Colloquium -- 2010-2020: a promising decade for Brazil?

Energy and Sustainable Development

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Renewable Energies

Instruments for Sustainable Development

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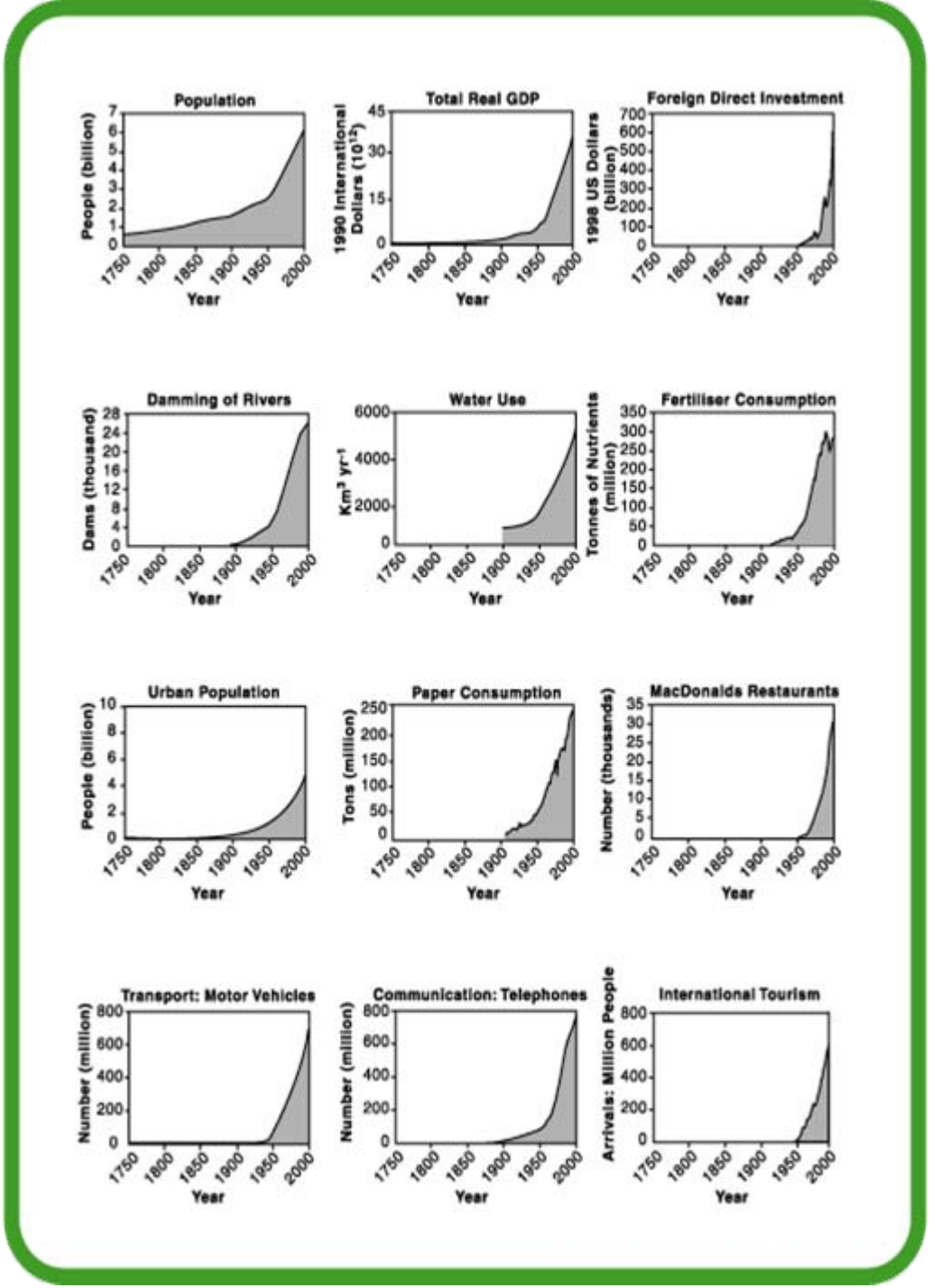
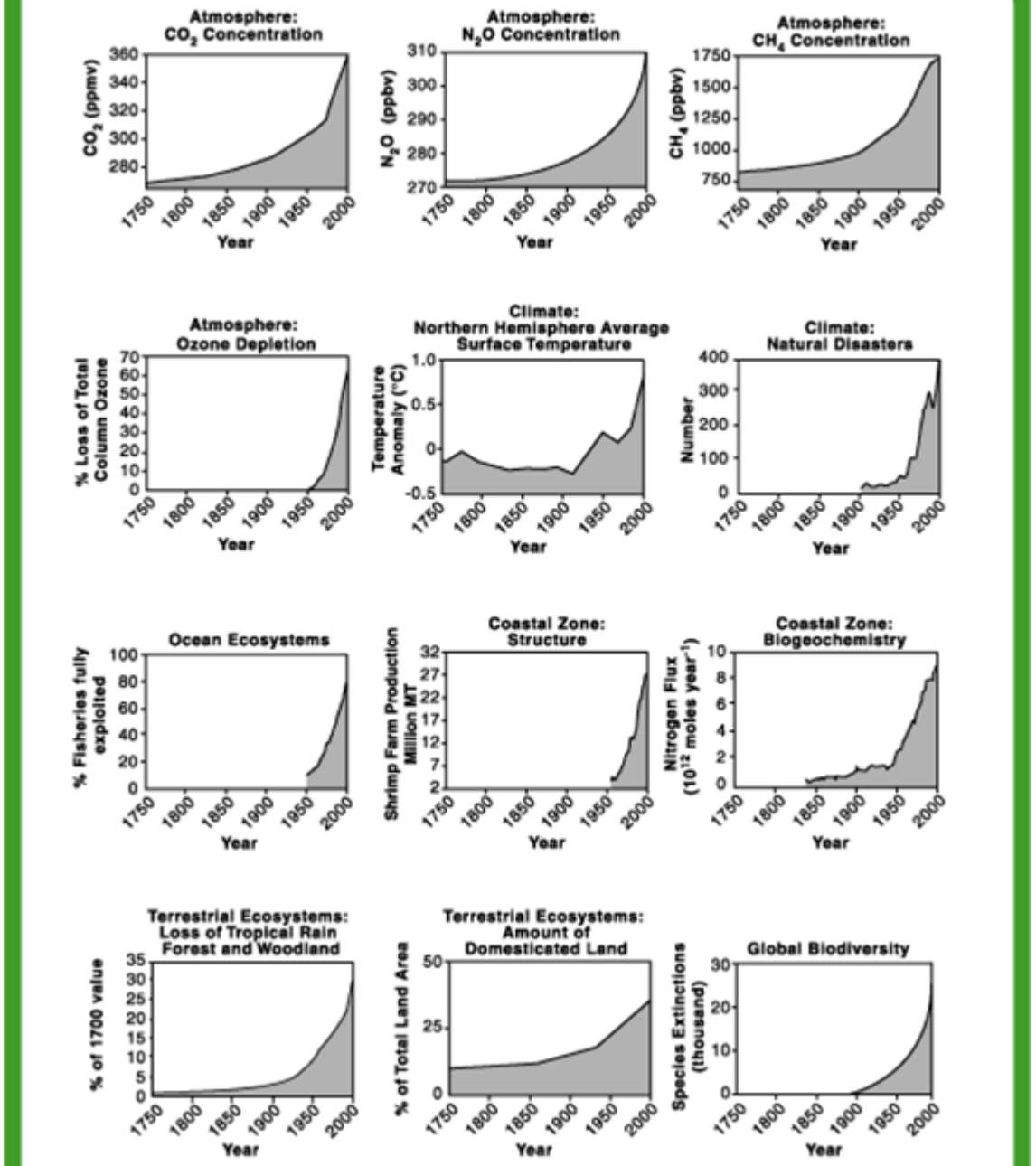

