A LOW CARBON ECONOMY

SERGIO LA MOTTA

ENEA

CLIMATE PROJECT

School of Fusion Reactor Technology
Erice, July 26th - August 1st 2004

OUTLINE

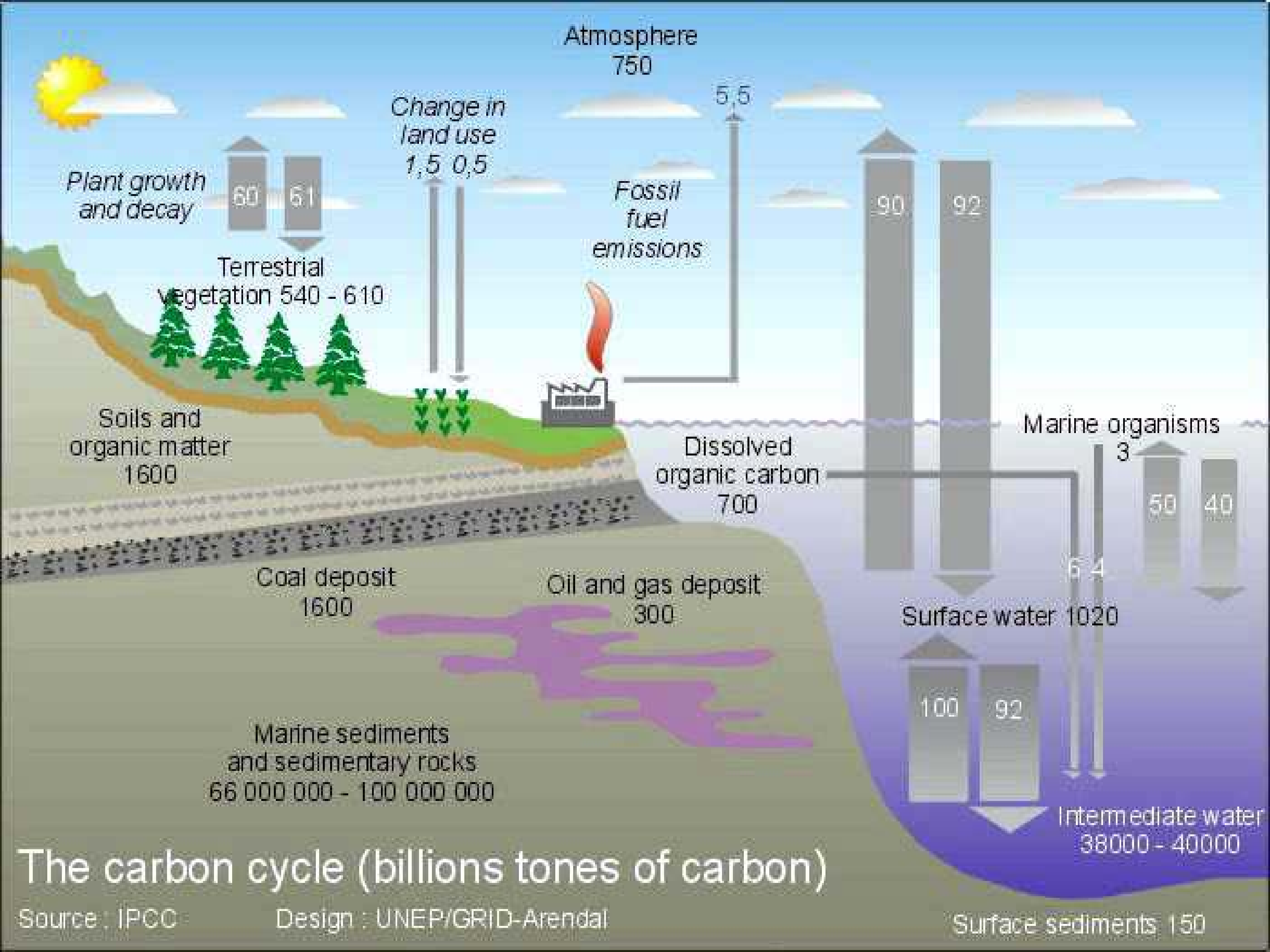
- MOTIVATIONS FOR MOVING TOWARDS A LOW CARBON ECONOMY;
- ENERGY AND CO2 EMISSIONS STATISTICS (WHERE ARE WE NOW?);
- CO2 EMISSIONS DRIVING FORCES;
- IPCC REFERENCE SCENARIOS (WHERE ARE WE LIKELY TO GO?);
- IPCC CO2 CONCENTRATION STABILIZATION SCENARIOS (WHERE SHOULD WE GO?);
- CONCLUSIONS.

WHY GOING TOWARDS A LOW CARBON ECONOMY?

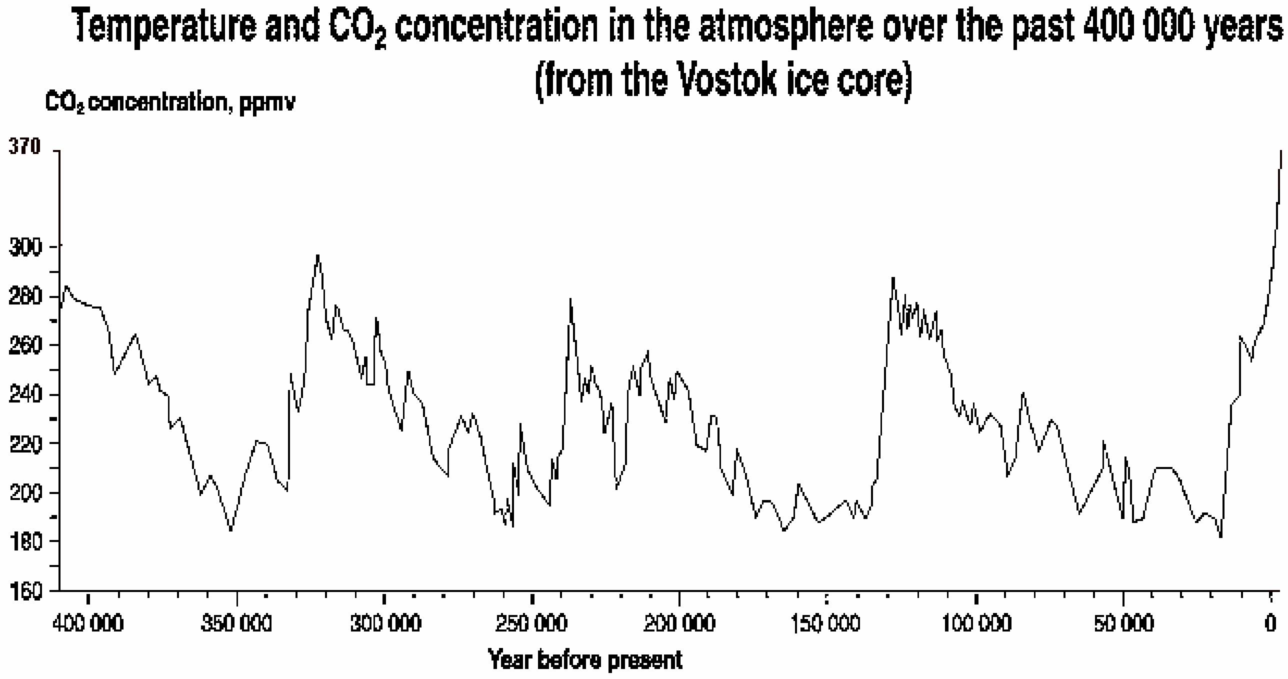
WHERE THERE IS A WILL
THERE IS A WAY!

Why going towards a low carbon economy?

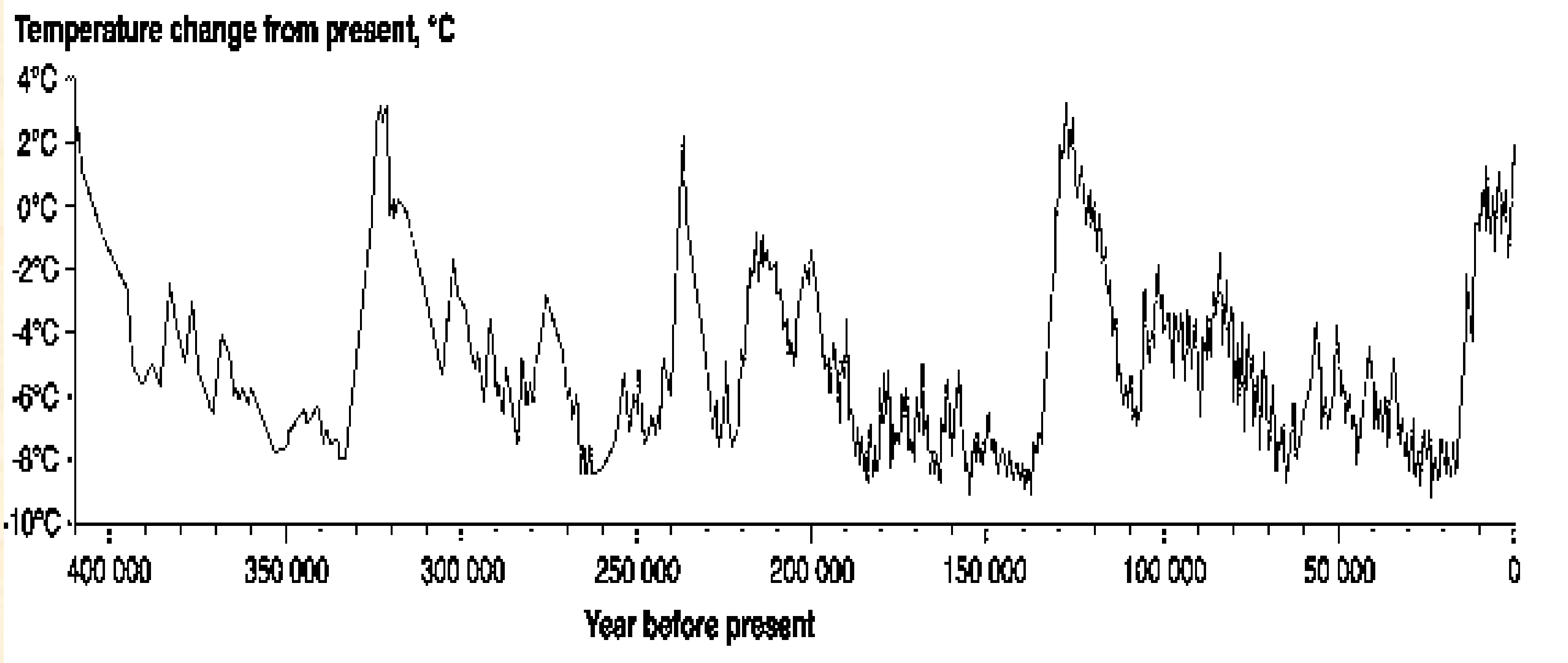
- Environmental Concerns (both global and local);
- Depletion of reserves and geopolitics;
- Use fossil fuels as raw material for valuable products (petrochemicals).


