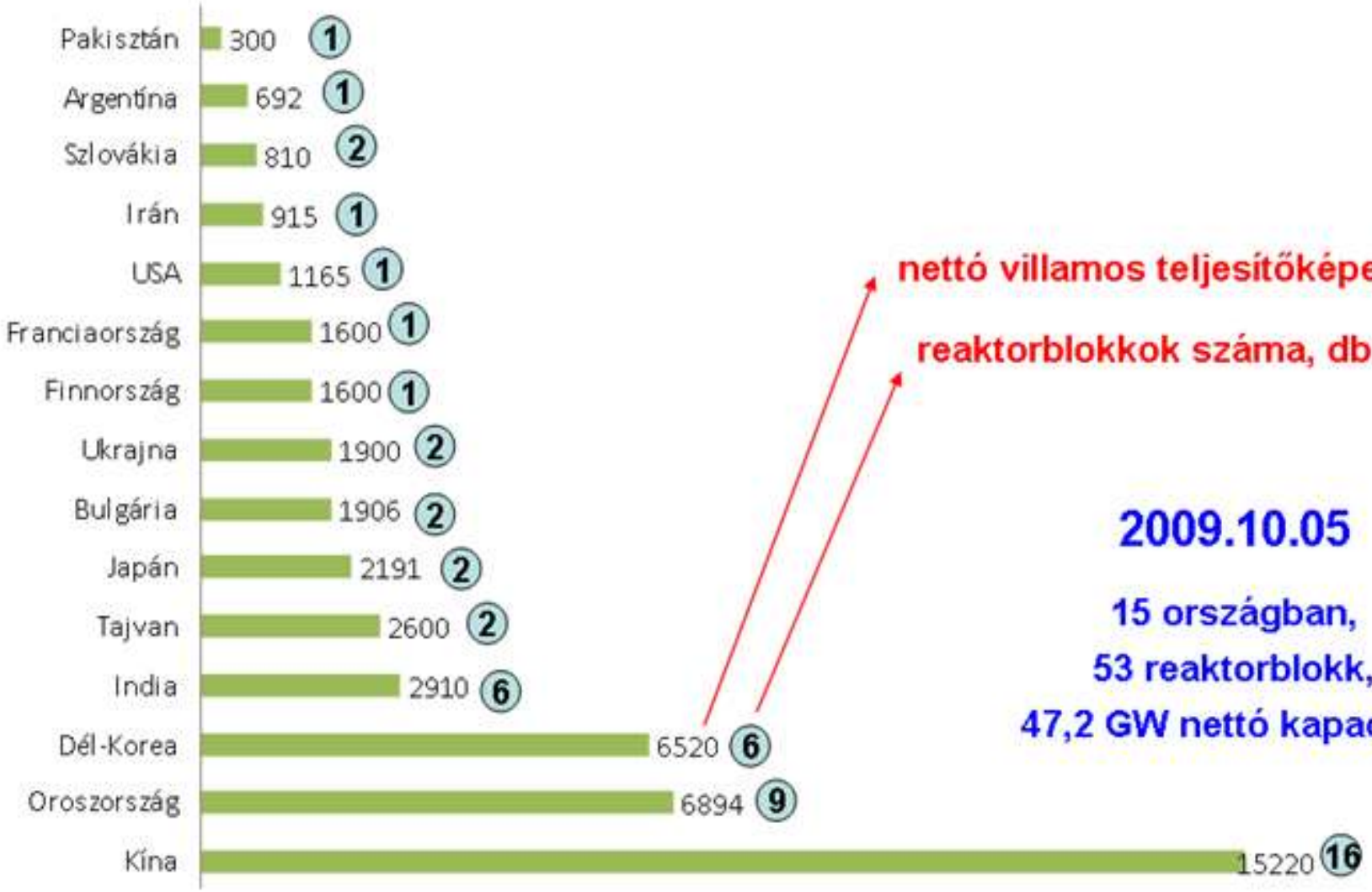
370,2 GW nettó kapacitás

Világ - 2008

2600 TWh termelés (70 x)

15% részesedés

Az atomenergia nemzetközi jelene, jövője – épülő atomerőművek



2009.10.05

15 országban,
53 reaktorblokk,
47,2 GW nettó kapacitás

1600 MW-os atomerőművi blokk helyett, amelynek 24 hónap alatt 64 t UO_2 az üzemanyag szükséglete szénerőmű v. gázerőmű épülne…

Szénerőmű esetén: évi 3,5 millió tonna feketeszén

Gázerőmű esetén: évi 2,9 milliárd m^3 földgáz többlet

2008-ban is legtöbbet és a legolcsóbban termelő erőmű:

14,818 GWh villamos energia, 1 kWh=10,16 Ft, hazai termelés 37%-a

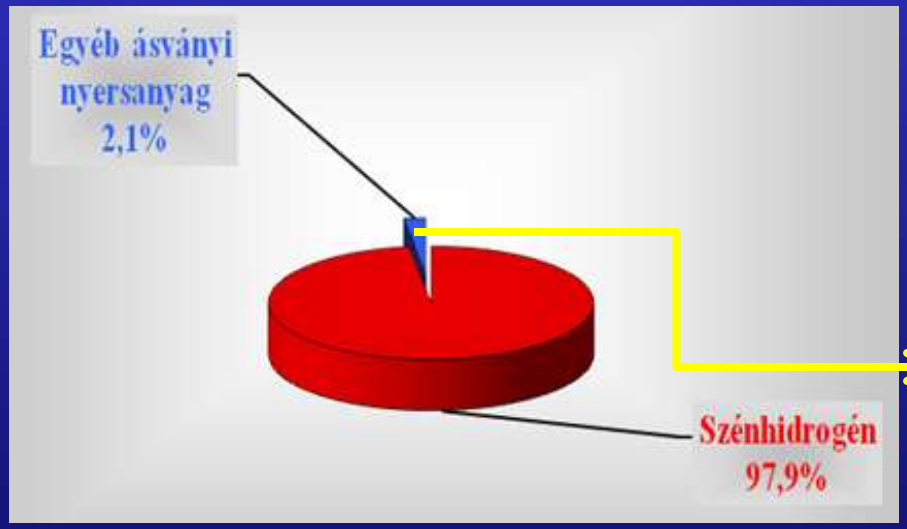
Erőmű típusok összehasonlítása 1000 MW teljesítmény, évi 6600 órás 75% kihasználtság [tonna]					
	Szén	Lignit	Olaj	Földgáz	Atom
Tüzelőanyag	2 000 000	7 600 000	1 289 768	920 000	20
O_2 felhasználás	3 800 000	4 800 000	3 270 047	1 600 000	0
CO_2 kibocsátás	5 200 000	6 600 000	4 496 314	2 200 000	0
SO_2 kibocsátás	3 800	4 300	3 134	1 200	0
NO_x kibocsátás	3 800	4 300	3 134	3 500	0
Por kibocsátás	600	640	470	200	0
Hamu, hulladék	150 000	950 000	2 000	0	100-200

HAZAI BÁNYÁSZAT:

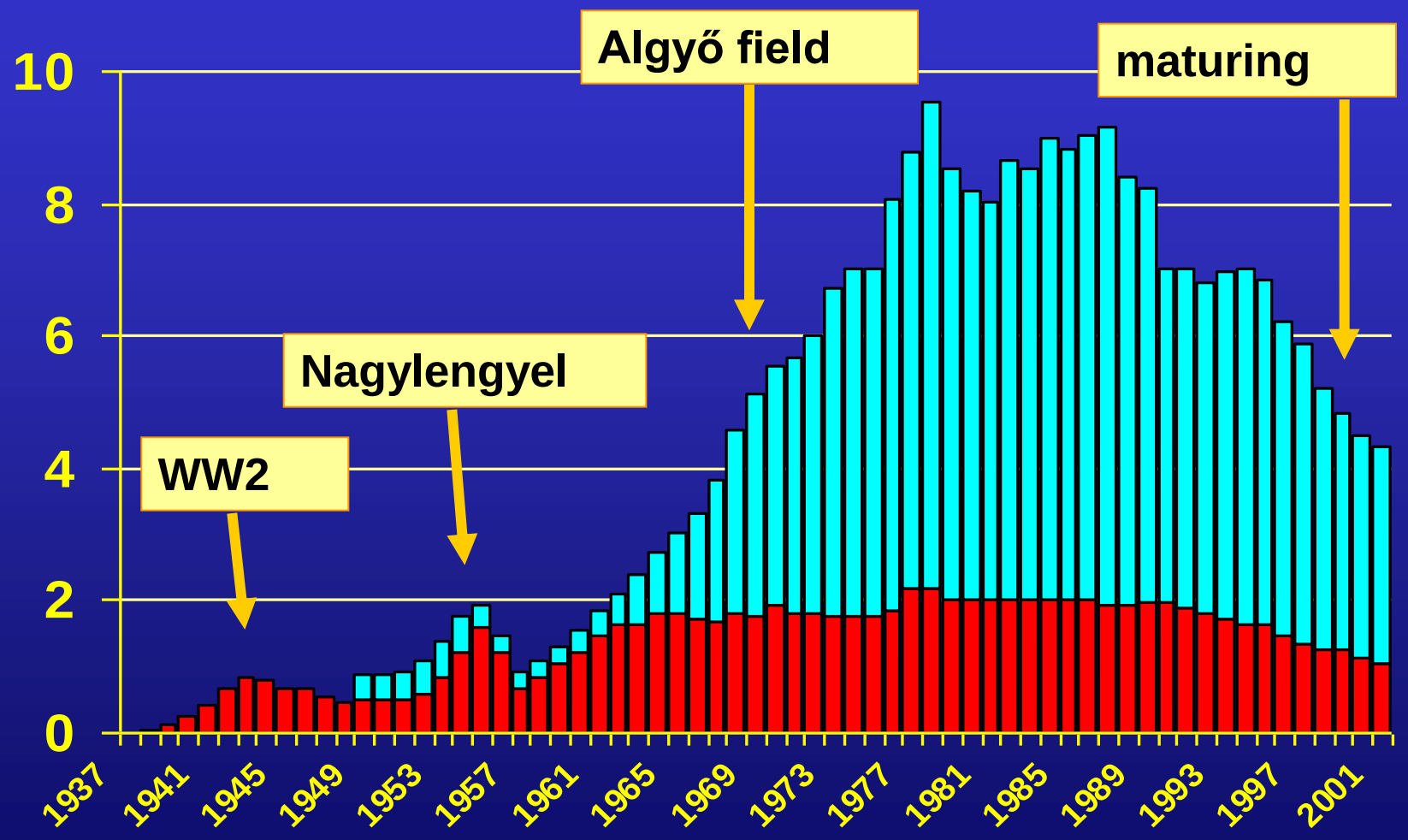
880 bányavállalkozó

1860 kitermelőhely

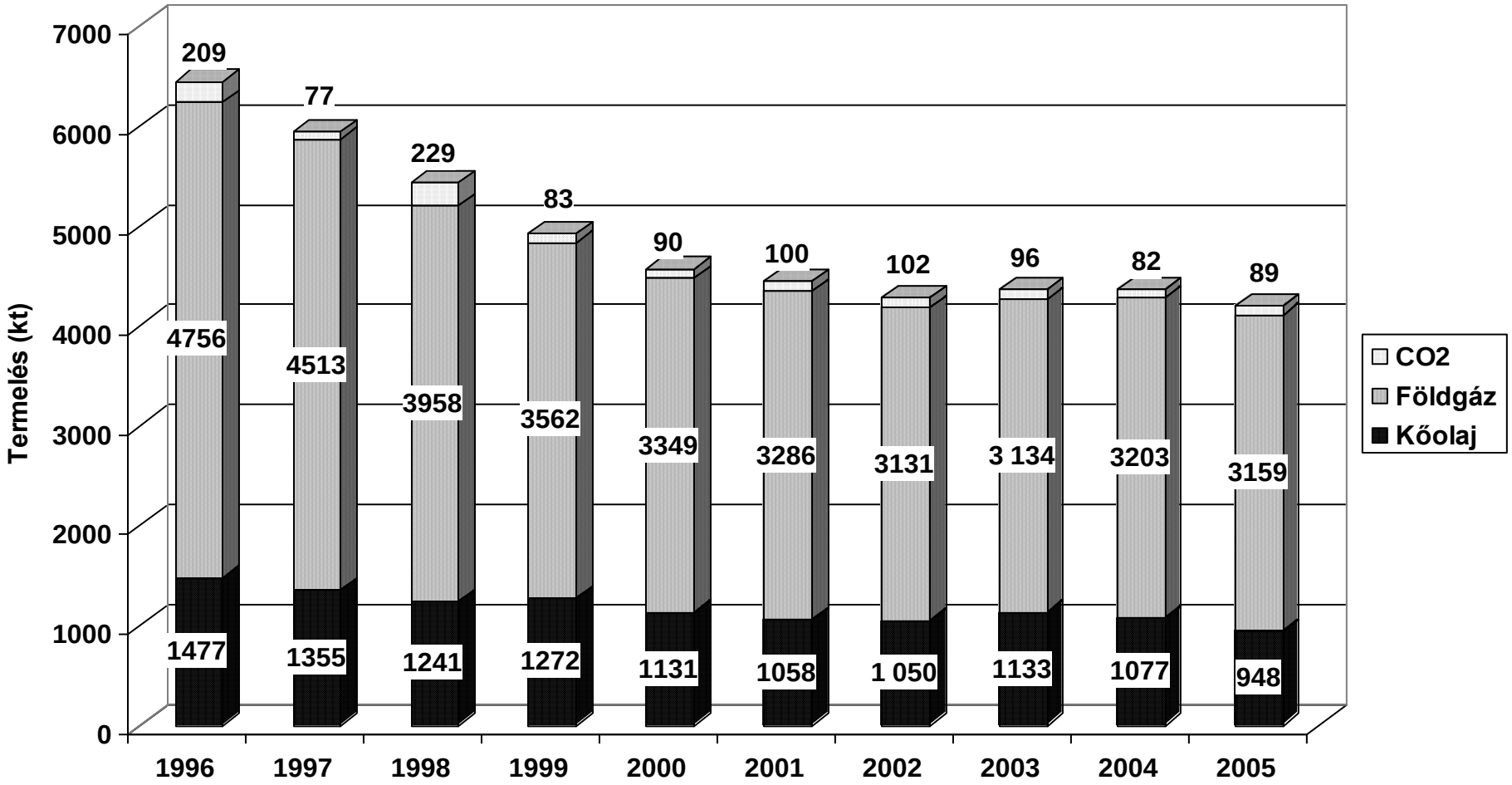
114 md Ft bányajáradék



OIL AND GAS PRODUCTION



A szénhidrogéntermelés alakulása Magyarországon az elmúlt tíz évben



COAL

Development of huge lignite open pits for power generation

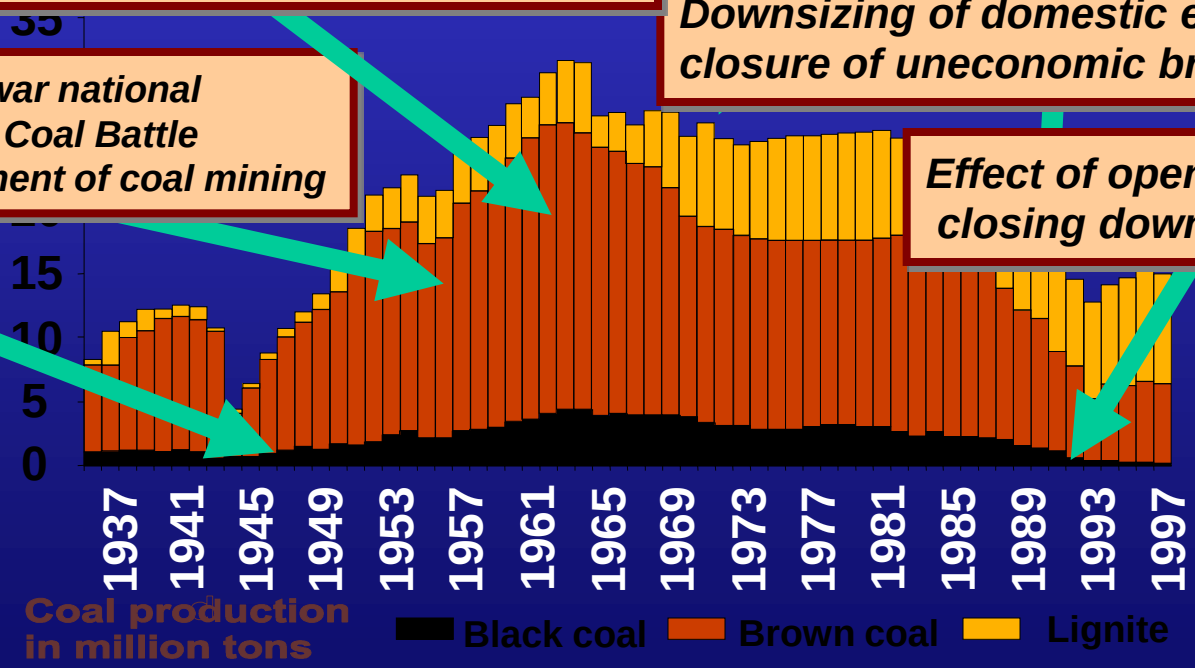
National projects for renewing coal reserves: Eocen, Lias, Ajka-II etc