Population
People (billion)
Year
Total Real GDP
1990 International Dollars (10^{12})
Year
Foreign Direct Investment
1998 US Dollars (billion)
Year
Damming of Rivers
Dams (thousand)
Year
Water Use
$Km^3\ yr^{-1}$
Year
Fertiliser Consumption
Tonnes of Nutrients (million)
Year
Urban Population
People (billion)
Year
Paper Consumption
Tons (million)
Year
MacDonalds Restaurants
Number (thousands)
Year
Transport: Motor Vehicles
Number (million)
Year
Communication: Telephones
Number (million)
Year
International Tourism
Arrivals: Million People
Year

IGBP


Atmosphere: CO_2 Concentration
CO_2 (ppmv)
360
340
320
300
280
1750
1800
1850
1900
1950
2000
Year
Atmosphere: N_2O Concentration
N_2O (ppbv)
310
300
290
280
270
Year
Atmosphere: CH_4 Concentration
CH_4 (ppbv)
1750
1500
1250
1000
750
Year
Atmosphere: Ozone Depletion
% Loss of Total Column Ozone
70
60
50
40
30
20
10
0
Year
Climate: Northern Hemisphere Average Surface Temperature
Temperature Anomaly (°C)
1.0
0.5
0
-0.5
Year
Climate: Natural Disasters
Number
400
300
200
100
0
Year
Ocean Ecosystems
% Fisheries fully exploited
100
80
60
40
20
0
Year
Coastal Zone: Structure
Shrimp Farm Production Million MT
32
27
22
17
12
7
2
Year
Coastal Zone: Biogeochemistry
Nitrogen Flux (10^{12} moles $year^{-1}$)
10
8
6
4
2
0
Year
Terrestrial Ecosystems: Loss of Tropical Rain Forest and Woodland
% of 1700 value
35
30
25
20
15
10
5
0
Year
Terrestrial Ecosystems: Amount of Domesticated Land
% of Total Land Area
50
25
0
Year
Global Biodiversity
Species Extinctions (thousand)
30
20
10
0
Year