Atmosphere
750
5,5
Change in
land use
1,5 0,5
Plant growth
and decay
60
61
Fossil
fuel
emissions
90
92
Terrestrial
vegetation 540 - 610
Soils and
organic matter
1600
Marine organisms
3
Dissolved
organic carbon
700
50
40
6
4
Coal deposit
1600
Oil and gas deposit
300
Surface water 1020
100
92
Marine sediments
and sedimentary rocks
66 000 000 - 100 000 000
Intermediate water
38000 - 40000
The carbon cycle (billions tones of carbon)
Source : IPCC
Design : UNEP/GRID-Arendal
Surface sediments 150

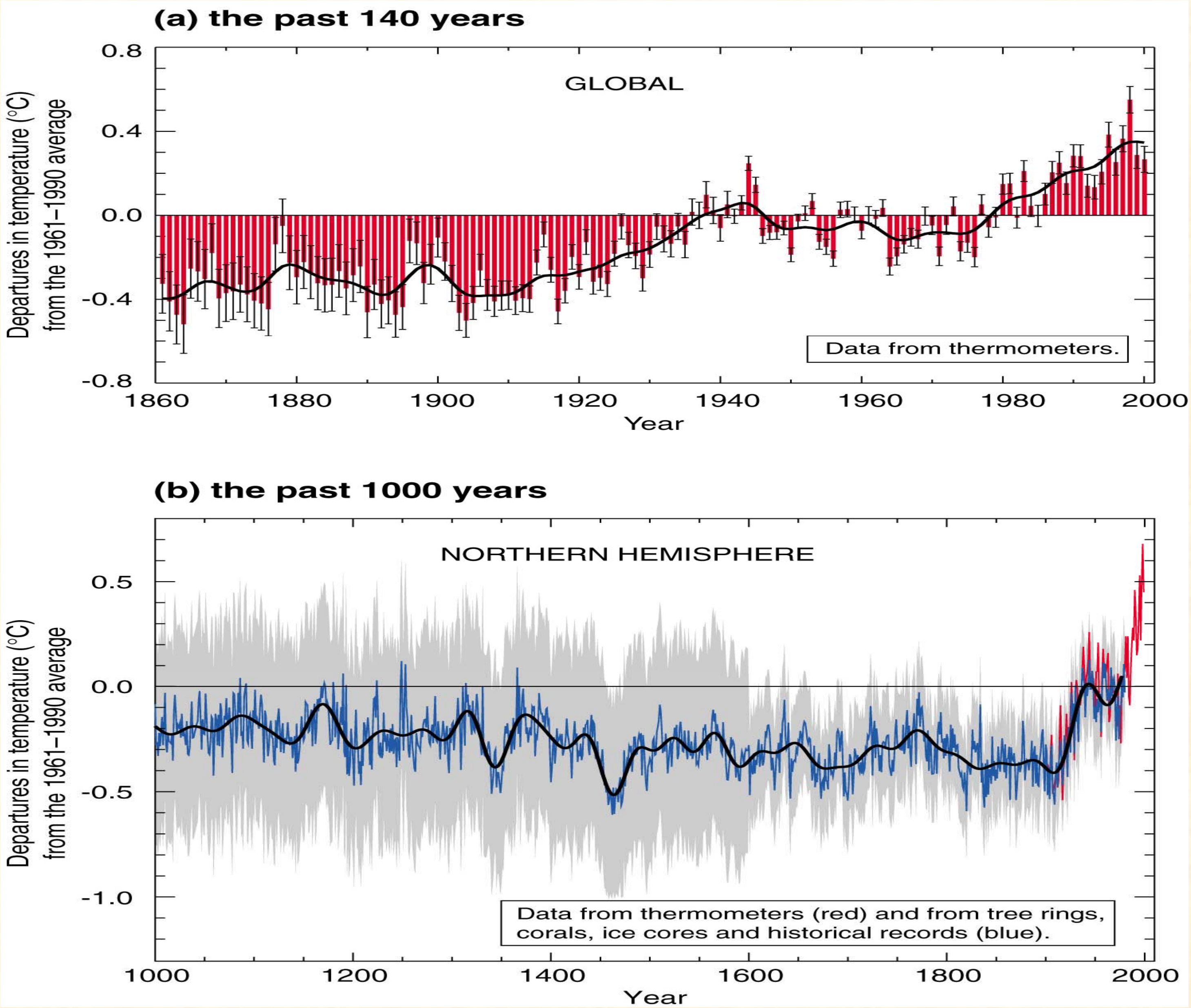
Paleoclimate reconstruction



Paleoclimate reconstruction



Variations of the Earth's Surface Temperature



UNFCCC: art. 2

The ultimate objective of the Convention is to achieve stabilization of GHG concentration in the atmosphere at a level that should prevent dangerous anthropogenic interference with the climate system. Such a level should achieved in a timeframe sufficient to allow ecosystems to adapt naturally to climate change.

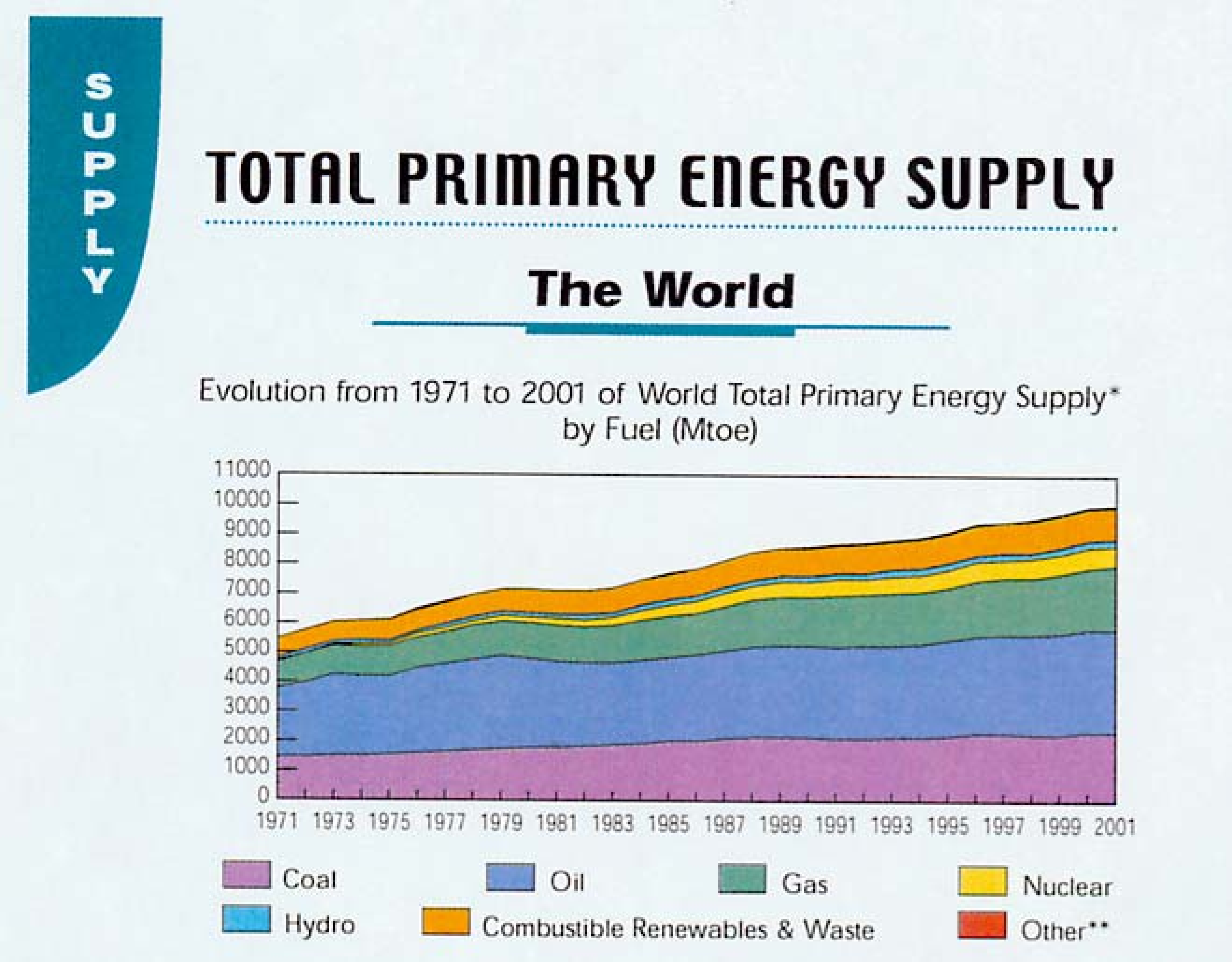
CLIMATE SENSITIVITY

$$1.5°C < \Delta T\ (2X) < 4.5°C$$

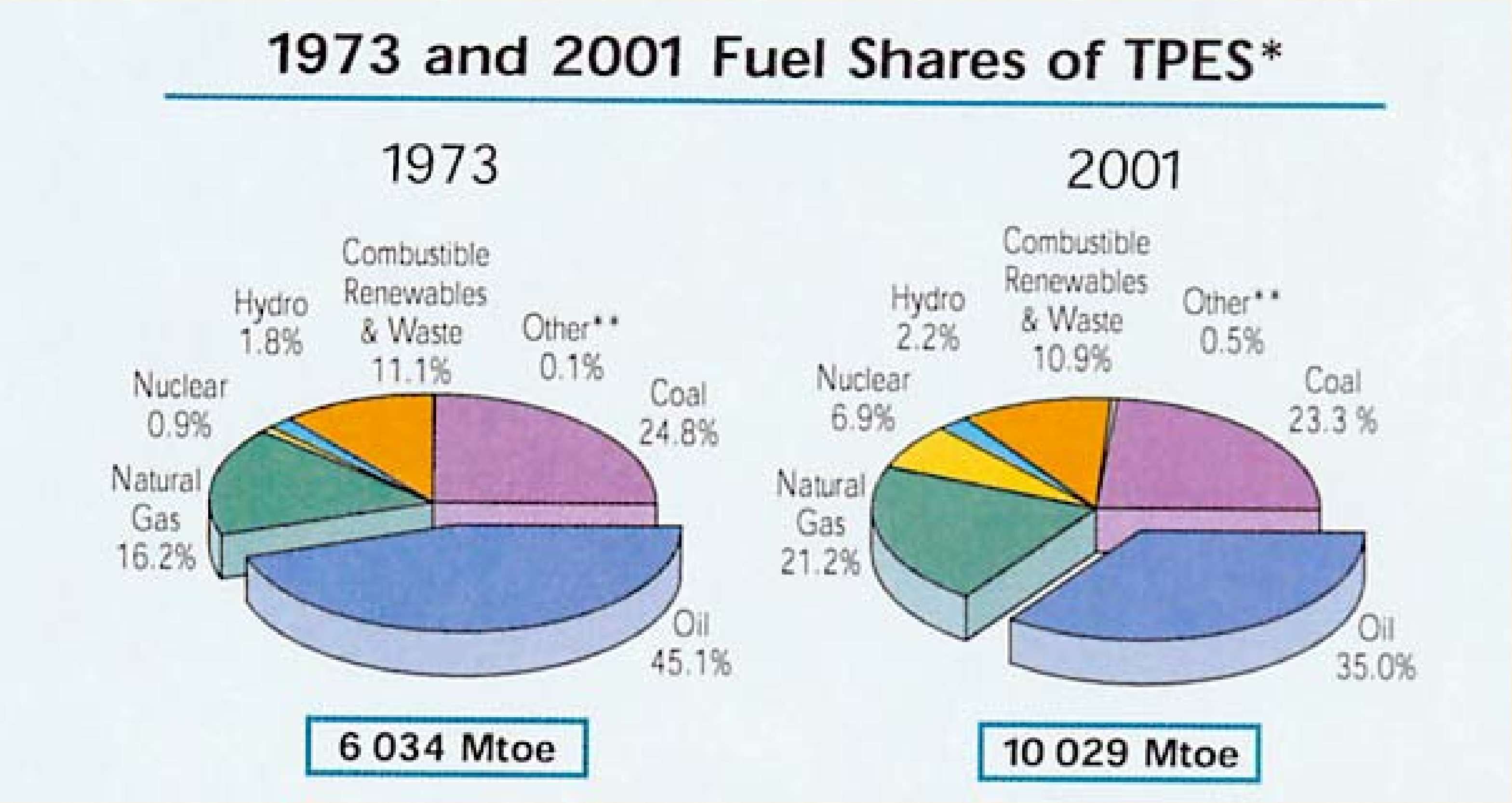
Stabilization at 550-650 ppmv may lessen or avoid some impacts associated with warming greater than 3°C.

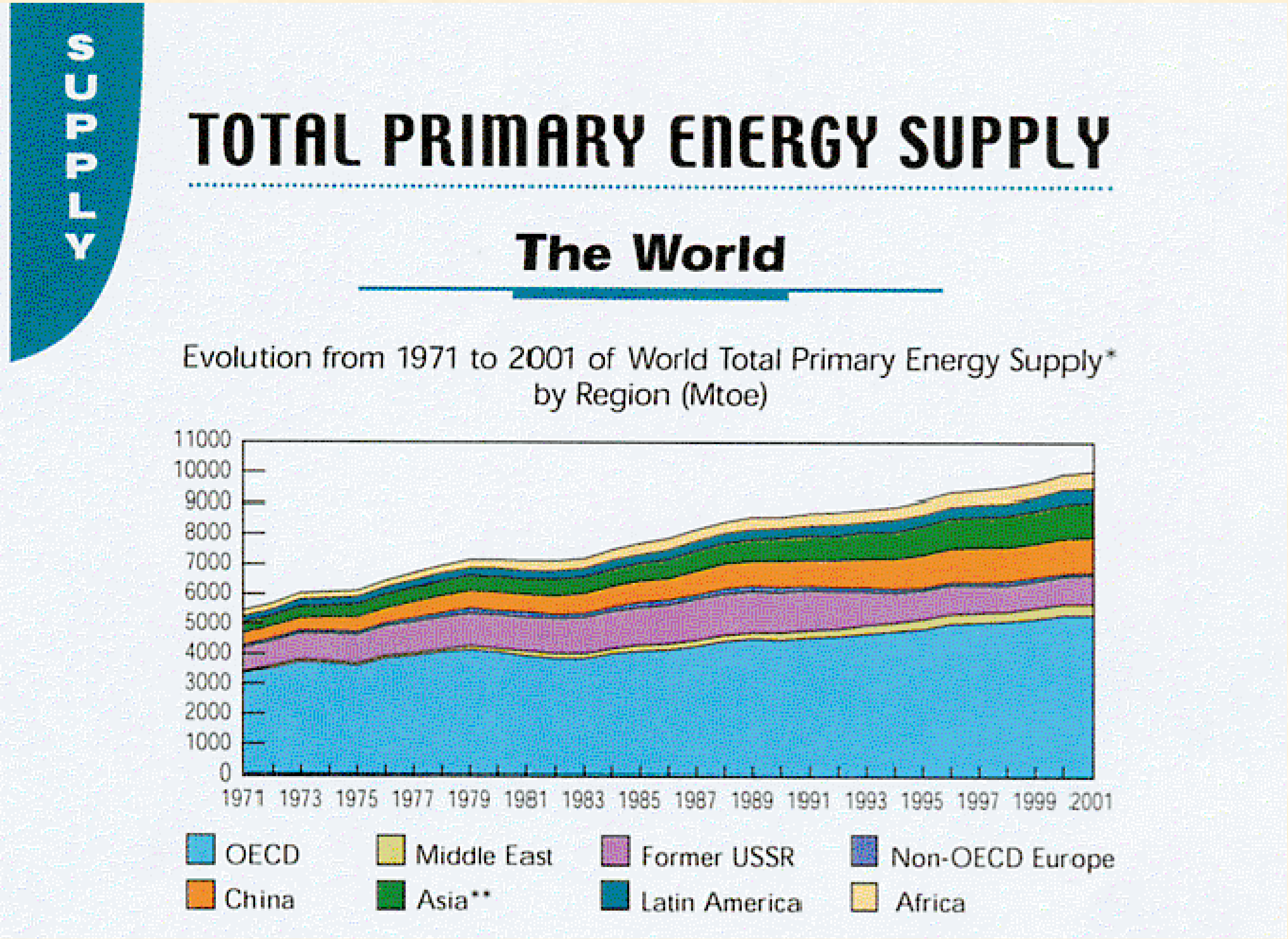
Stabilization at 450 ppmv may limit warming to less that 3°C.