Downsizing of domestic energy needs: closure of uneconomic brown coal mines

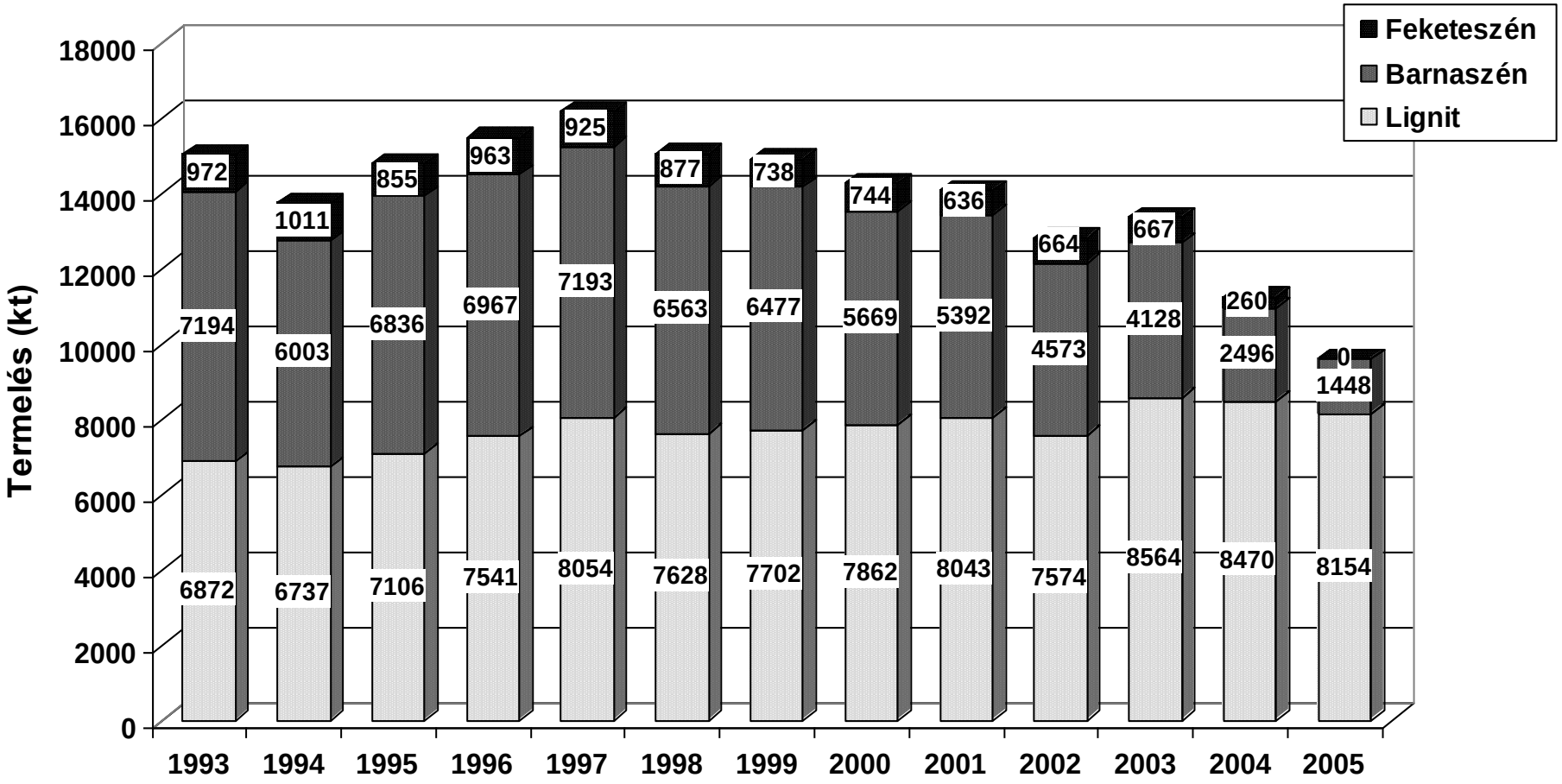
Source of the post-war national reconstruction: the Coal Battle extensive development of coal mining

Effect of open coal markets: closing down the Lias mines

Word War II destruction



A széntermelés alakulása Magyarországon az elmúlt években



URANIUM

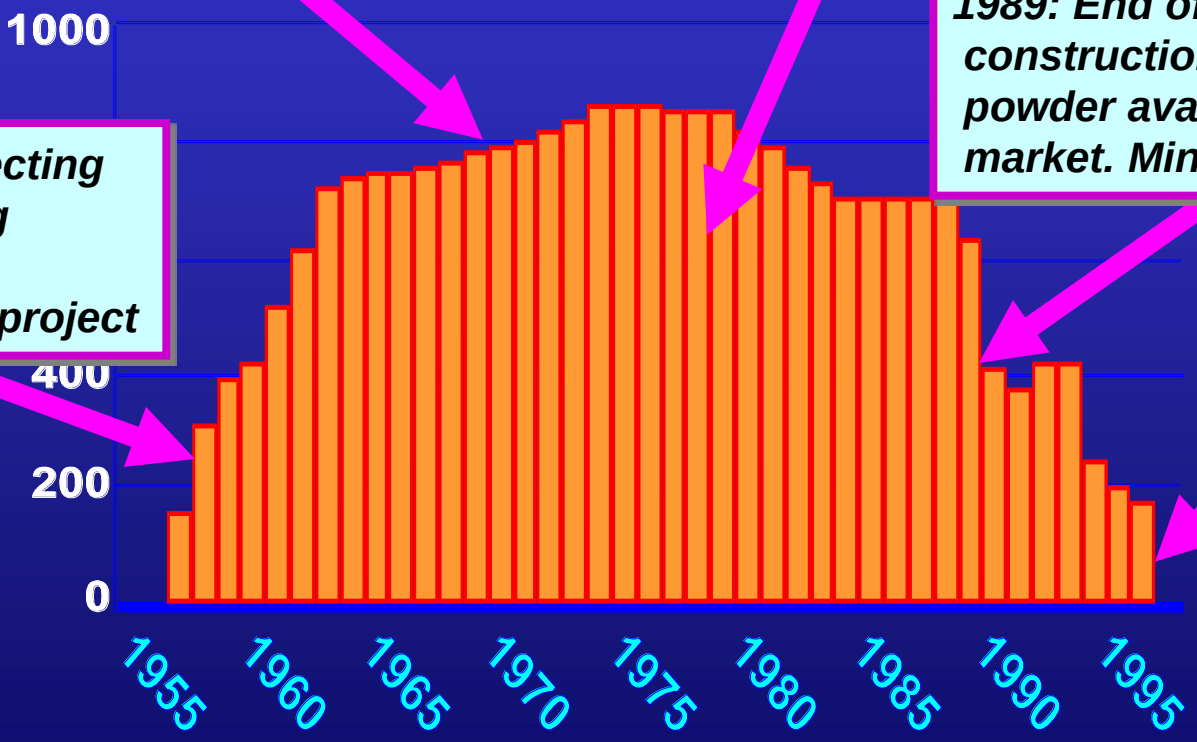
1966-68: first national aerogeophysics survey, budgeted by nuclear industry

With Soviet barter in refining and smelting, the Mecsek mine supplies the Paks NPP

1989: End of artificial price construction. Cheap yellow powder available at the free market. Mine output reduced.