IGBP

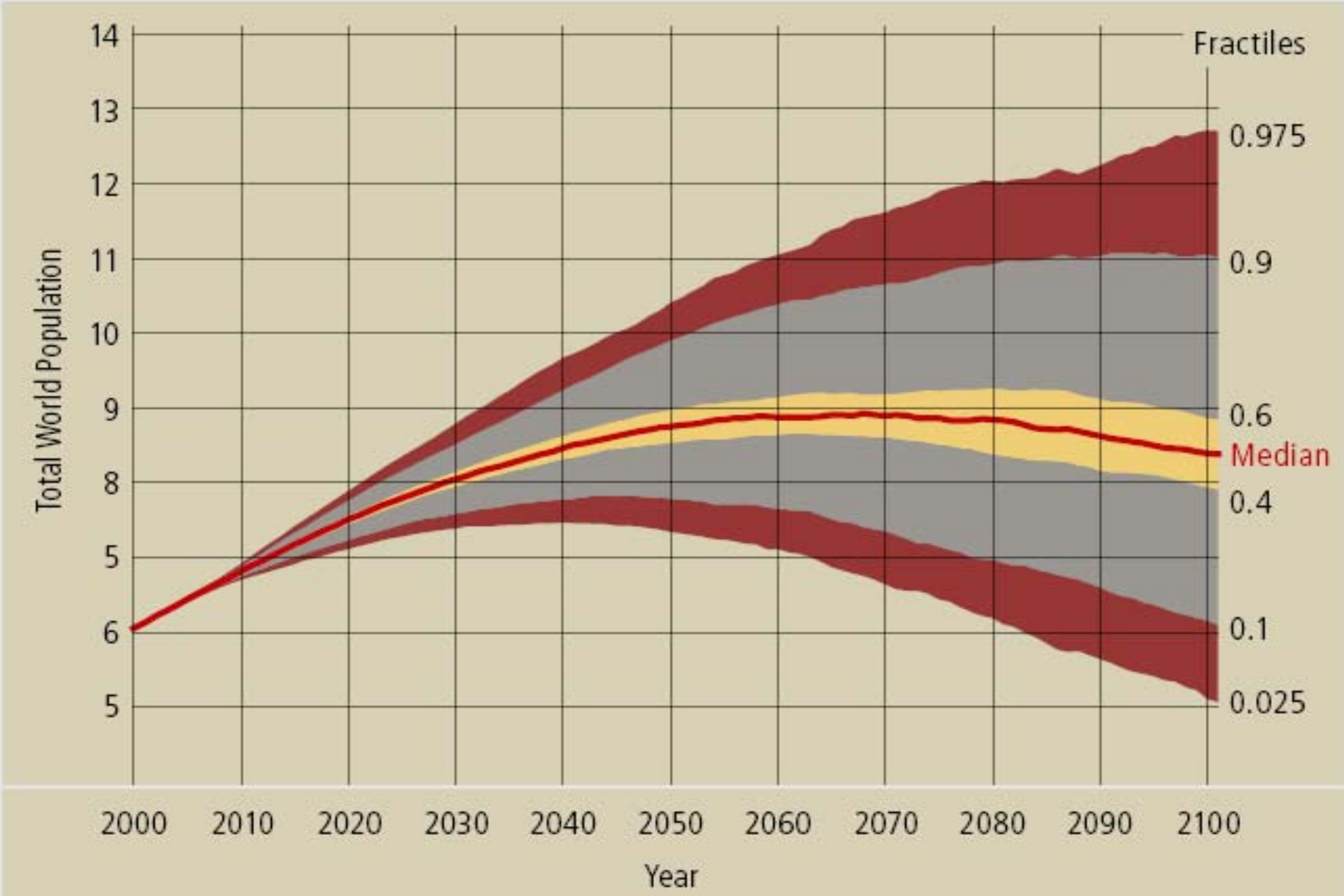