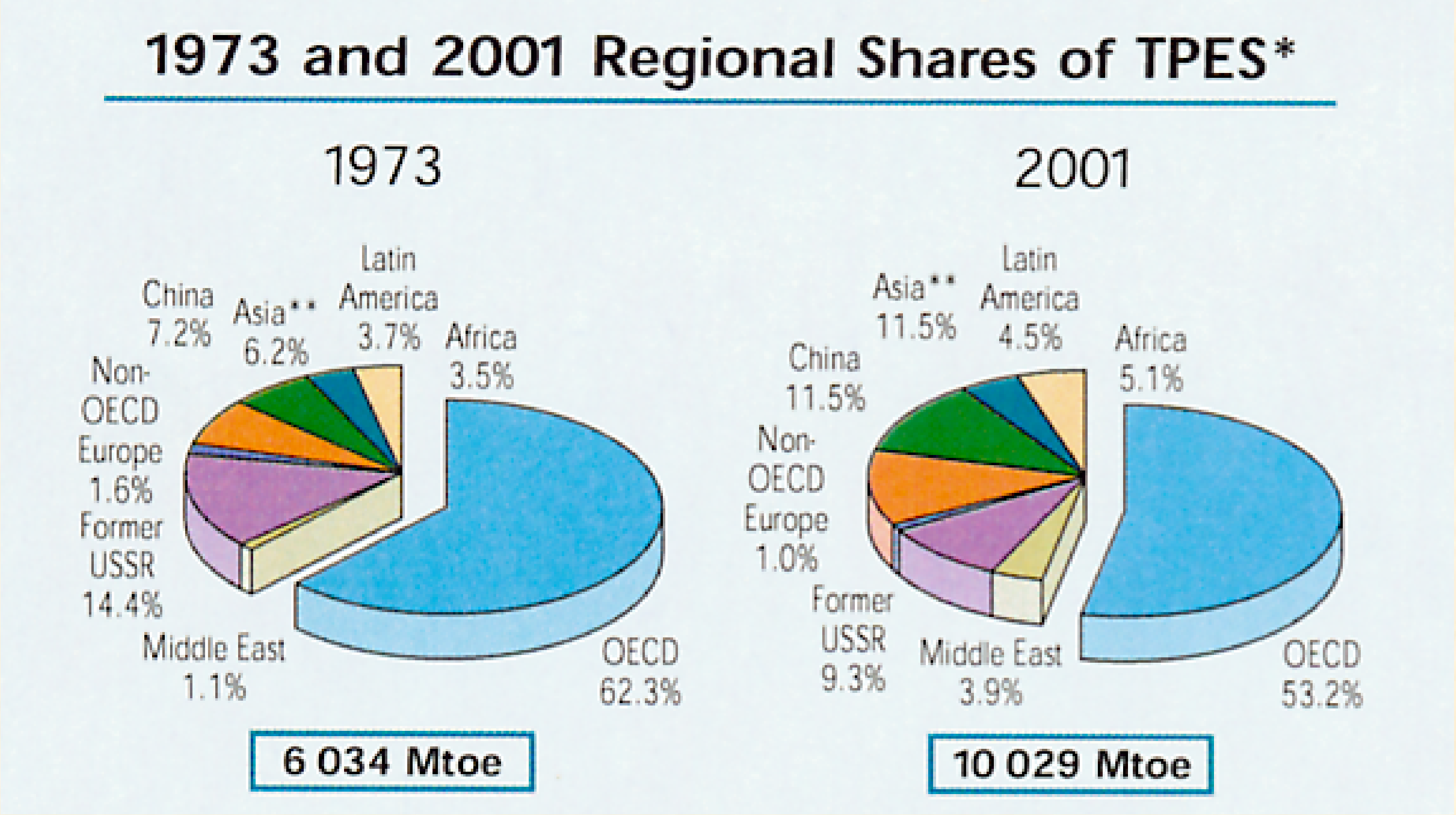
WHERE ARE WE NOW?



Source: IEA - Key World Energy Statistics 2003


1973 and 2001 Fuel Shares of TPES*
1973
2001
Hydro 1.8%
Combustible Renewables & Waste 11.1%
Other** 0.1%
Nuclear 0.9%
Coal 24.8%
Natural Gas 16.2%
Oil 45.1%
6 034 Mtoe
Hydro 2.2%
Combustible Renewables & Waste 10.9%
Other** 0.5%
Nuclear 6.9%
Coal 23.3 %
Natural Gas 21.2%
Oil 35.0%
10 029 Mtoe

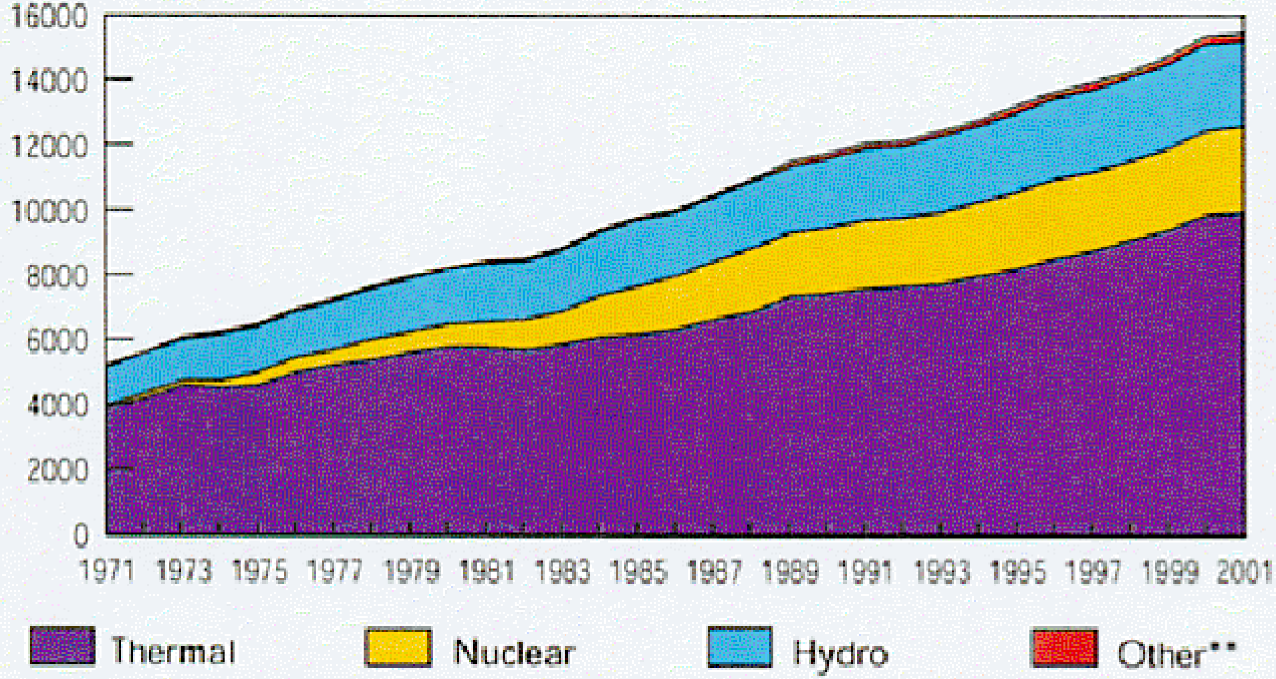

SUPPLY
TOTAL PRIMARY ENERGY SUPPLY
The World
Evolution from 1971 to 2001 of World Total Primary Energy Supply*
by Region (Mtoe)
11000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
1971
1973
1975
1977
1979
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
OECD
Middle East
Former USSR
Non-OECD Europe
China
Asia**
Latin America
Africa

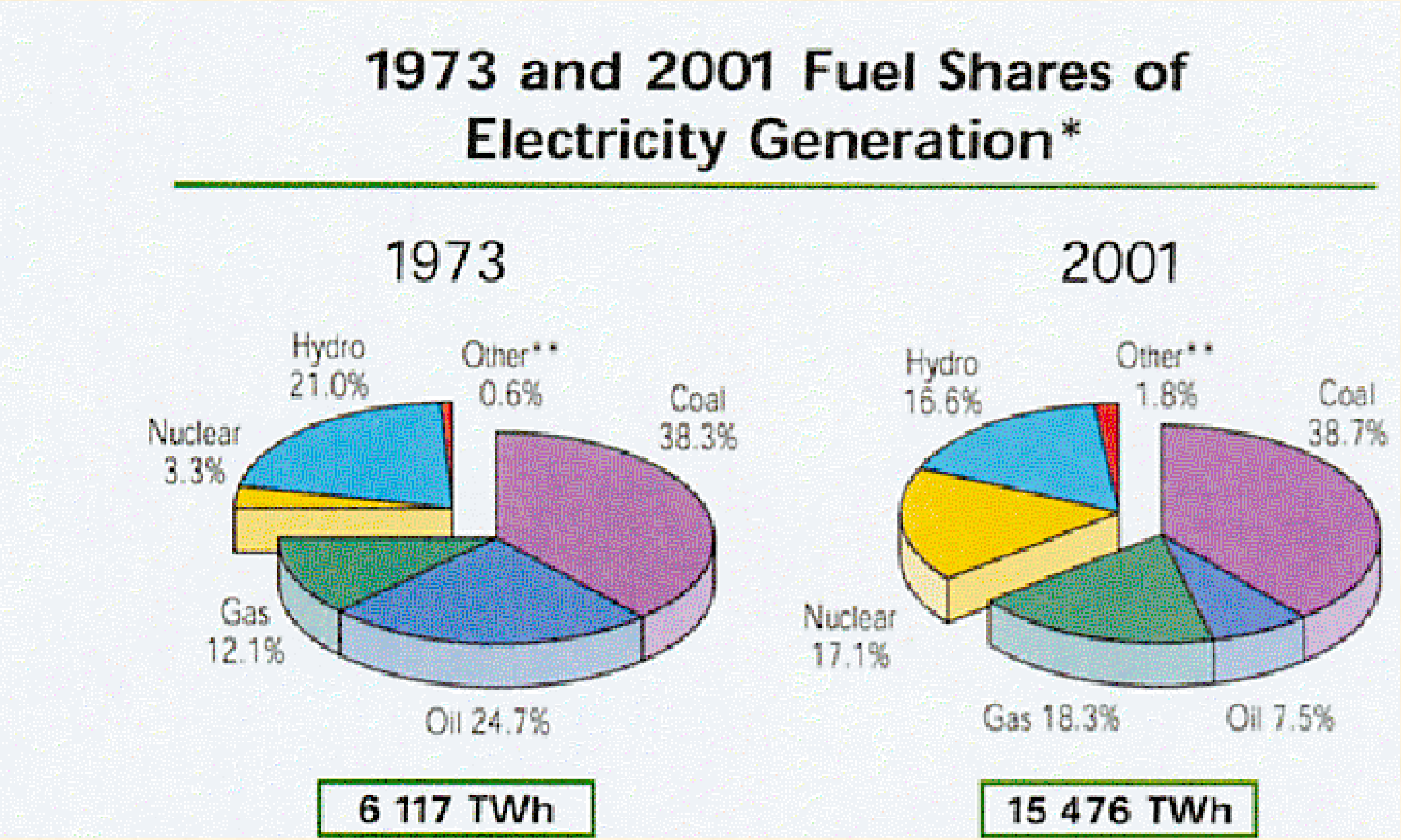

1973 and 2001 Regional Shares of TPES*
1973
China 7.2%
Asia** 6.2%
Latin America 3.7%
Africa 3.5%
Non-OECD Europe 1.6%
Former USSR 14.4%
Middle East 1.1%
OECD 62.3%
6 034 Mtoe
2001
Asia** 11.5%
Latin America 4.5%
Africa 5.1%
China 11.5%
Non-OECD Europe 1.0%
Former USSR 9.3%
Middle East 3.9%
OECD 53.2%
10 029 Mtoe