1955-1962: detecting and developing Mecsek occur-rence, a secret project

1997: Mecsek mine closure



Uranium ore production in thousand (metric) tons

BAUXITE

Alumina/metal barter contract with the Soviet Union, using the comparative benefits

Intensive prospecting for new deposits, applying successful geophysical methods

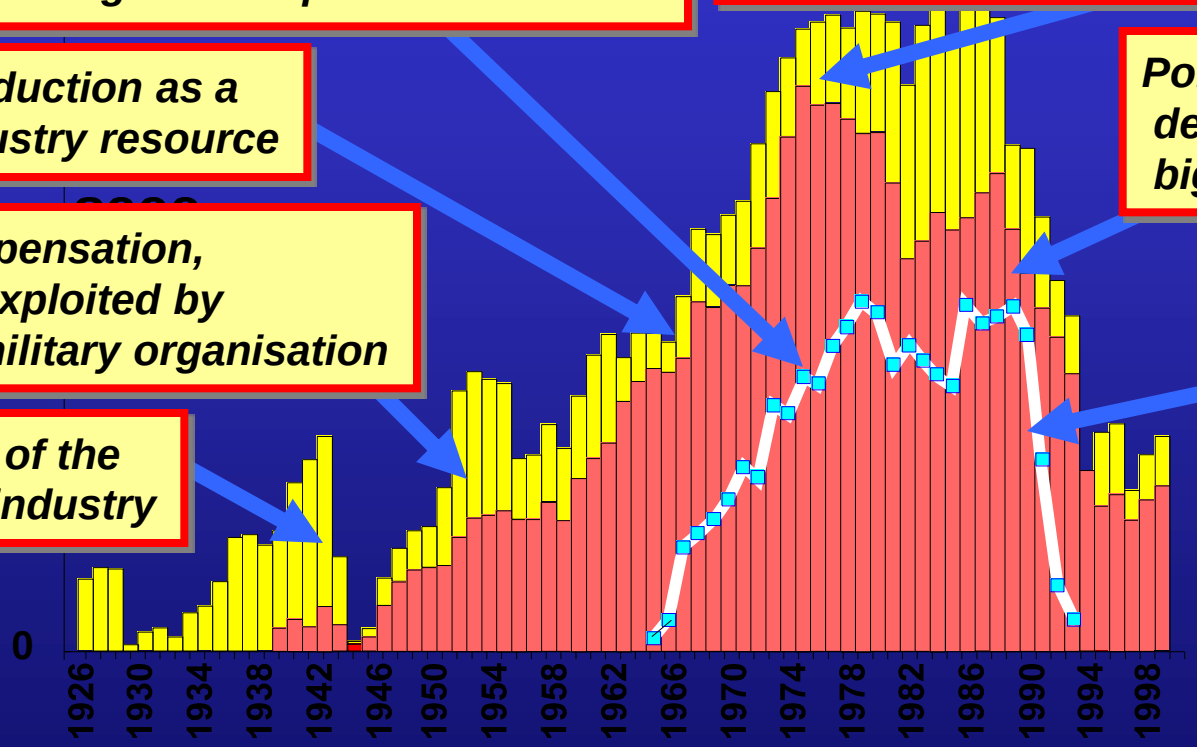
Upturn of production as a strategic industry resource

Politic decision ends dewatering mines: big mines abandoned

As a war compensation, mines were exploited by Soviet semi-military organisation

End of the Soviet barter contract: export reduced

Main supplier of the German war industry



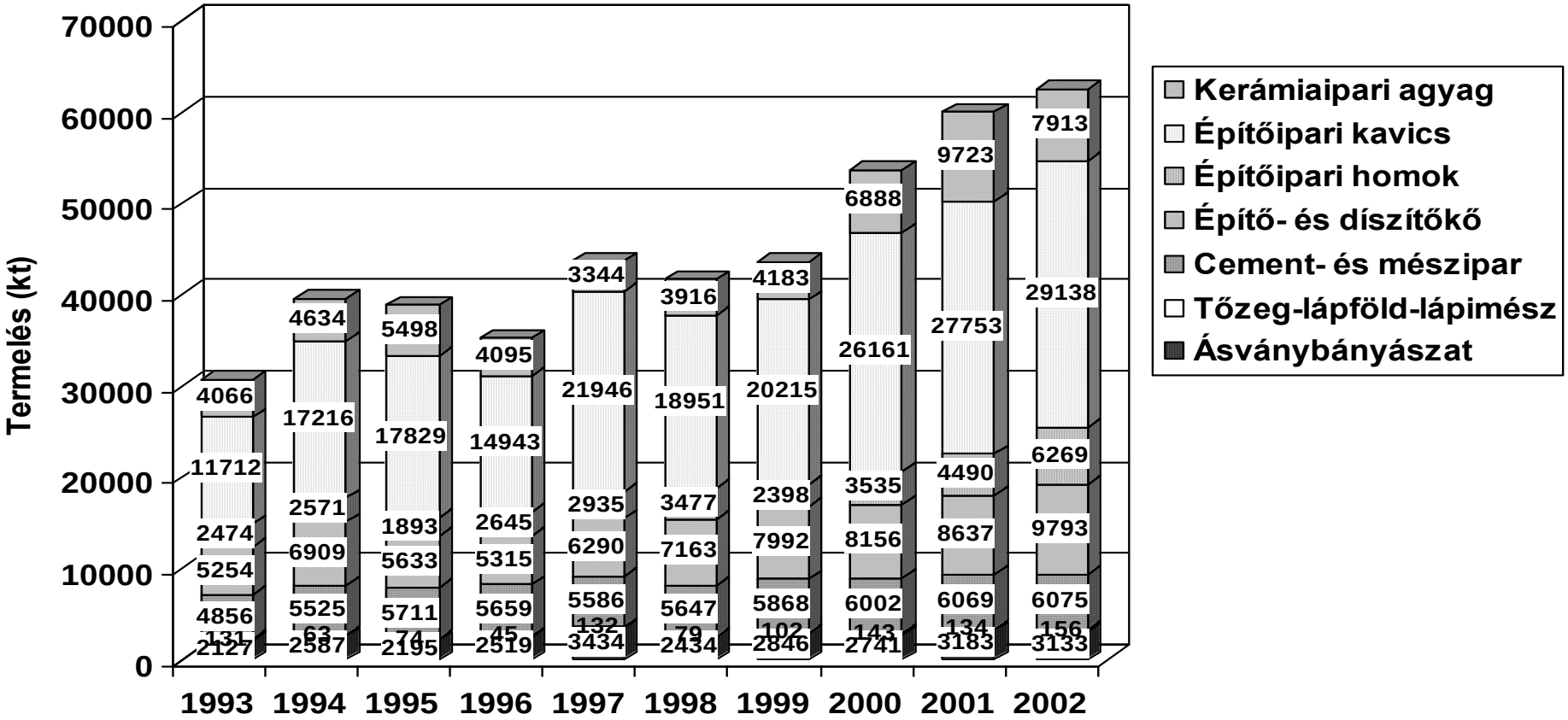
Bauxite production in thousand tons

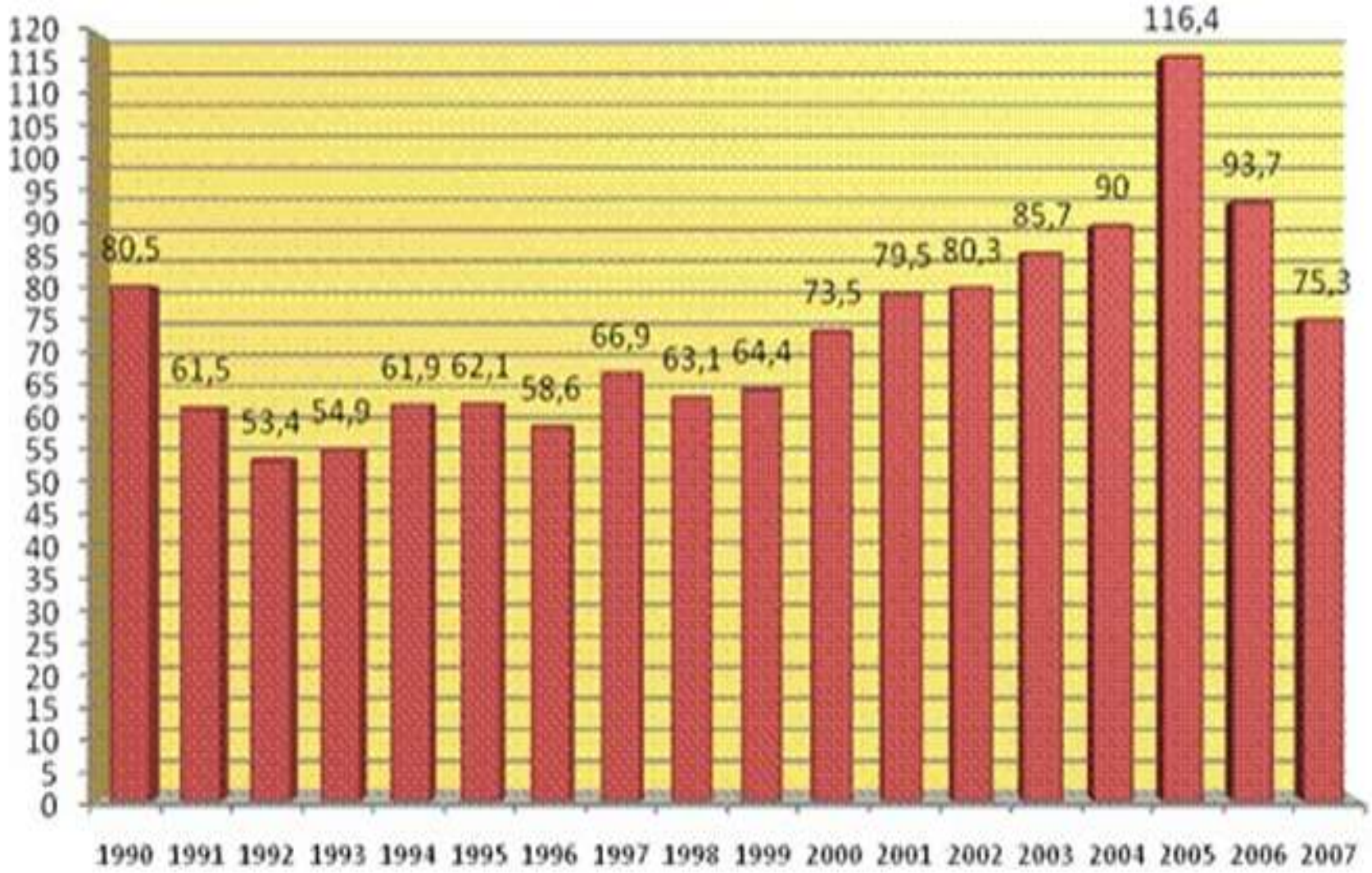
from mines

from open pits

Exported alumina (in bauxite equivalent) according to long-term strategic contracts