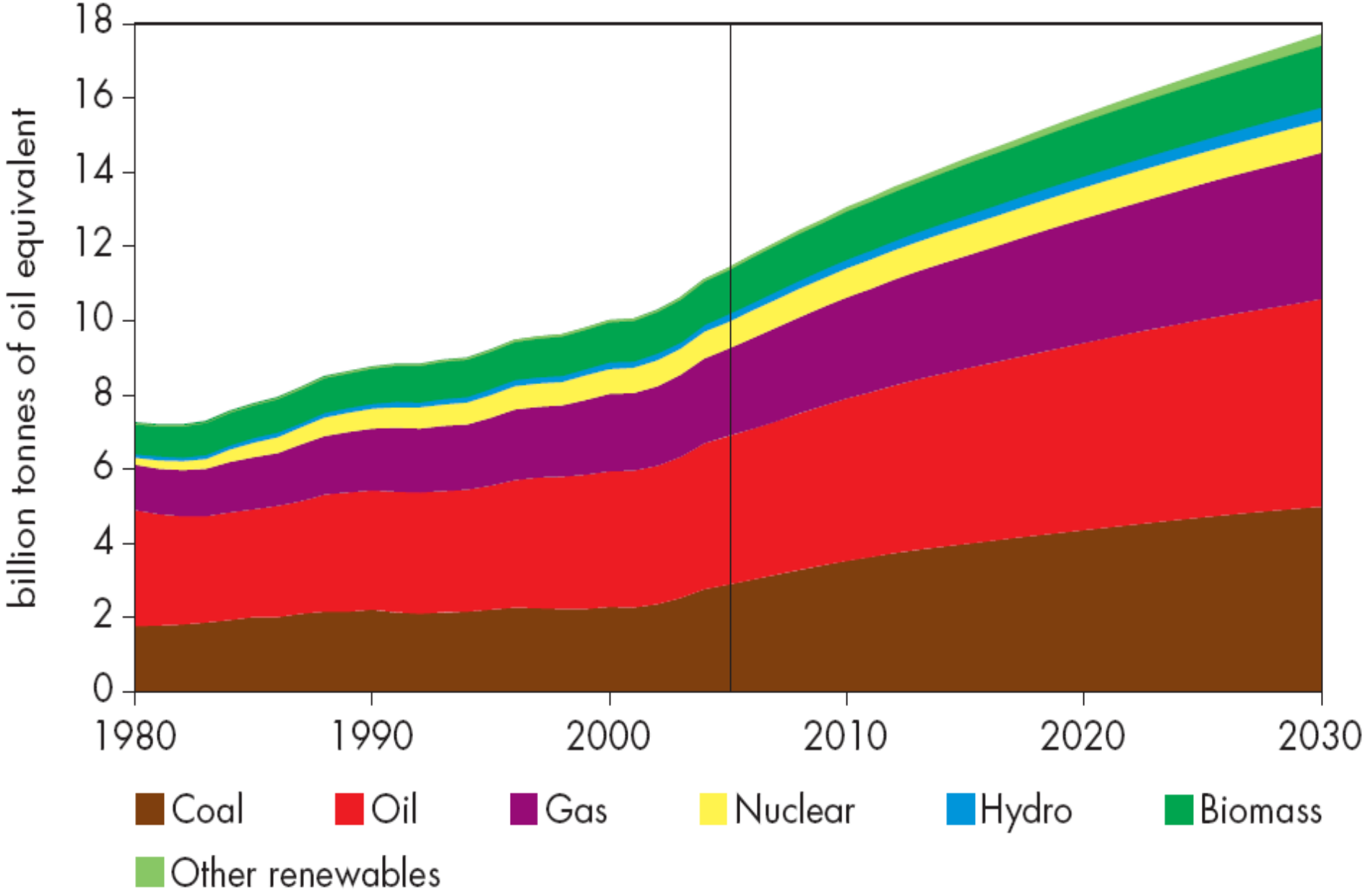
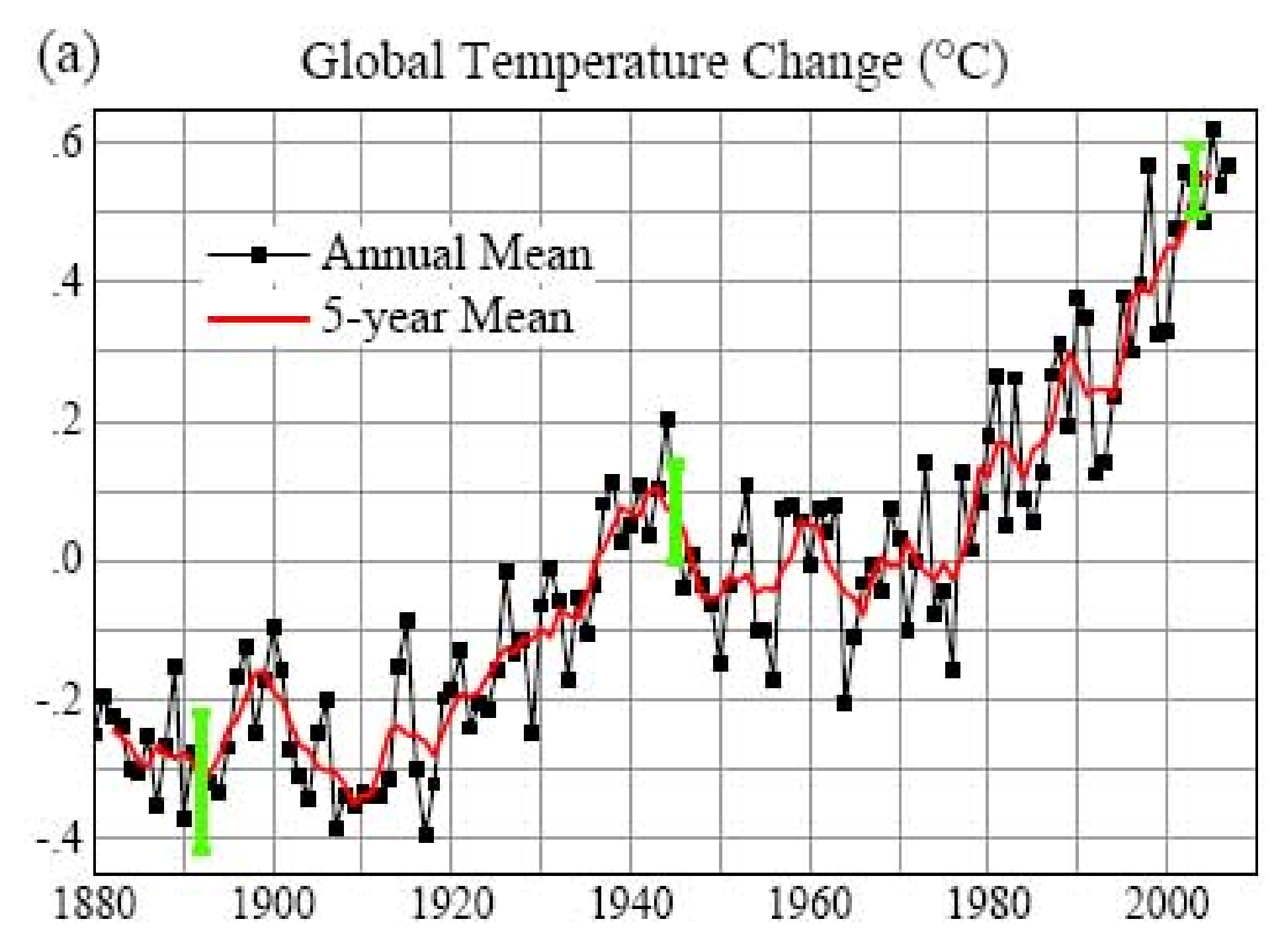