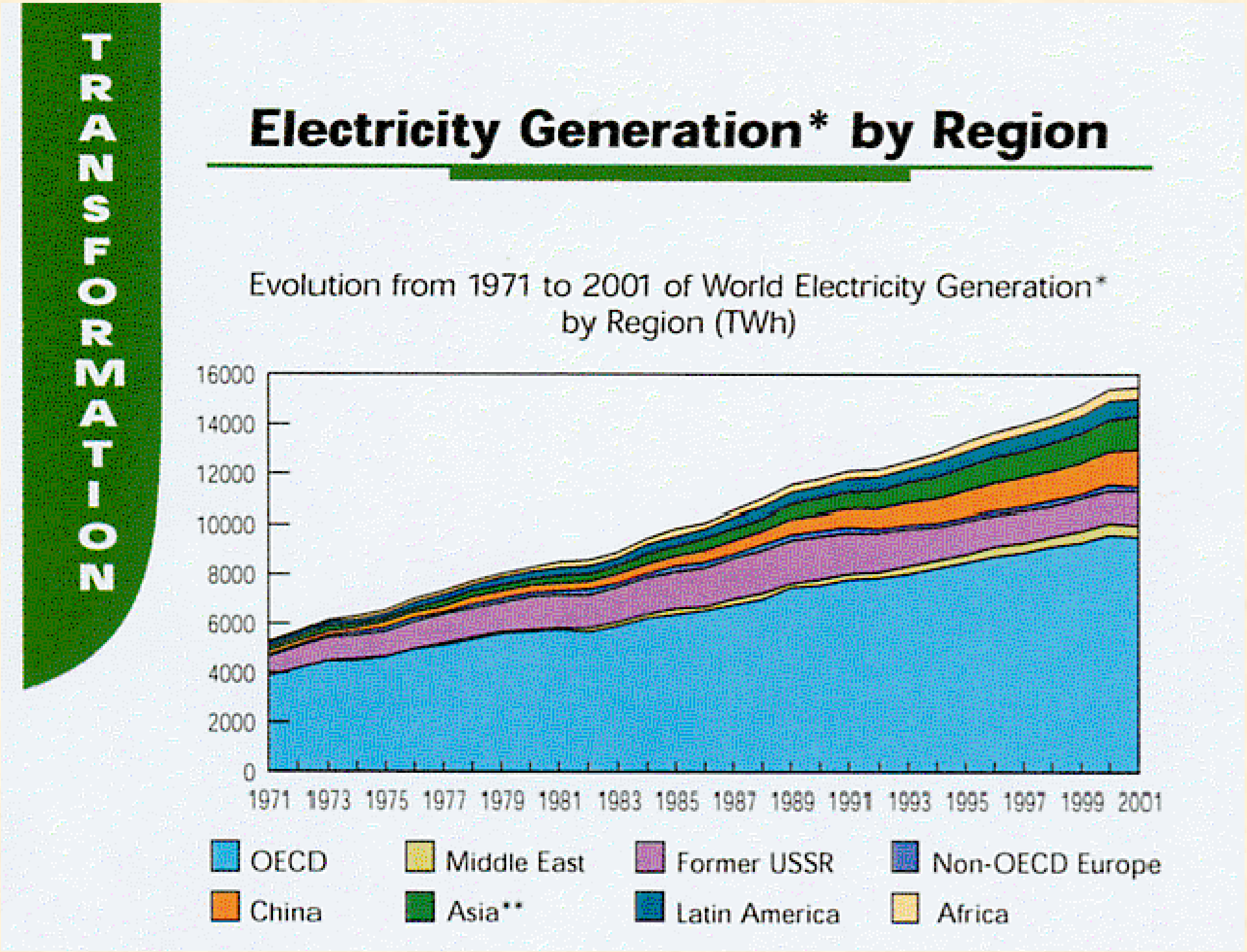
TRANSFORMATION

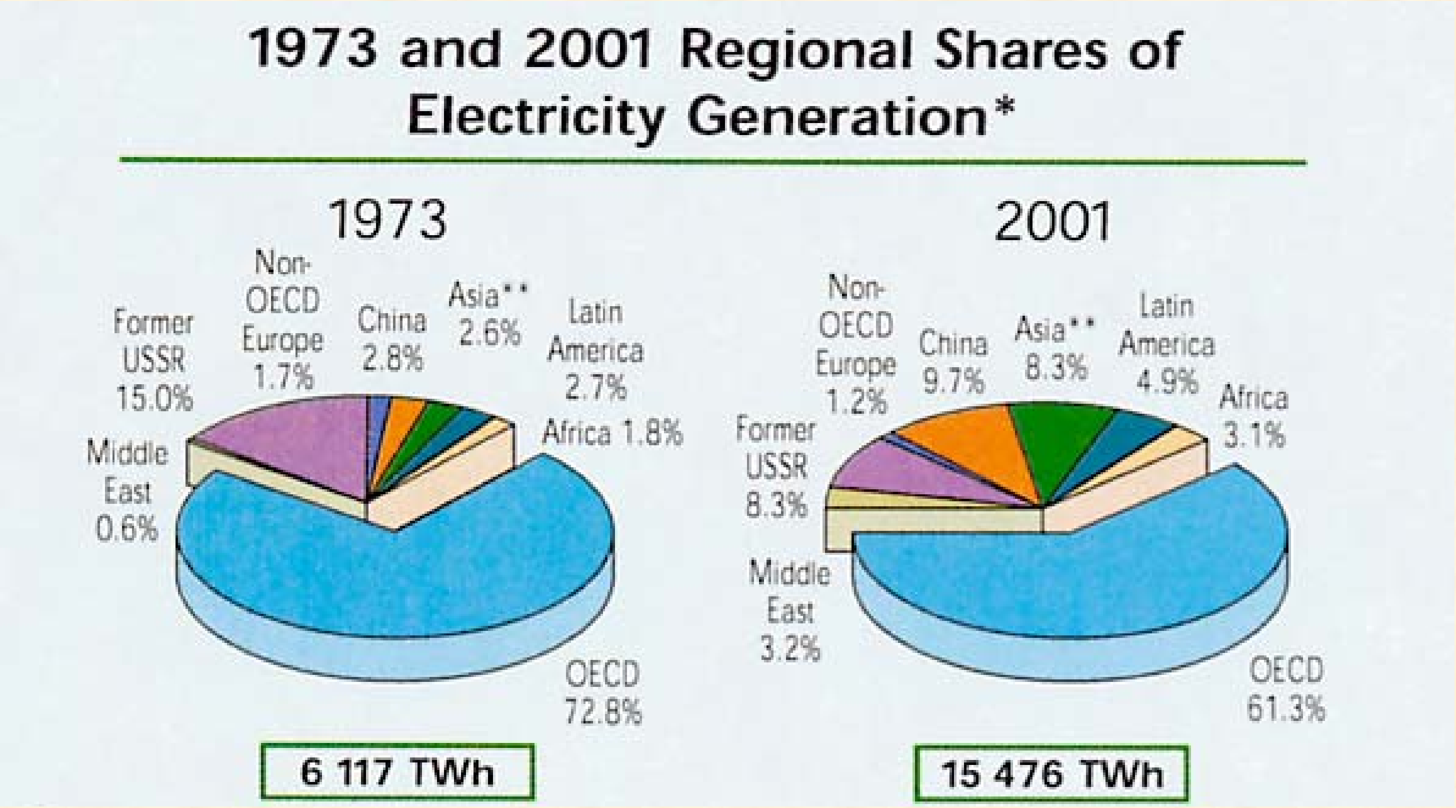
Electricity Generation* by Fuel

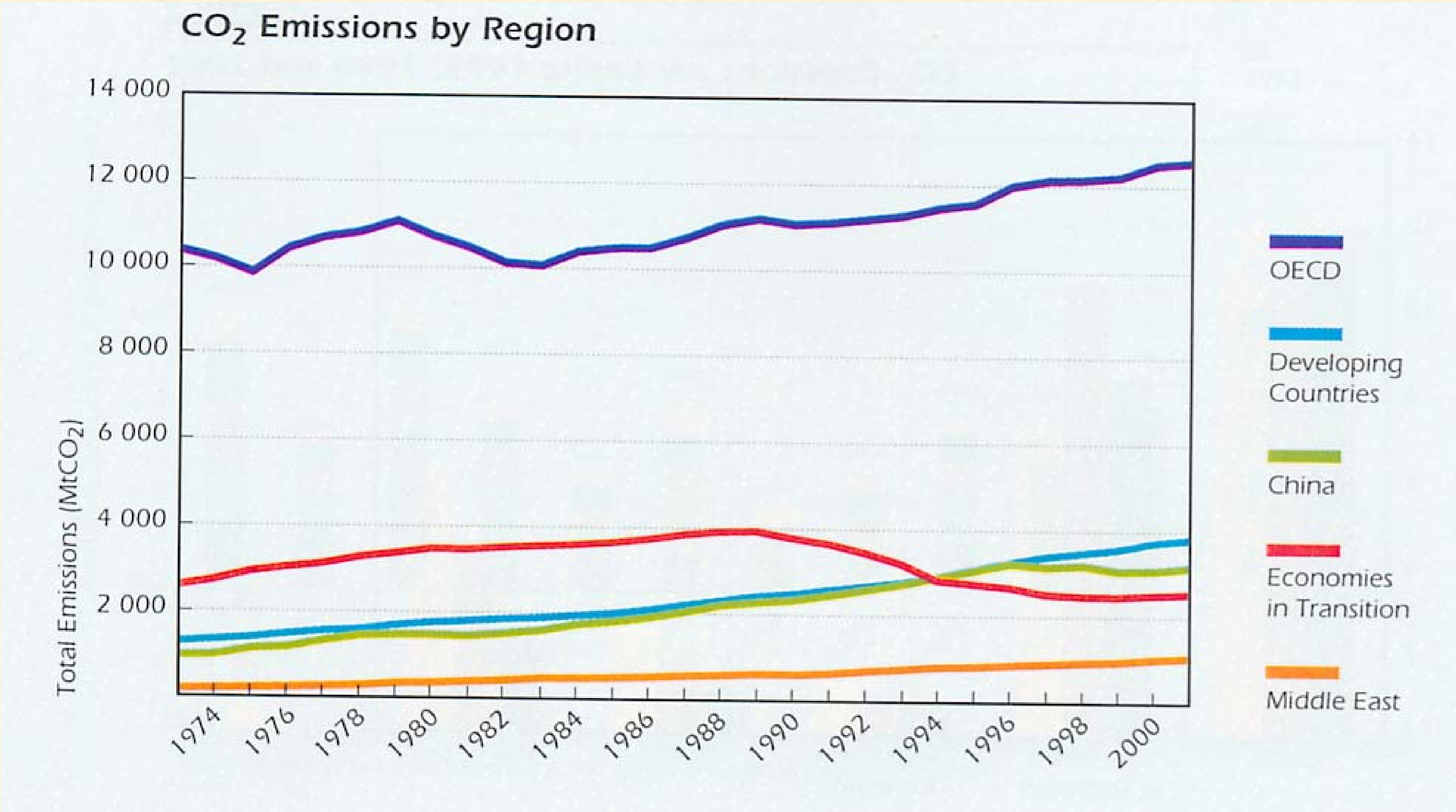
Evolution from 1971 to 2001 of World Electricity Generation*
by Fuel (TWh)