NEM-FÉMES ÁSVÁNYI NYERSANYAGOK TERMELÉSE





Minerals production in Hungary 1990-2006 (Mtons) - source: Hungarian Office for Mining and Geology

Magyarország ismert ásványi nyersanyagvagyonának összefoglaló adatai (2005-2006)

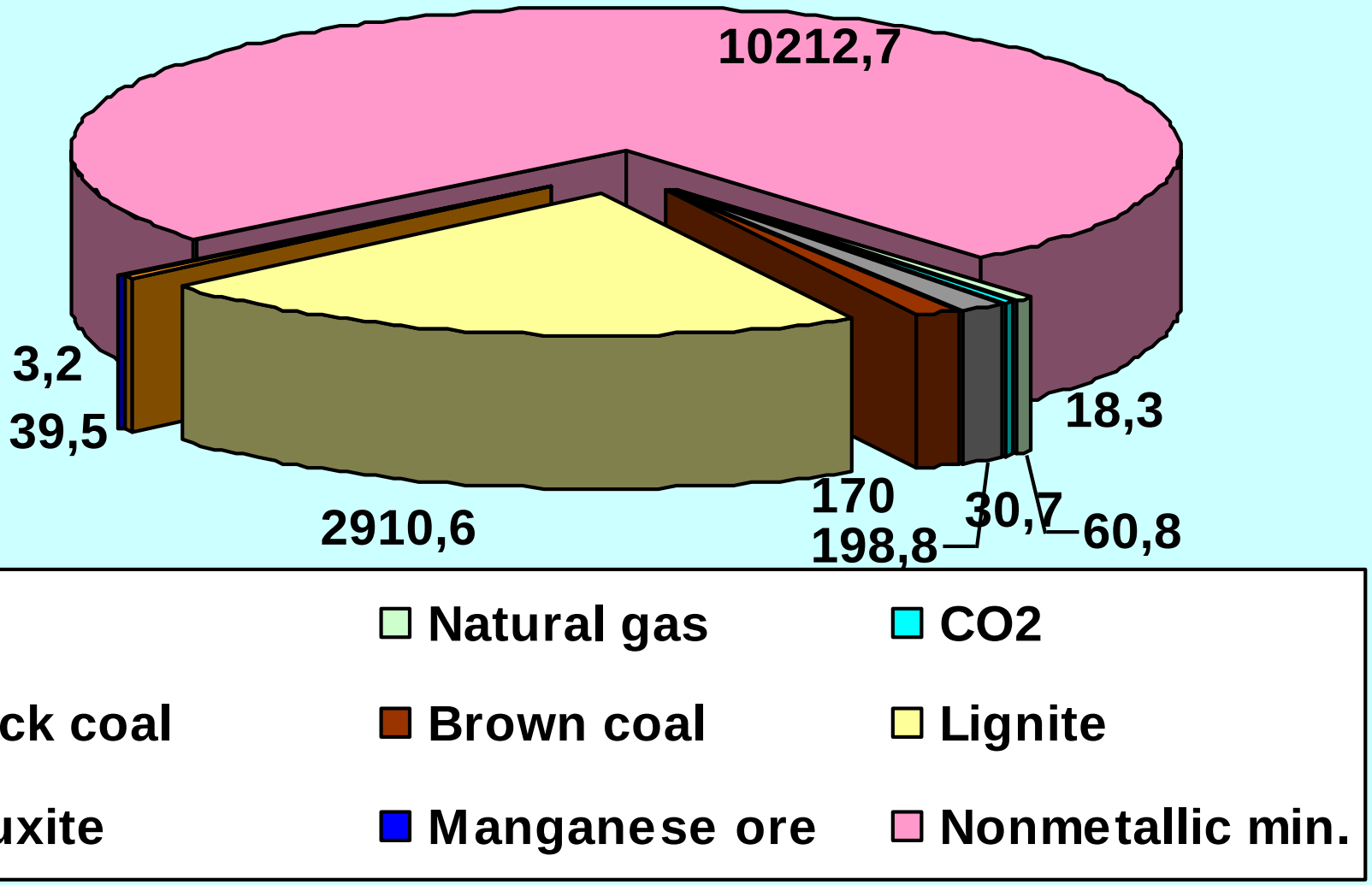
Nyersanyag	Termelés 2005-ben	Földtani vagyon 2006. I. 1.	Ipari vagyon 2006.I. 1.	Ellátottság 2006. I. 1.	NGE* 2006. I. 1.
	Mt	Mt	Mt	év	Mrd Ft
Kőolaj	0,9	208,7	18,3	20	1208,8
Földgáz**	3,2	164,3	60,8	19	2534,1
Szén-dioxid gáz**	0,1	46,3	30,8	>100	9,7
Feketekőszén	-	1 596,6	198,8	-	41,1
Barnakőszén	1,4	3 202,0	169,7	>100	87,7
Lignit (külfejtéses)	8,2	5 795,1	2 925,8	>100	1 510,2
Uránérc	-	26,8	-	-	-
Bauxit	0,5	128,3	39,5	73	37,9
Ólom-cinkérc	-	90,8	-	-	-
Rézérc	-	781,2	0,01	-	-
Nemesfémércek	-	36,6	1,05	-	2,8
Mangánérc	0,05	79,8	3,1	62	1,7
Ásványbányászati nyersanyagok	3,5	3 203,6	1 045,1	>100	807,8
Cement- és mészipari nyersanyagok	5,0	2 842,5	1 277,0	>100	482,1
Építő- és díszítőkőipari nyersanyagok	15,1	3 969,3	2 170,4	>100	888,0
Homok és kavics	69,0	7 792,6	4 551,2	65	1201,1
Kerámiaipari nyersanyagok	9,3	1 861,5	1 058,5	>100	93,5
Tőzeg, lápföld, lápimész	0,1	182,2	110,5	>100	124,6
Magyarország összesen	116,4	32 008,2	13 660,6	-	9 031,1

*NGE = Nominál Gazdasági Eredmény = az ipari ásványvagyon mennyiségének a fajlagos árbevétel (költséghatár) és a fajlagos ráfordítás (reálköltség) különbségével való szorzata, mely nincs diszkontálva