Figure 1. Uncertainty distribution of total world population to 2100, in billions.

Figure 1.1: **World Primary Energy Demand in the Reference Scenario**




(a)
Global Temperature Change (°C)
.6
.4
.2
.0
-.2
-.4
Annual Mean
5-year Mean
1880
1900
1920
1940
1960
1980
2000

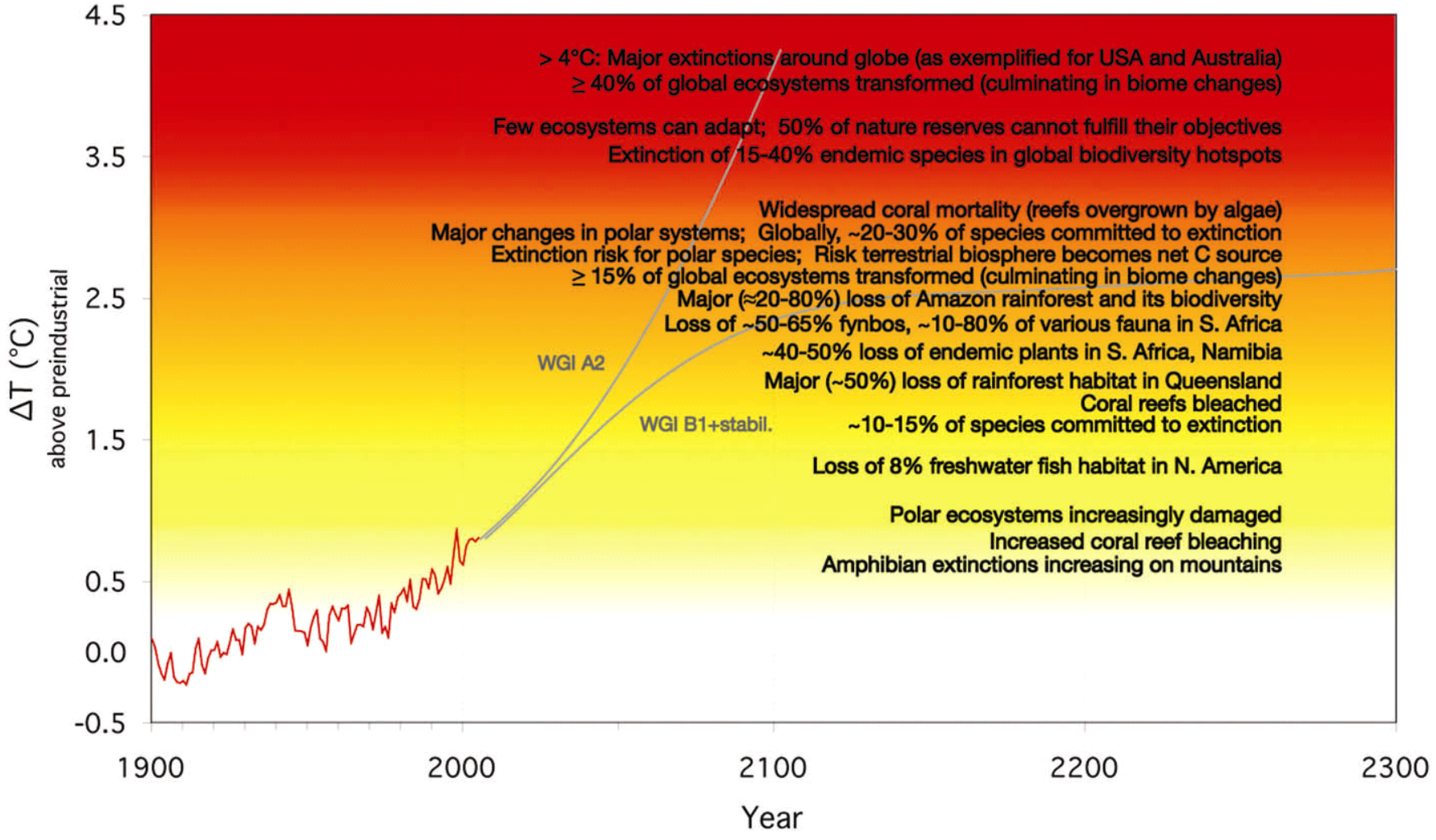

National Snow and Ice

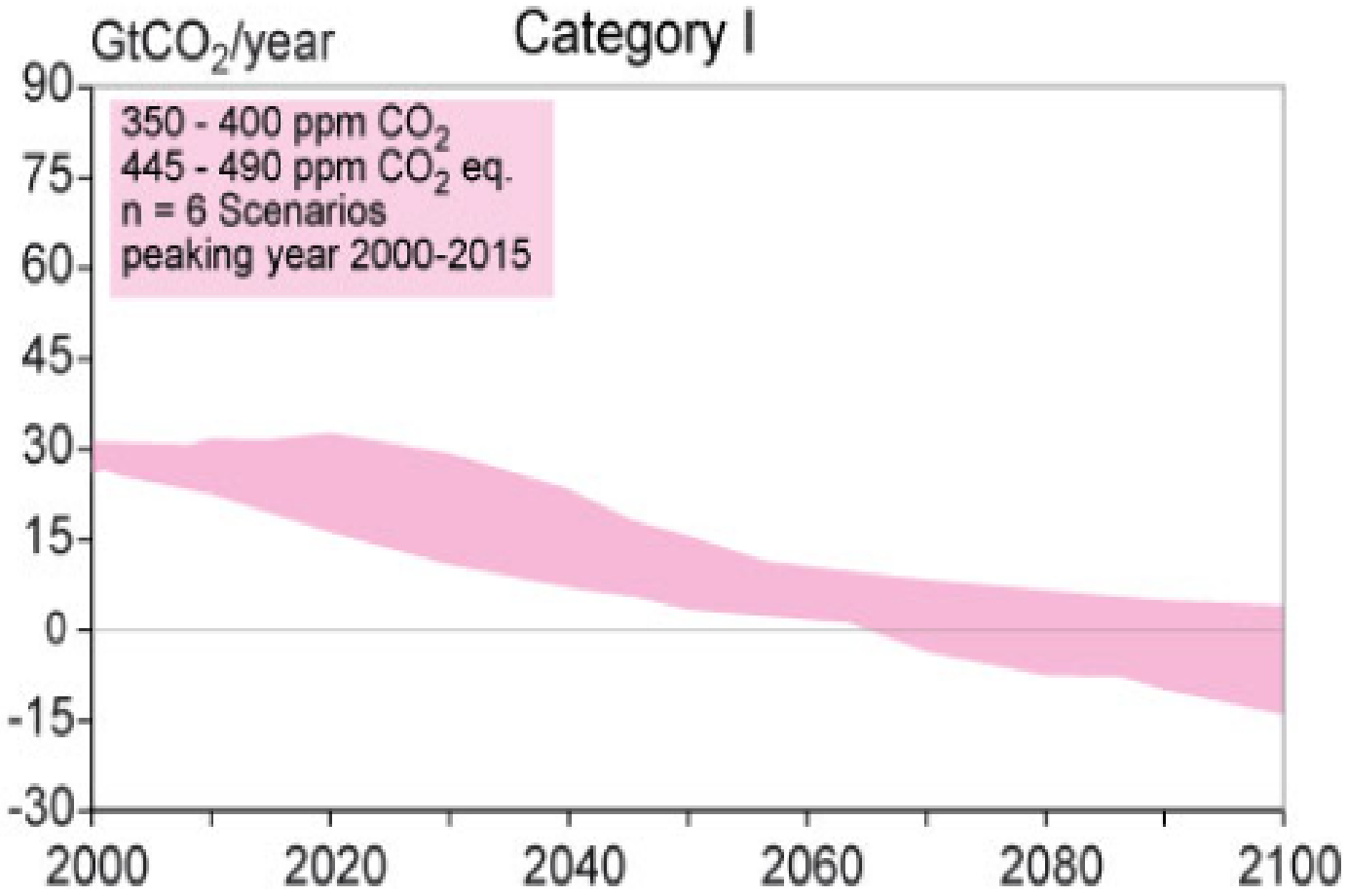
warming affects much:

- Water supply
- Precipitation
- Sea level
- Severe weather
- Biodiversity
- Food supply

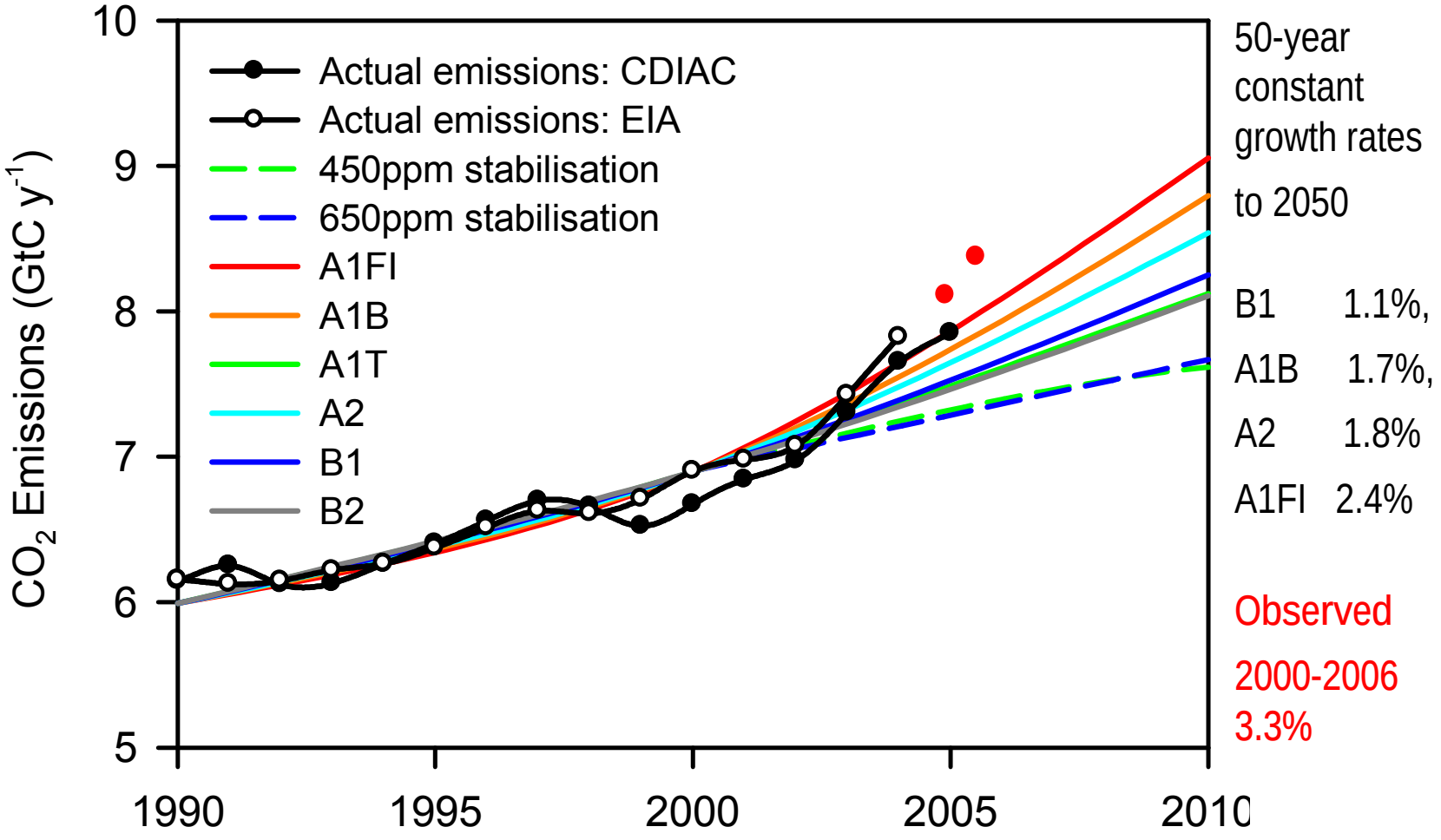
- Distribution of vector born diseases
- Heat waves
- Forest fires
- …and much more…