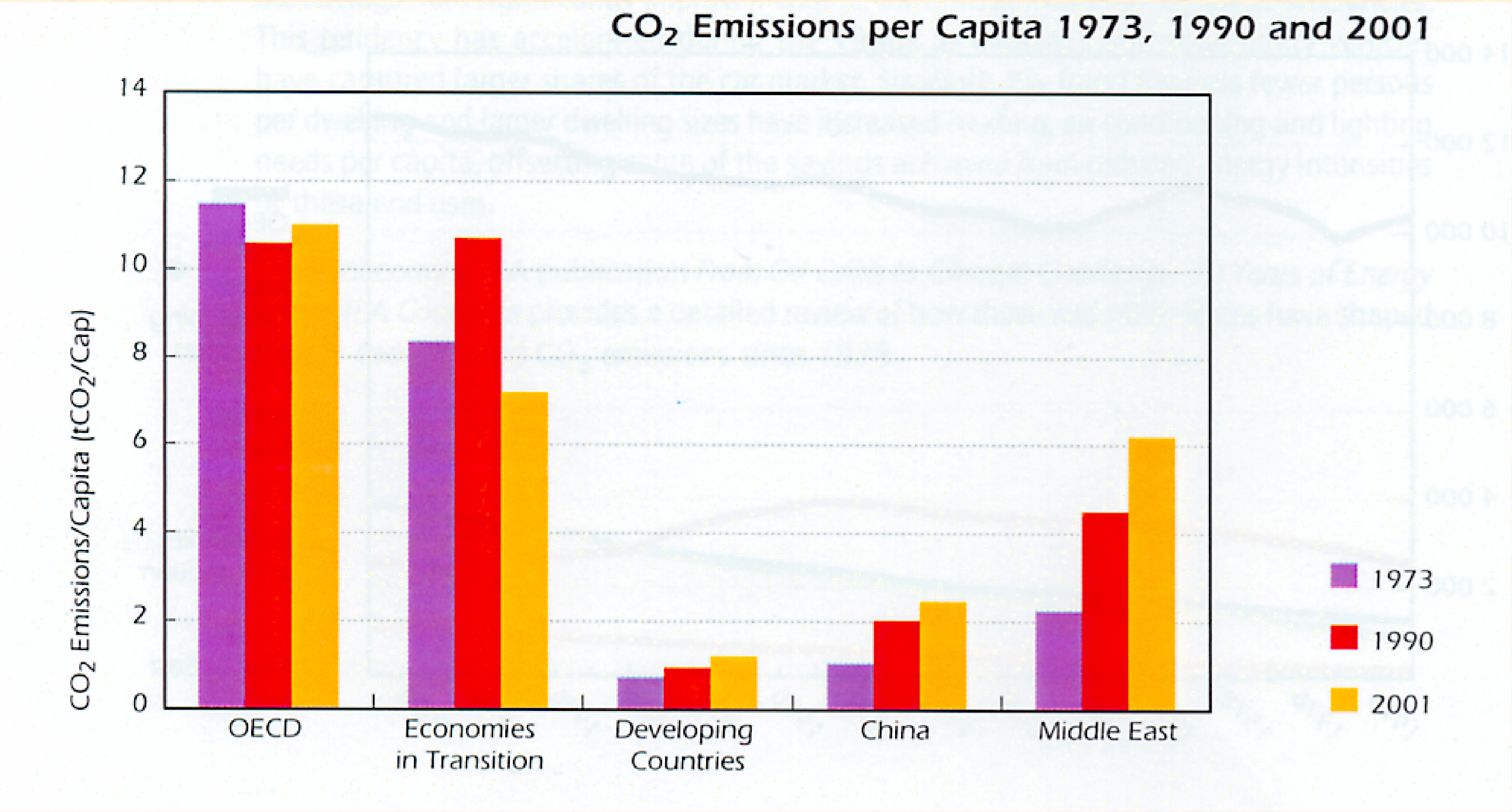

1973 and 2001 Fuel Shares of
Electricity Generation*
1973
2001
Hydro
21.0%
Other**
0.6%
Coal
38.3%
Nuclear
3.3%
Gas
12.1%
Oil 24.7%
6 117 TWh
Hydro
16.6%
Other**
1.8%
Coal
38.7%
Nuclear
17.1%
Gas 18.3%
Oil 7.5%
15 476 TWh


TRANSFORMATION
Electricity Generation* by Region
Evolution from 1971 to 2001 of World Electricity Generation*
by Region (TWh)
16000
14000
12000
10000
8000
6000
4000
2000
0
1971 1973 1975 1977 1979 1981 1983 1985 1987 1989 1991 1993 1995 1997 1999 2001
OECD
Middle East
Former USSR
Non-OECD Europe
China
Asia**
Latin America
Africa


1973 and 2001 Regional Shares of
Electricity Generation*
1973
Non-OECD Europe 1.7%
Former USSR 15.0%
China 2.8%
Asia** 2.6%
Latin America 2.7%
Africa 1.8%
Middle East 0.6%
OECD 72.8%
6 117 TWh
2001
Non-OECD Europe 1.2%
China 9.7%
Asia** 8.3%
Latin America 4.9%
Africa 3.1%
Former USSR 8.3%
Middle East 3.2%
OECD 61.3%
15 476 TWh



CO2 Emissions by Region
14 000
12 000
10 000
8 000
6 000
4 000
2 000
Total Emissions (MtCO2)
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
OECD
Developing Countries
China
Economies in Transition
Middle East



CO_2 Emissions per Capita 1973, 1990 and 2001
CO_2 Emissions/Capita (tCO_2/Cap)
14
12
10
8
6
4
2
0
OECD
Economies in Transition
Developing Countries
China
Middle East
1973
1990
2001

WHAT ARE THE MAIN DRIVING FORCES FOR CO2 EMISSIONS?

The KAYA Identity …to start with

Kaya Identity

$$CO_2 = \frac{CO_2}{ENERGY} \times \frac{ENERGY}{GDP} \times \frac{GDP}{POP} \times POP$$

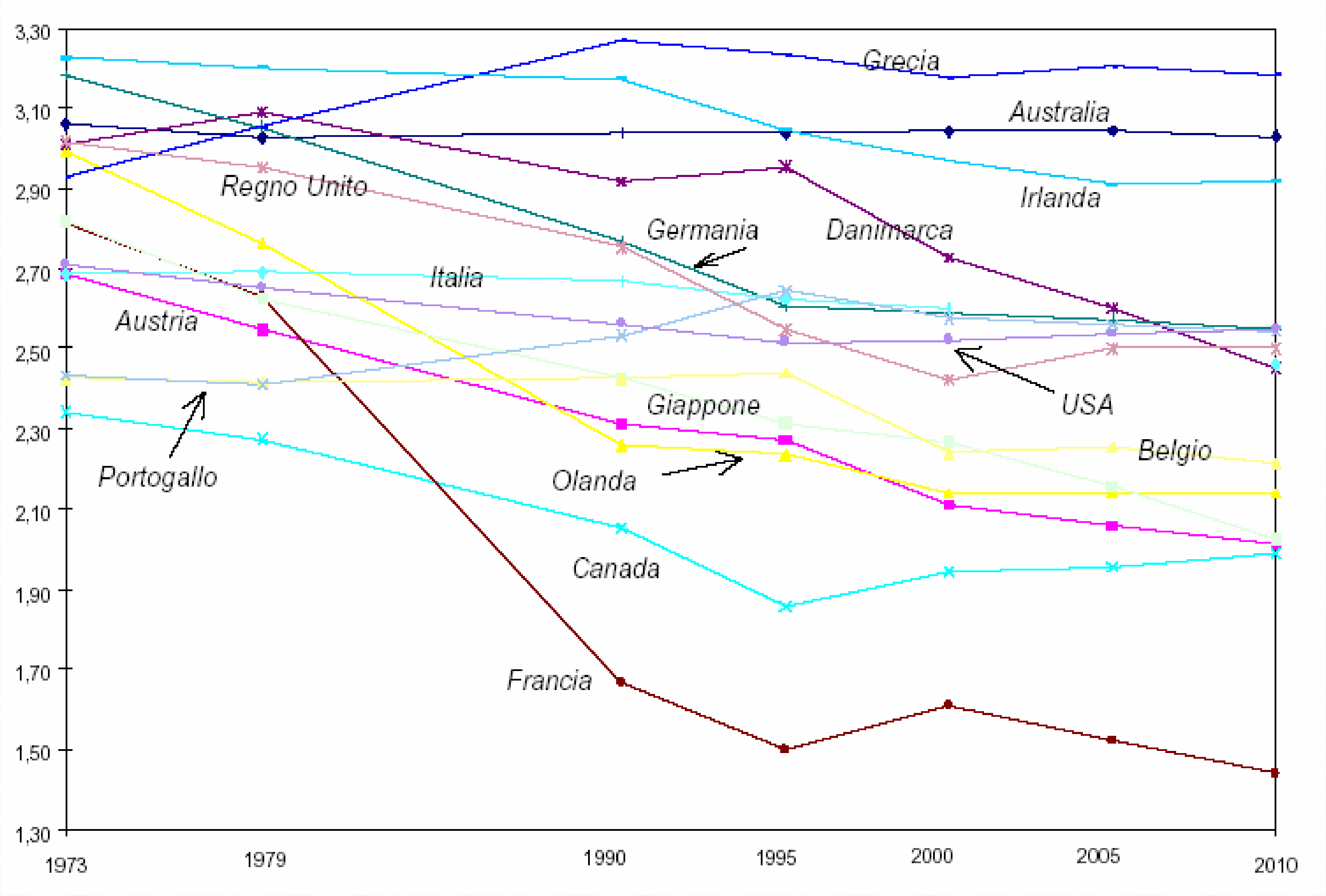
Carbon Intensity	Energy Intensity	Per-capita Income

KAYA FACTORS AND CO_2 EMISSIONS

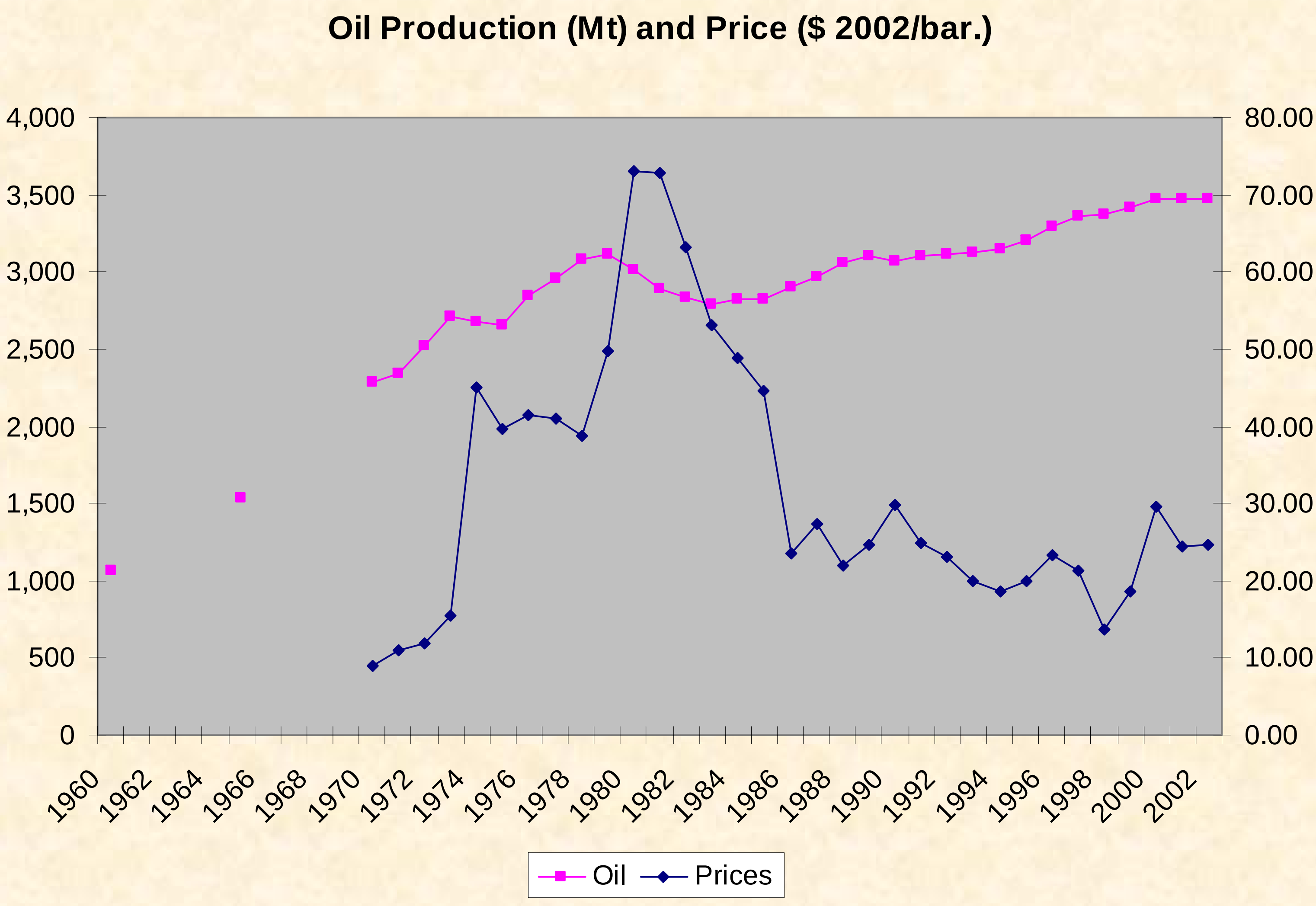
Kaya Factor	**Unit of Measure**	**Driving Factor**	**Policies**
CO2/Energy (Carbon Intensity)	tonCO2/ toe	Energy Mix	Less Carbon Emitting Fuels
Energy/GDP (Energy Intensity)	toe/Monetary Unit	Economic Structure	• Diffusion of Energy Efficient Technologies • Energy Saving
GDP/POP (per-capita Income)	Monetary Unit/POP	Socio-Economic Factors	Economic Policies
POP (Population)	Inhabitants	Socio-Economic and Cultural Factors	Demographic Policies