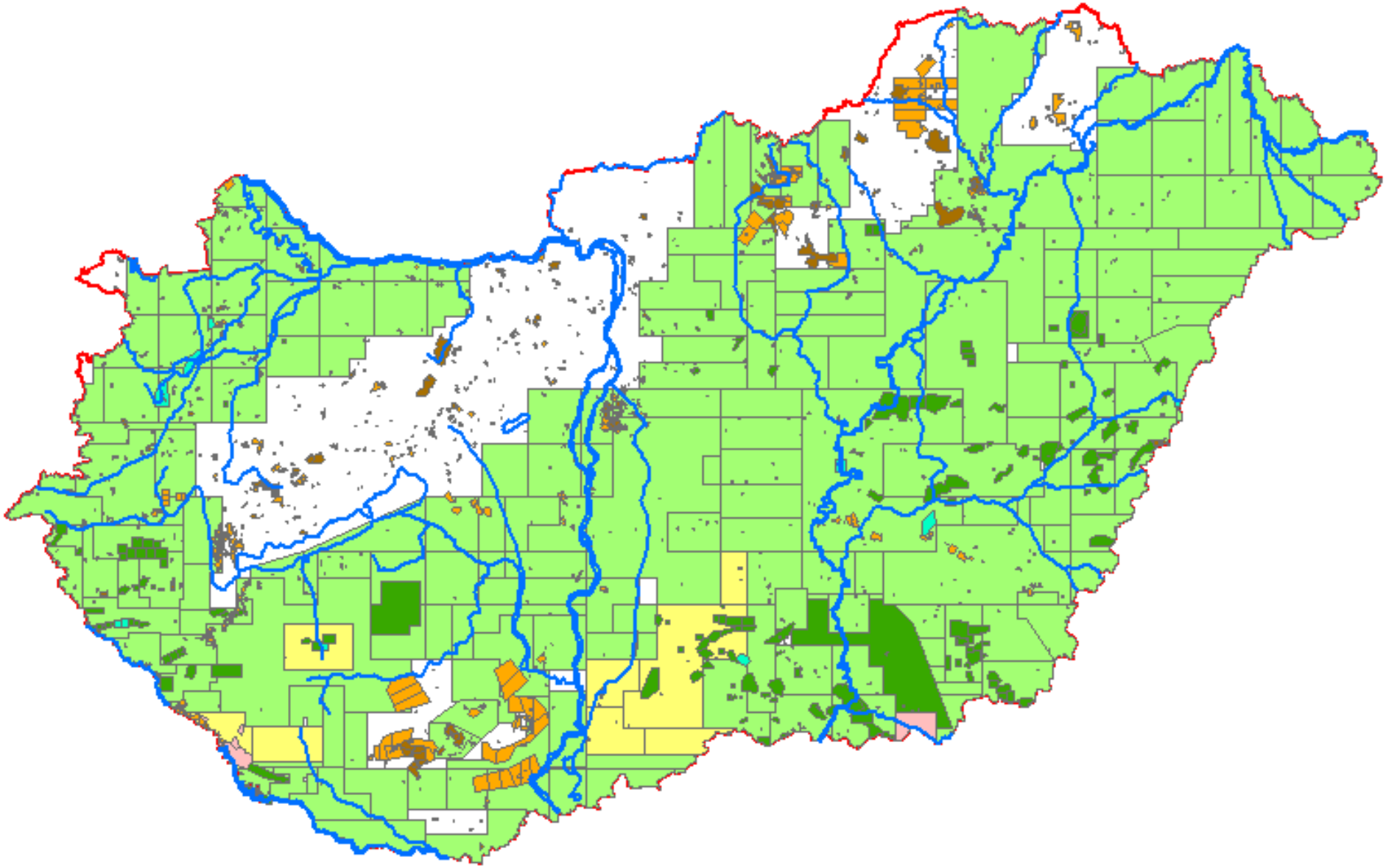
**1000 m^3 gáz = 1 tonna

Economic mineral reserves of Hungary (2005)

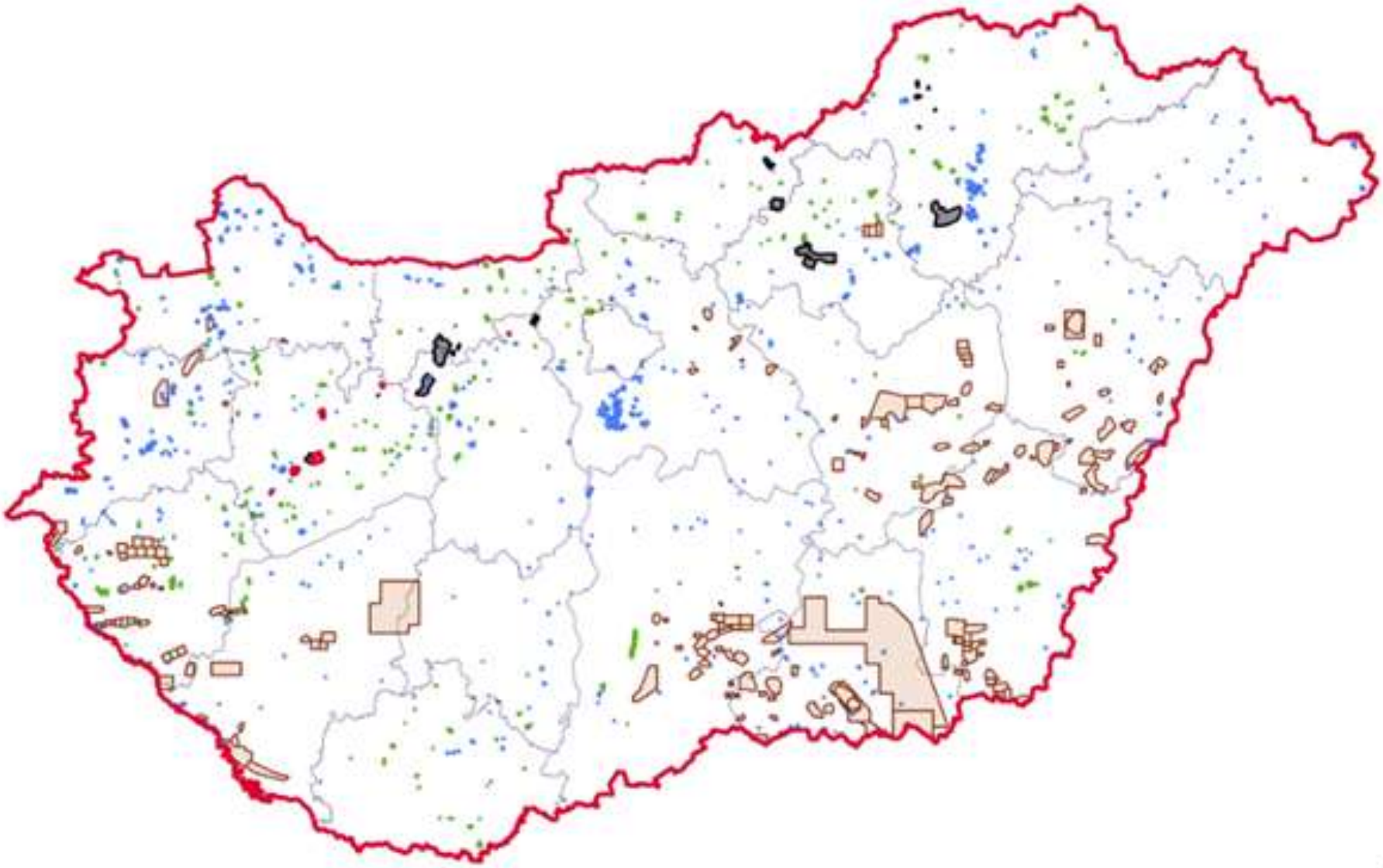
Sum: 13646 Mtons



MINERAL EXPLORATION & EXPLOITATION AREAS

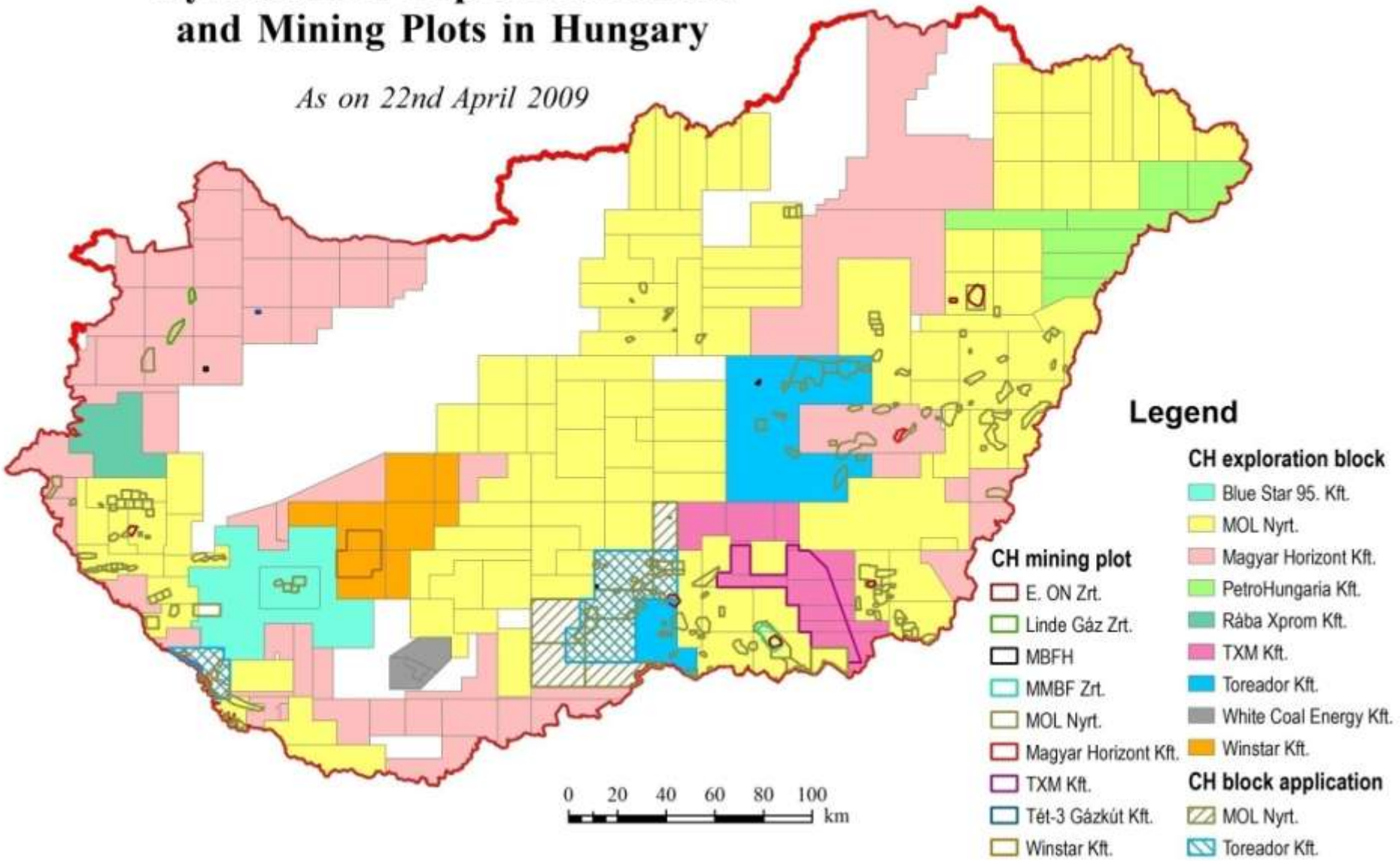


MINING PLOTS (LICENSED EXPLOITATION AREAS) JUNE 2009 (Legend: brown: oil and gas, black: coal, red: ore, blue: aggregates, green: other)