CARBON INTENSITY FOR SOME OECD COUNTRIES

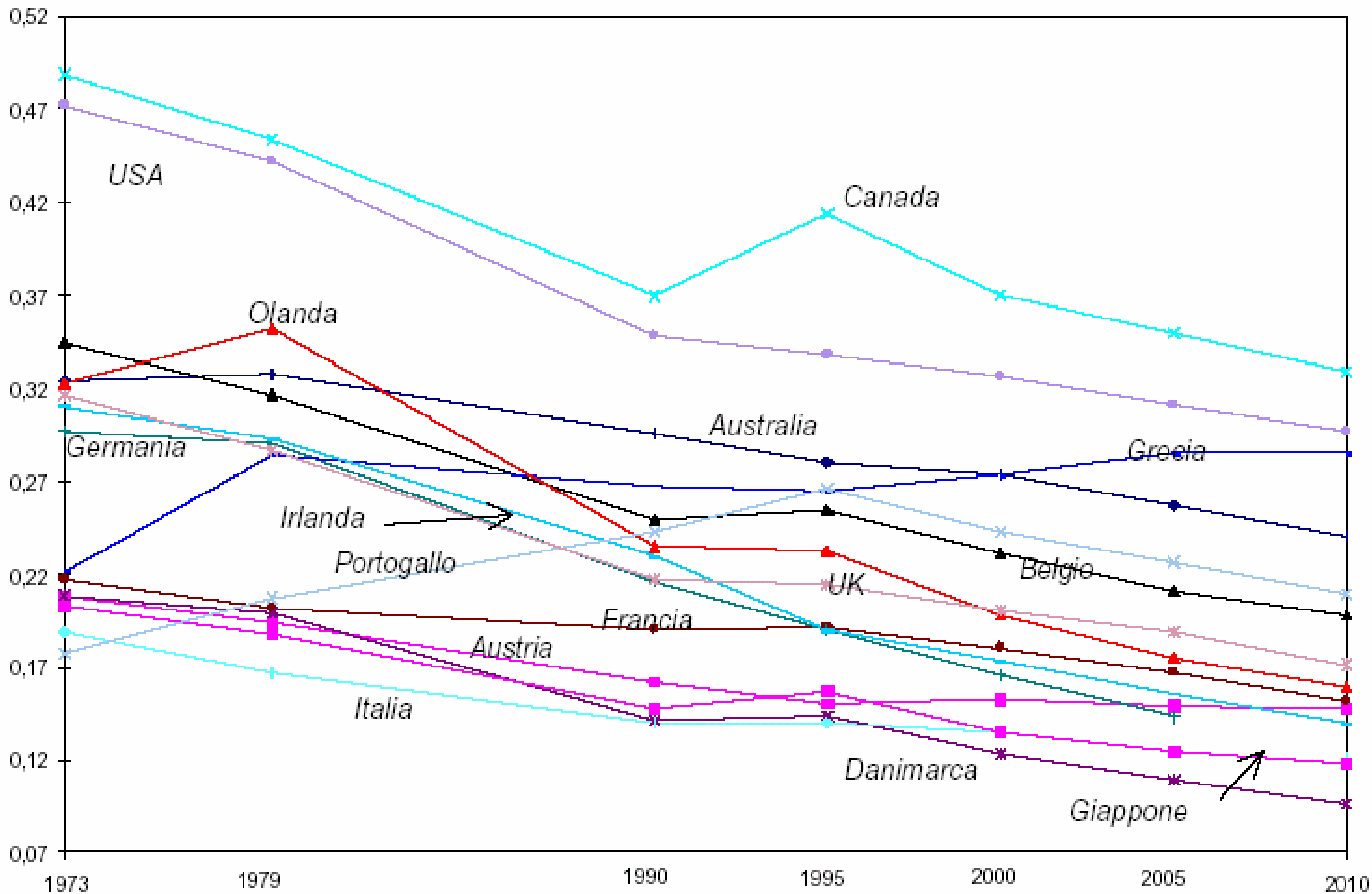
(ton CO2/toe)



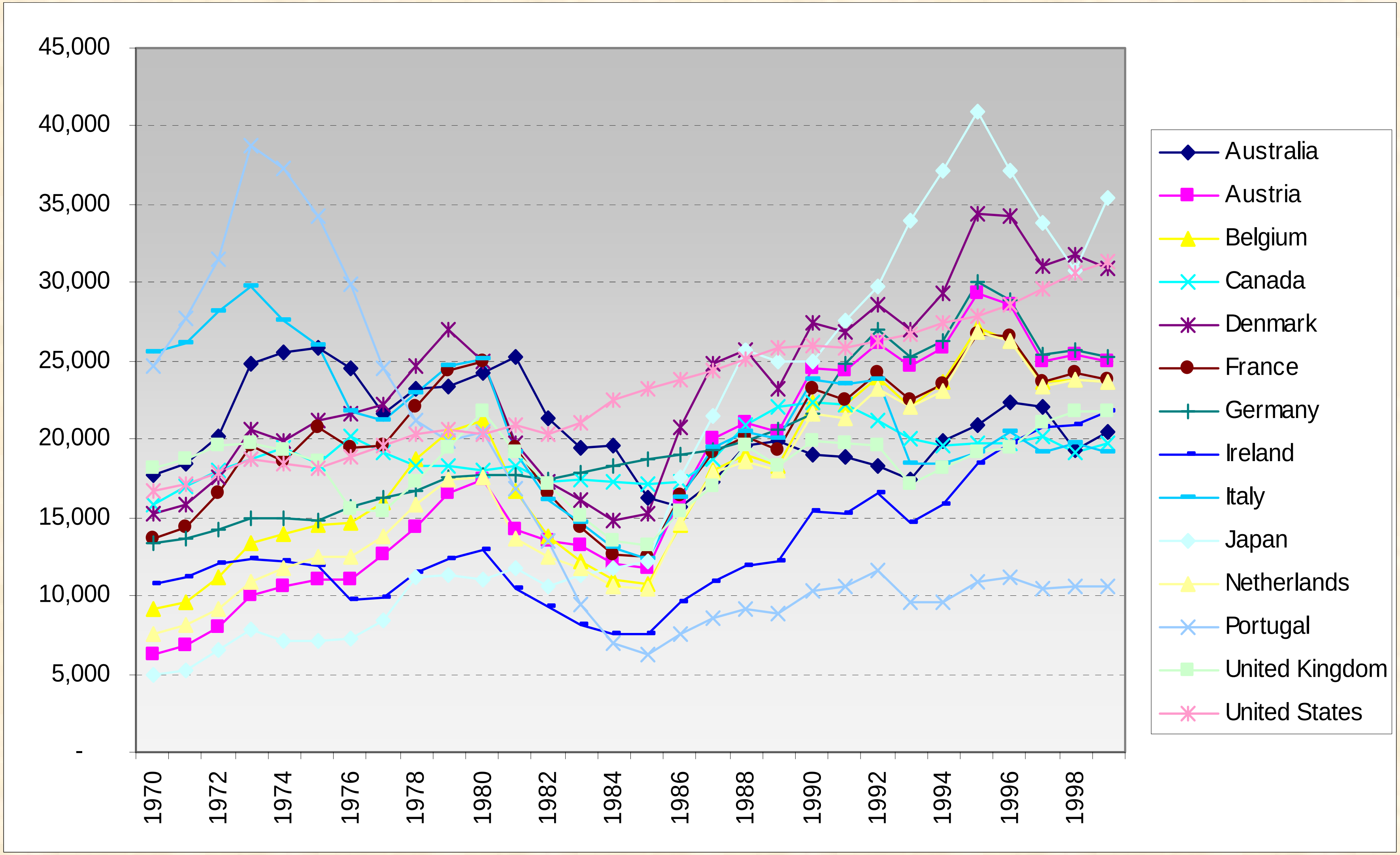
Source: IEA, International Energy Outlook 2001


Oil Production (Mt) and Price ($ 2002/bar.)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
80.00
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
1960
1962
1964
1966
1968
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
Oil
Prices

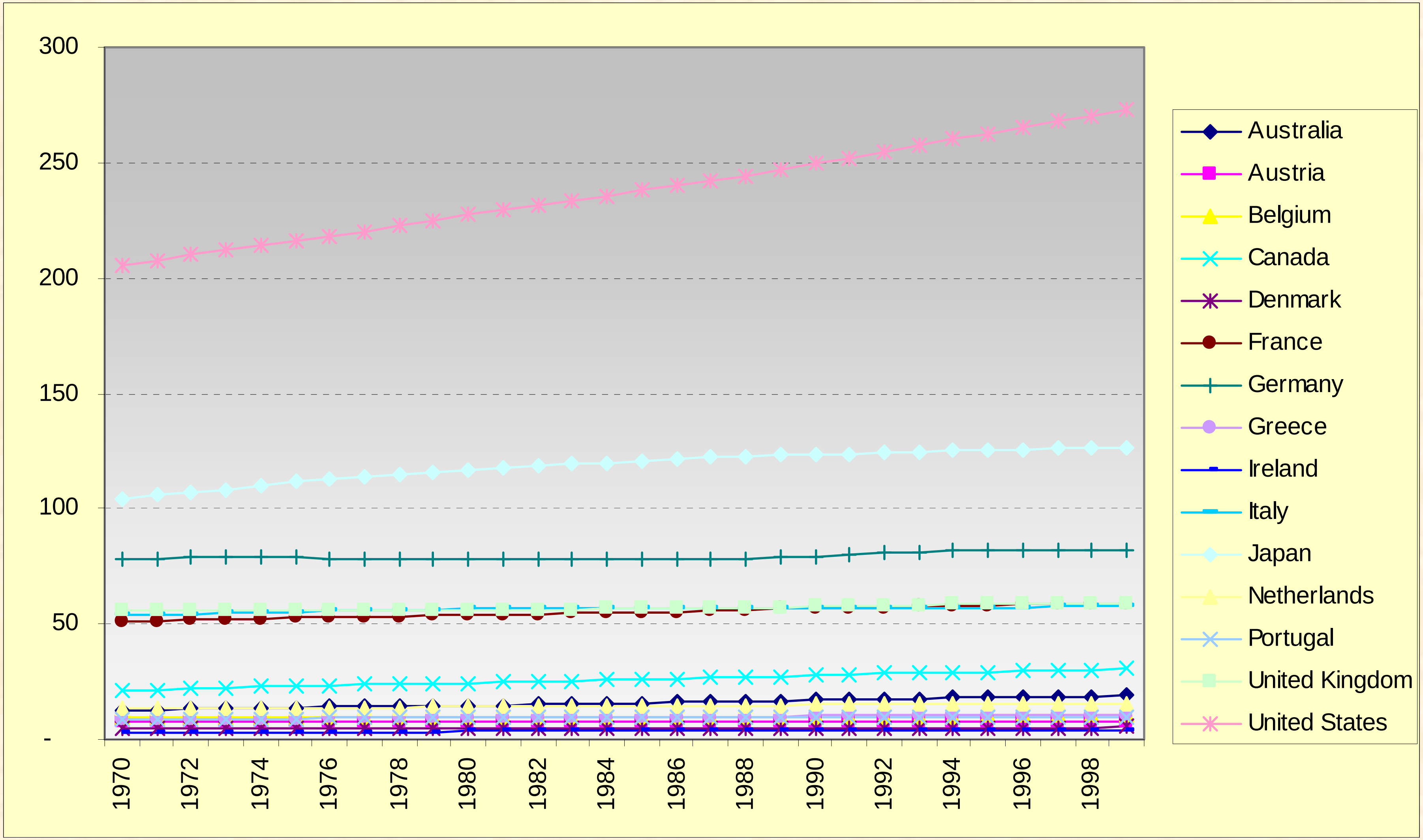
ENERGY INTENSITY FOR SOME OECD COUNTRIES (toe/’90US$1000)



PER CAPITA INCOME (US$ 95/PERSON)



POPULATION (Million of inhabitants)