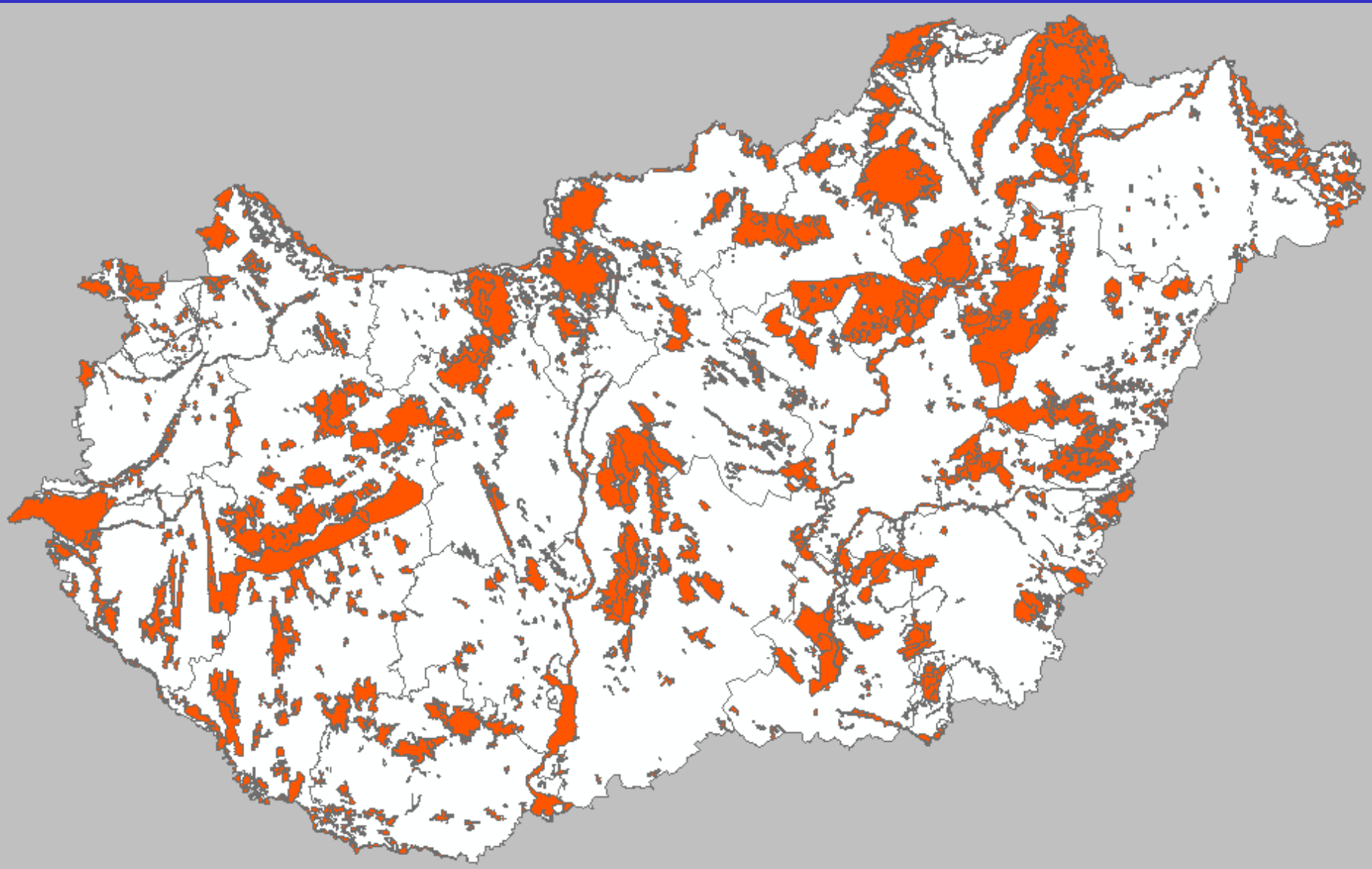


Hydrocarbon Exploration Areas and Mining Plots in Hungary

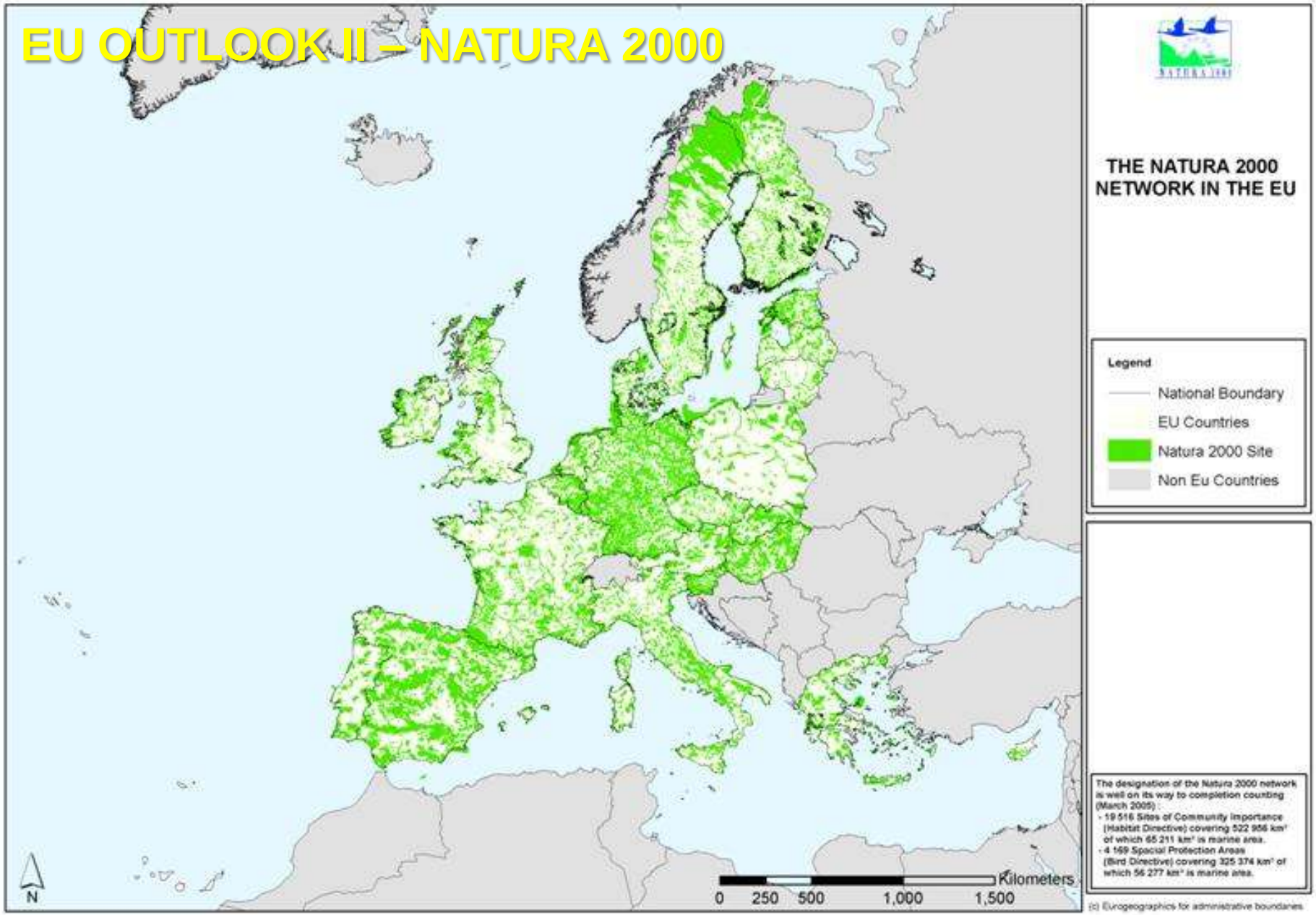
As on 22nd April 2009



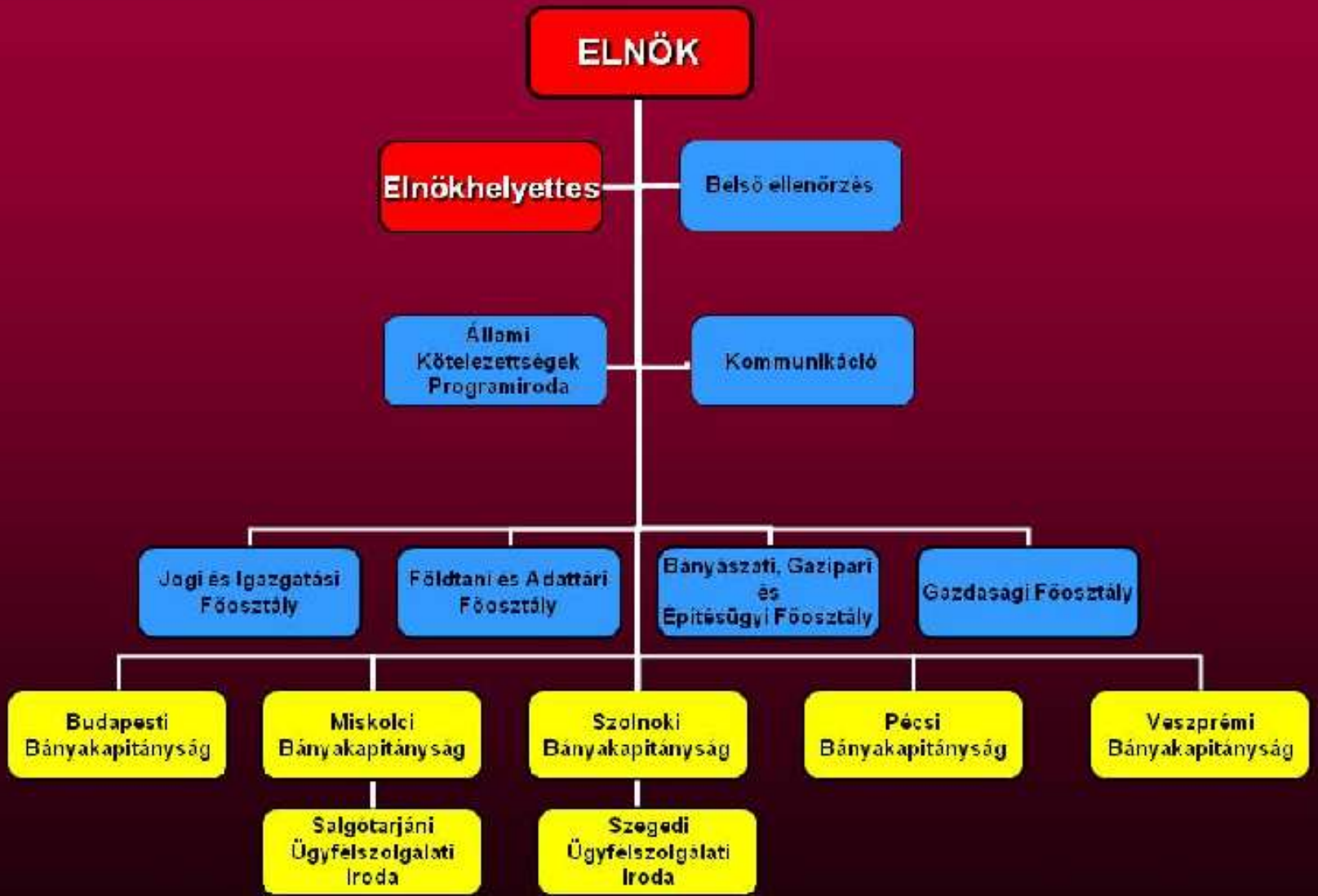
NATURA 2000 AREAS: > 1/5 OF HUNGARY



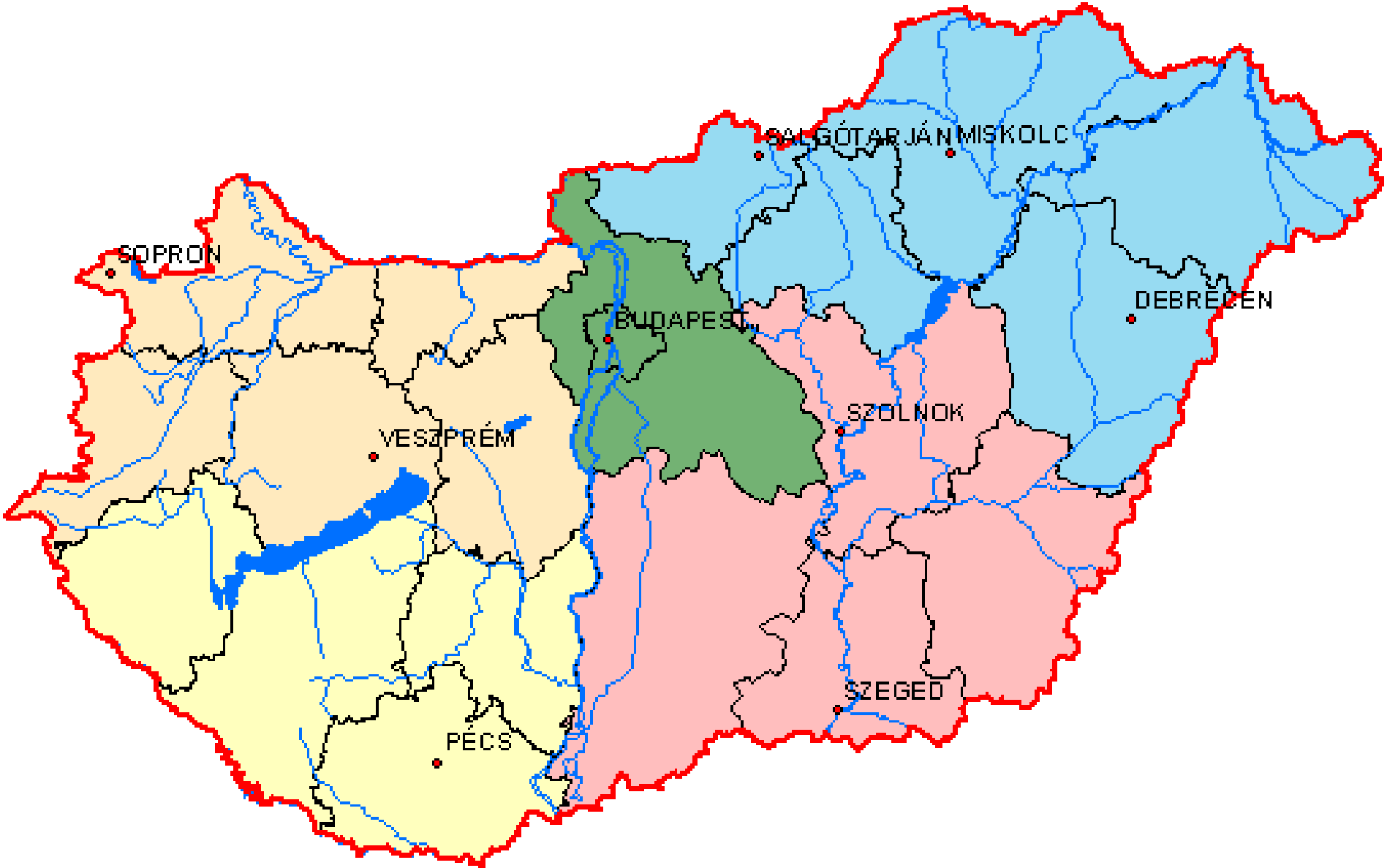
EU OUTLOOK II – NATURA 2000



Magyar Bányászati és Földtani Hivatal



MINING INSPECTORATES (CAPTAINSHIPS), AND LOCAL OFFICES



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THANK YOU FOR THE ATTENTION