Kaya Identity in incremental terms

$$E = A * B * C * D$$

where

E = CO_2 Emissions

A = Carbon Intensity

B = Energy Intensity

C = Per-capita Income

D = Population

$$\frac{dE}{E} = \frac{dA}{A} + \frac{dB}{B} + \frac{dC}{C} + \frac{dD}{D}$$

CO_2 Emission Kaya Factors Dynamics (%) per Region, 1970-2020

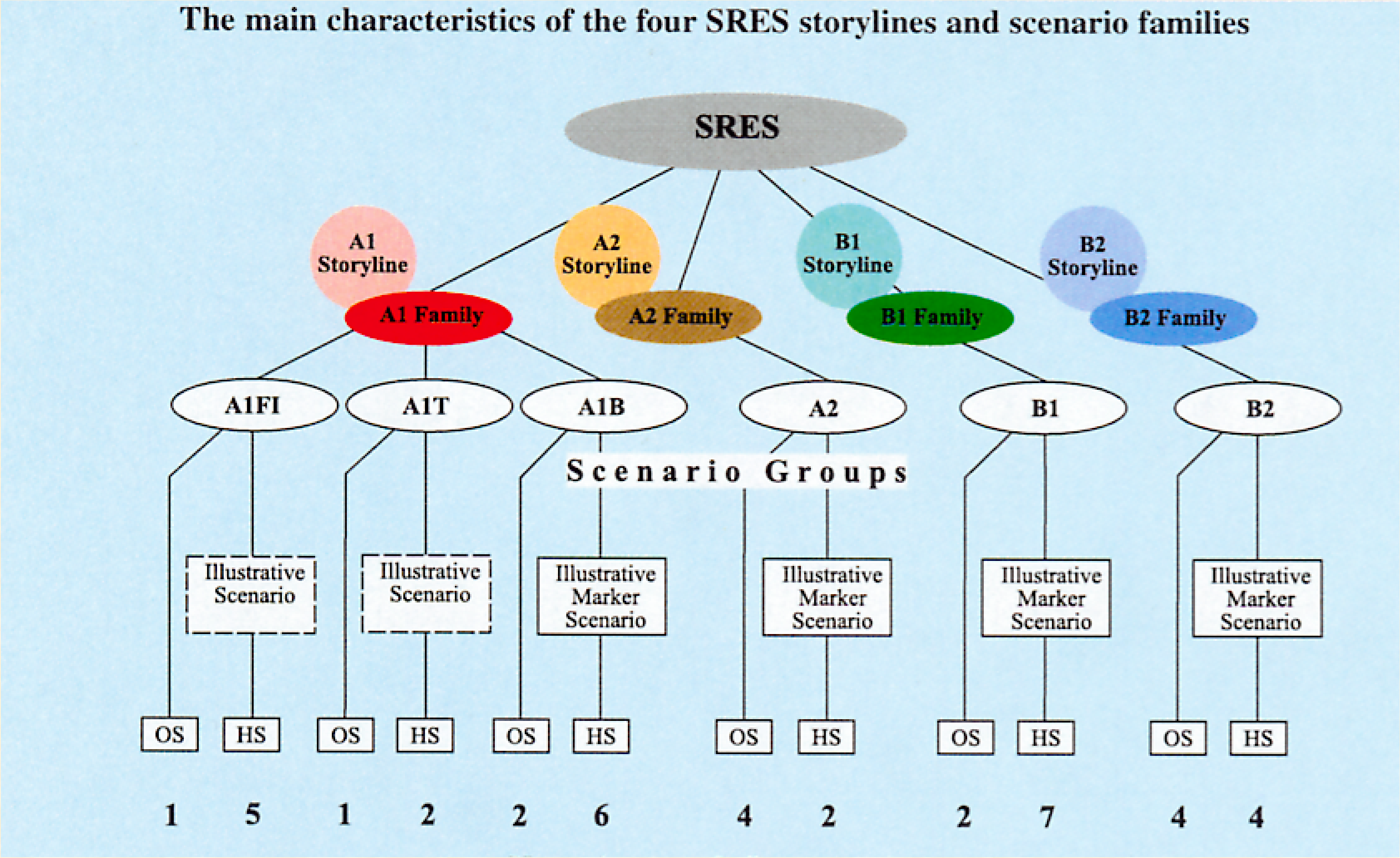
(IEA, International Energy Outlook, 2001)

Factor	Historical Trend			Projections	
	1970-1980	**1980-1990**	**1990-1999**	**1999-2010**	**2010-2020**
OECD Countries					
Carbon Intensity	-0,5%	-0,7%	-0,5%	0,0%	0,1%
Energy Intensity	-1,1%	-2,0%	-0,7%	-1,3%	-1,3%
Per-capita Income	2,4%	2,2%	1,6%	2,2%	2,0%
Population	0,9%	0,7%	0,6%	0,5%	0,4%
CO_2 Emissions	1,7%	0,2%	1,0%	1,4%	1,1%
Developing Countries					
Carbon Intensity	-0,8%	-0,2%	-0,7%	-0,1%	-0,1%
Energy Intensity	-0,4%	0,9%	-1,0%	-1,4%	-1,4%
Per-capita Income	3,5%	1,7%	3,1%	3,7%	4,2%
Population	2,2%	2,1%	1,7%	1,7%	0,8%
CO_2 Emissions	4,6%	4,5%	3,1%	3,9%	3,5%
Countries with Economy inTransition					
Carbon Intensity	-0,8%	-0,3%	-1,0%	-0,3%	-0,3%
Energy Intensity	1,4%	0,6%	-0,5%	-2,4%	-2,6%
Per-capita Income	2,4%	0,6%	-4,0%	4,1%	4,5%
Population	0,9%	0,7%	0,0%	0,0%	0,0%
CO_2 Emissions	3,9%	1,6%	-5,4%	1,4%	1,5%

WHERE ARE WE GOING?

WHAT ARE SCENARIOS AND WHAT IS THEIR PURPOSE?

IPCC SPECIAL REPORT ON EMISSIONS SCENARIOS


The main characteristics of the four SRES storylines and scenario families
SRES
A1 Storyline
A2 Storyline
B1 Storyline
B2 Storyline
A1 Family
A2 Family
B1 Family
B2 Family
A1FI
A1T
A1B
A2
B1
B2
Scenario Groups
Illustrative Scenario
Illustrative Scenario
Illustrative Marker Scenario
Illustrative Marker Scenario
Illustrative Marker Scenario
Illustrative Marker Scenario
OS HS OS HS OS HS OS HS OS HS OS HS
1 5 1 2 2 6 4 2 2 7 4 4

The A1 storyline and scenario

Describes a future world of:

- Very rapid economic growth;
- Global population that peaks in mid-century and declines thereafter;
- Rapid introduction of new and more efficient technologies
- Convergence among regions.

The A1 storyline and scenario

A1 scenarios develops into three groups that describe alternative directions of technological change in the energy system. The three A1 groups are:

- Fossil intensive (A1FI);
- Non fossil energy sources (A1T);
- Balance across all sources (A1B).

The A2 storyline and scenario

It describes a very heterogeneous world:

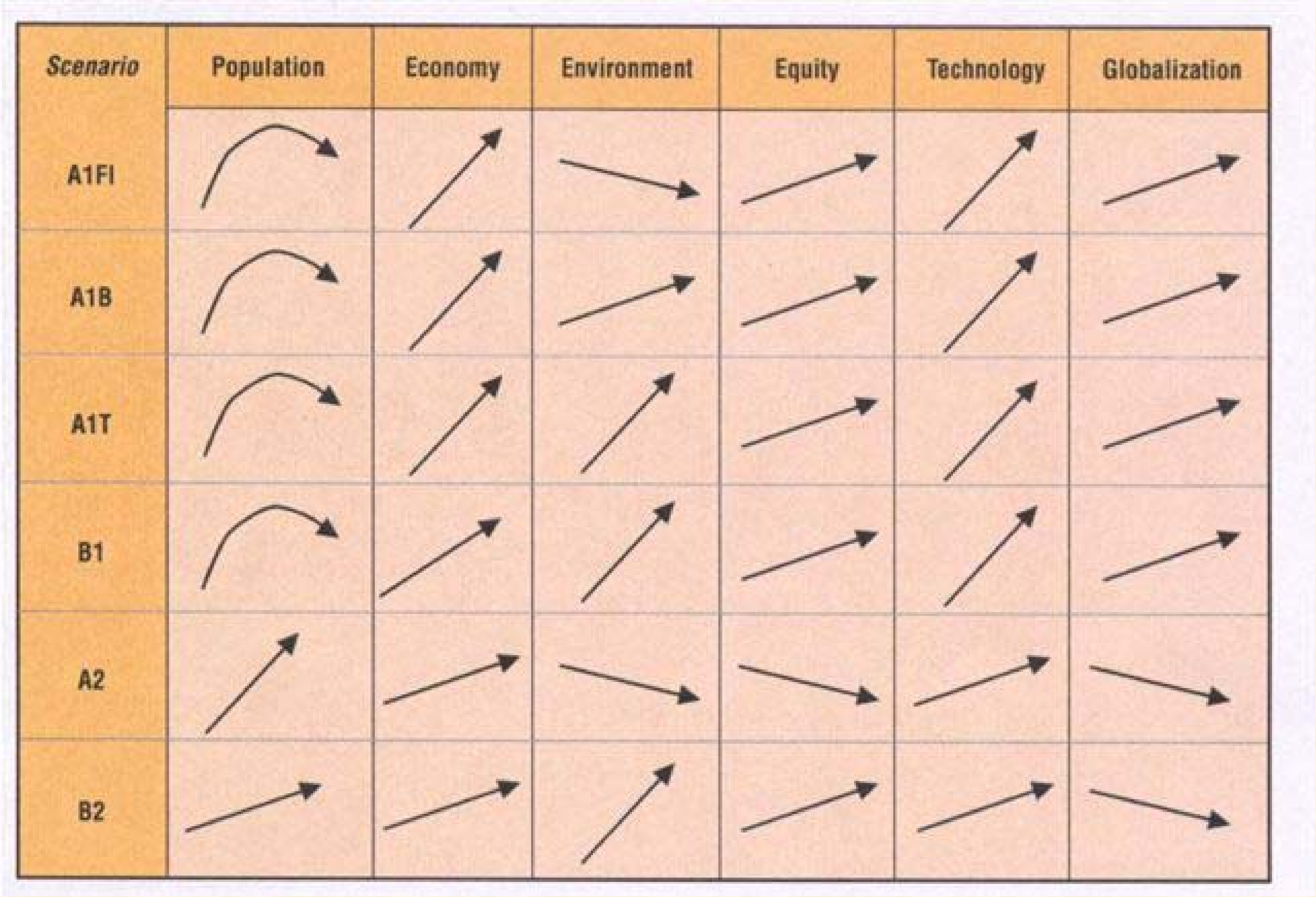
- Continuous increase in global population;
- Economic development is primarily regionally oriented;
- Per capita economic growth and technological change are more fragmented and slower that in A1 scenario.

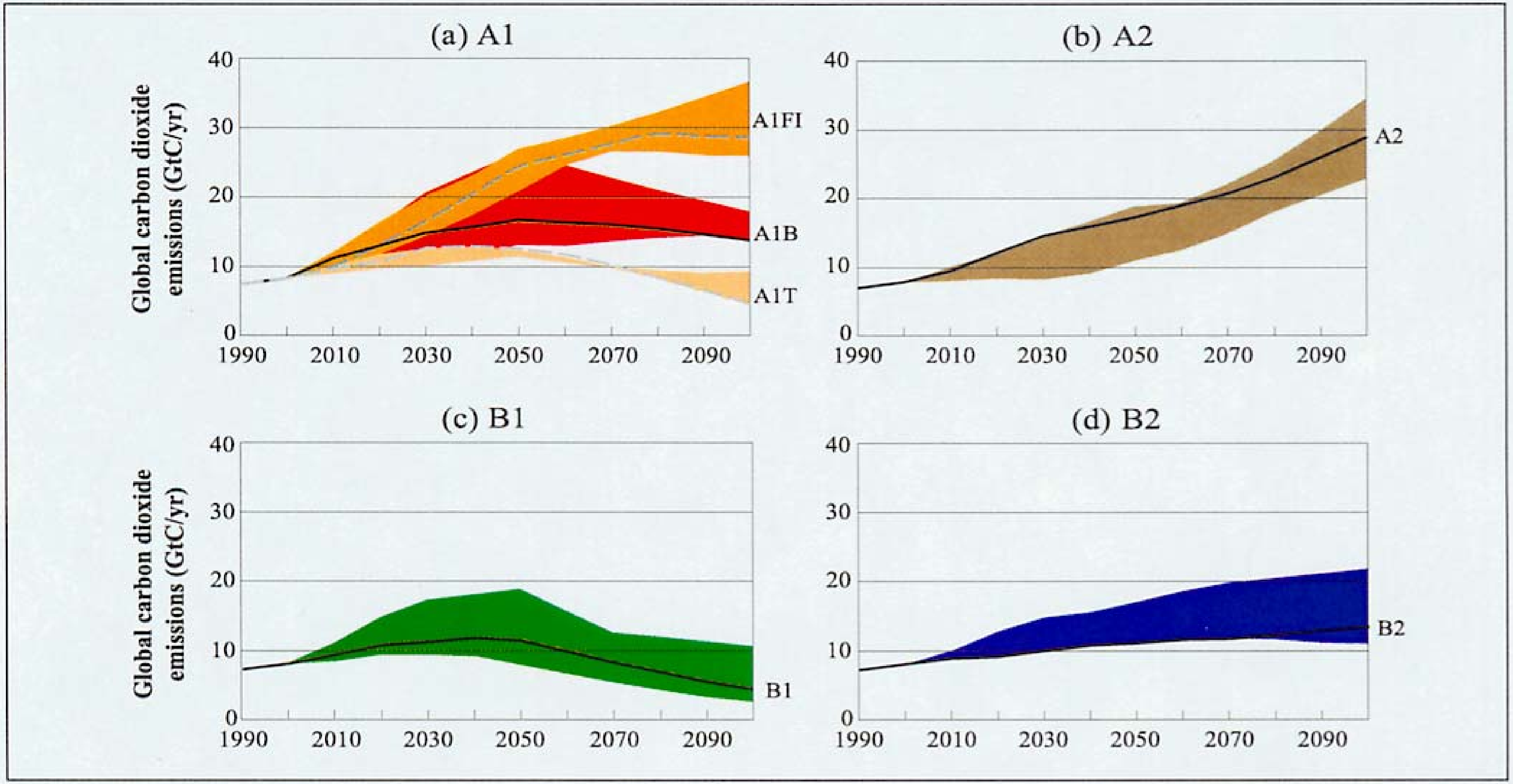
The B1 storyline and scenario

The B1 storyline and scenario family describes a convergent world with the same global population dynamics as in A1 storyline, but with rapid changes in in economic structures towards a service and information economy.

The B2 storyline and scenario

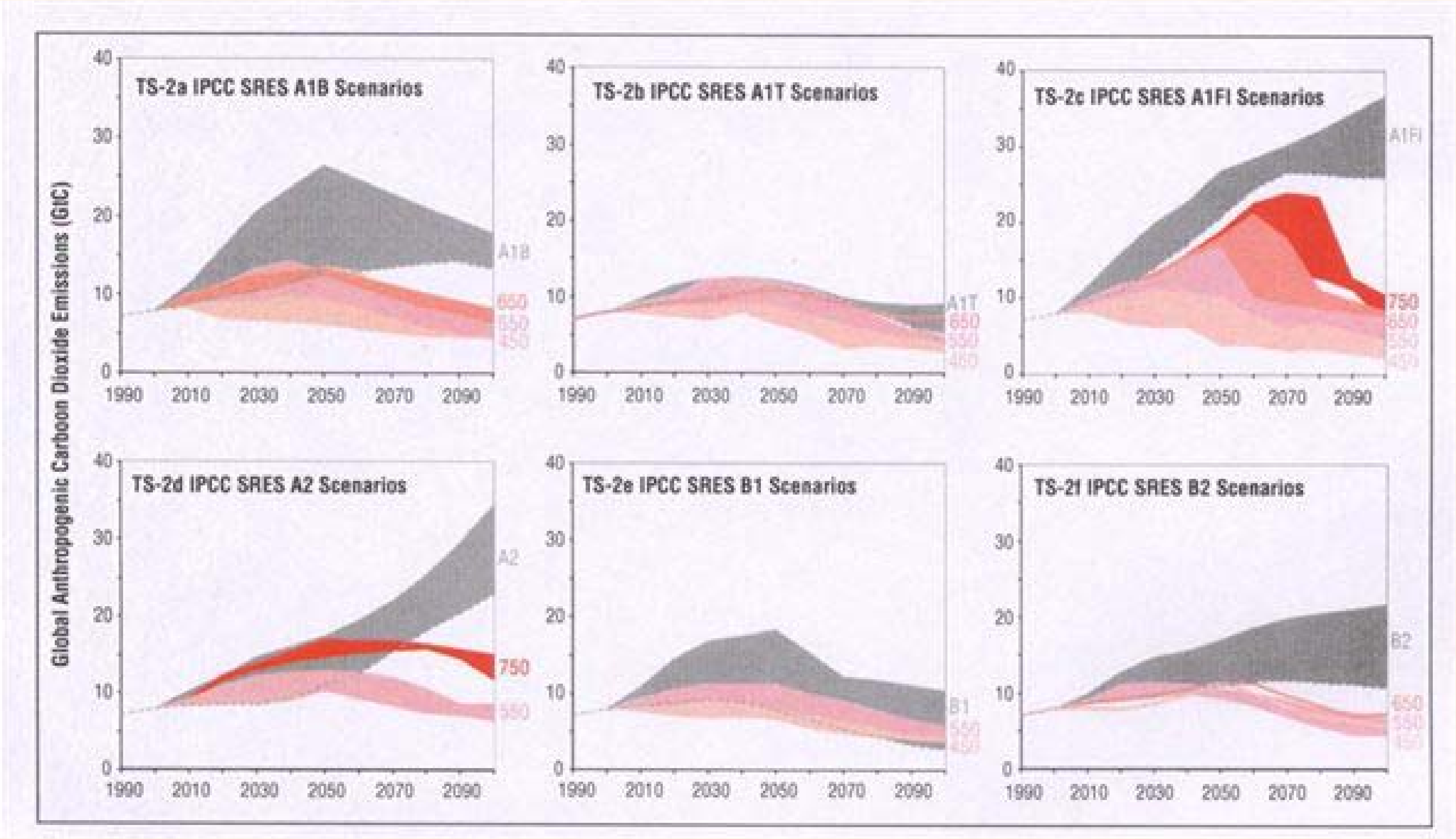
It describes a world in which the emphasis is on local solutions to economic, social and environmental sustainabilty. It is a world of intermediate level of economic development, and less rapid and more diverse technological change than in B1 and A1 storylines.


Scenario
Population
Economy
Environment
Equity
Technology
Globalization
A1FI
A1B
A1T
B1
A2
B2


(a) A1
(b) A2
(c) B1
(d) B2
Global carbon dioxide emissions (GtC/yr)
0
10
20
30
40
1990
2010
2030
2050
2070
2090
A1FI
A1B
A1T
A2
B1
B2

IPCC CO2 CONCENTRATION STABILIZATION SCENARIOS

WHERE SHOULD WE GO?



Global Anthropogenic Carbon Dioxide Emissions (GtC)
TS-2a IPCC SRES A1B Scenarios
A1B
650
550
450
TS-2b IPCC SRES A1T Scenarios
A1T
650
550
450
TS-2c IPCC SRES A1FI Scenarios
A1FI
750
650
550
450
TS-2d IPCC SRES A2 Scenarios
A2
750
550
TS-2e IPCC SRES B1 Scenarios
B1
550
450
TS-2f IPCC SRES B2 Scenarios
B2
650
550
450
0
10
20
30
40
1990
2010
2030
2050
2070
2090

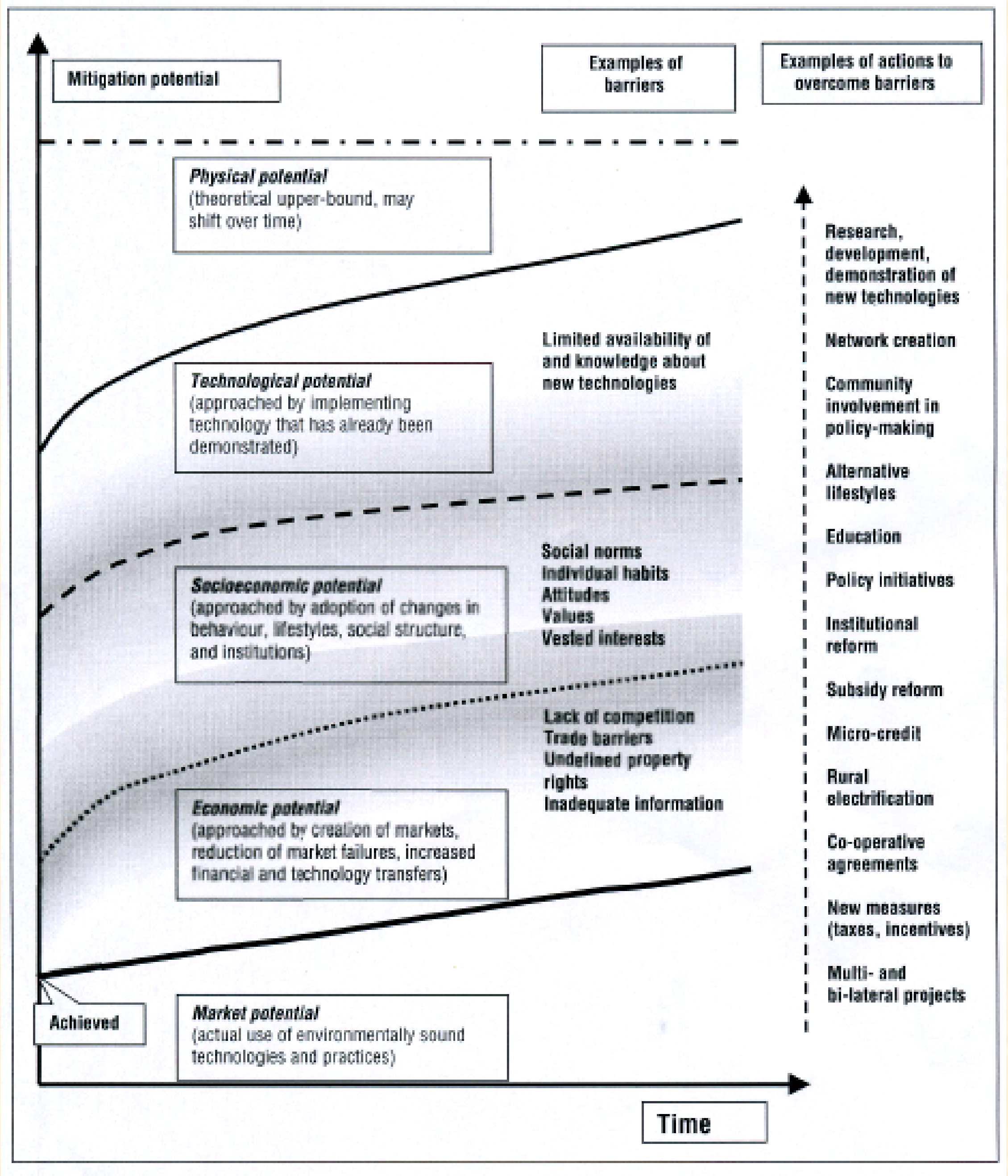
Estimates of potential global greenhouse gas emission reduction in 2010 and in 2020

Sector	Historic emissions in 1990 (MtC/yr)	Historic C annual growth rate in 1990-1995 (%)	Potential emission reductions in 2010 (MtC/yr)	Potential emission reductions in 2020 (MtC/yr)
Buildings	1650	1.0	700-750	1000-1100
Transport	1080	2.4	100-300	300-700
Industry	2300	0.4	300-500	700-900

Most reductions are available at negative net direct costs

Source: IPCC 2001

BARRIERS TO IMPLEMENTATION


Mitigation potential
Examples of barriers
Examples of actions to overcome barriers
Physical potential
(theoretical upper-bound, may shift over time)
Technological potential
(approached by implementing technology that has already been demonstrated)
Socioeconomic potential
(approached by adoption of changes in behaviour, lifestyles, social structure, and institutions)
Economic potential
(approached by creation of markets, reduction of market failures, increased financial and technology transfers)
Market potential
(actual use of environmentally sound technologies and practices)
Achieved
Time
Limited availability of and knowledge about new technologies
Social norms
Individual habits
Attitudes
Values
Vested interests
Lack of competition
Trade barriers
Undefined property rights
Inadequate information
Research, development, demonstration of new technologies
Network creation
Community involvement in policy-making
Alternative lifestyles
Education
Policy initiatives
Institutional reform
Subsidy reform
Micro-credit
Rural electrification
Co-operative agreements
New measures (taxes, incentives)
Multi- and bi-lateral projects

COSTS OF IMPLEMENTATION

COSTS OF IMPLEMENTATION

- Actions taken to abate CO2 emissions imply the use of economic resources and divert these resources from other alternative uses.
- Assessing the costs of these actions should ideally consider the total value that the society attaches to the goods and services forgone because of the diversion of resources to climate protection.
- In some case, the sum of benefits and costs will be negative, meaning that society gains from undertaking the mitigation action.

COSTS OF IMPLEMENTATION

- Policies aimed at mitigating CO_2 emissions can yield other social benefit and costs, the so called ancillary or co-benefits and costs. For example, reducing carbon emissions in many cases will result in the simultaneous reduction in local and regional air pollution.
- Cost for ton of CO_2 emissions avoided are unevenly distributed among sectors and among Countries;

CONCLUSIONS

- The current level of CO_2 emissions seems to be not sustainable for the climate system;
- IPCC reference scenarios show that a CO_2 concentration stabilization will unlike be seen;
- IPCC CO_2 concentration stabilization scenarios show that it is possible achieve stabilization by means of the diffusion of known technological options;

CONCLUSIONS

- The associated costs depend on the level of CO_2 concentration stabilization.
- A number of co-benefits are associated with CO_2 emission mitigation policies.
- The process towards a low carbon economy will be not easy to implement, hence the need for an Institution to steer it.