Figure TS.6. Projected risks due to critical climate change impacts on ecosystems




GtCO2/year
Category I
350 - 400 ppm CO2
445 - 490 ppm CO2 eq.
n = 6 Scenarios
peaking year 2000-2015
90
75
60
45
30
15
0
-15
-30
2000
2020
2040
2060
2080
2100

Trajectory of Global Fossil Fuel Emissions



Challenges requiring actions on Energy

a. **equity** in energy services
b. **affordable** energy services
c. **secure** supplies
d. **local and regional environmental challenges**
e. **climate change mitigation**
f. **ancillary risks**

Major Energy System Changes Needed!

These **challenges** must be addressed

simultaneously

adequately

timely

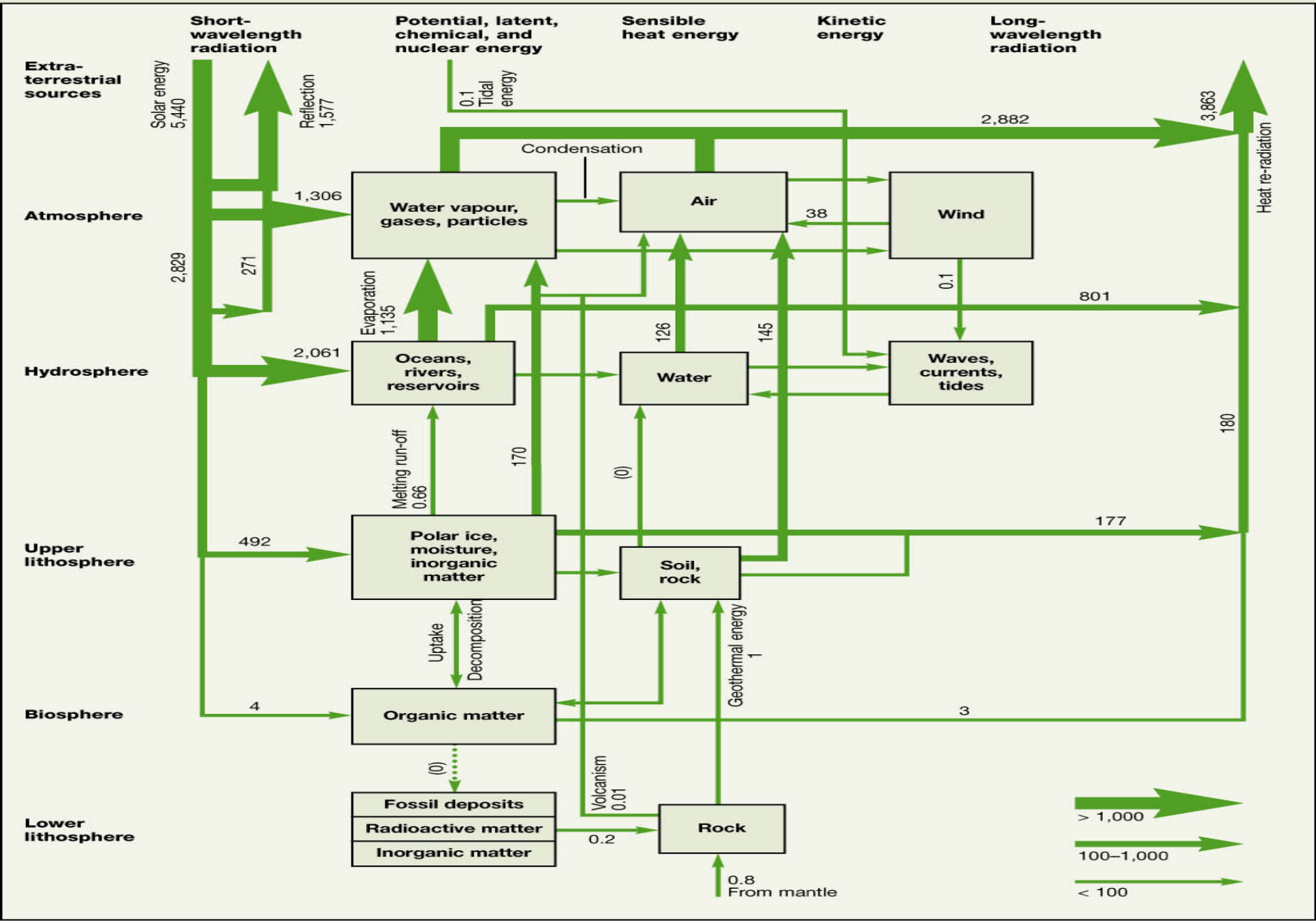
this translates into a need for a major energy system transformation

Main elements:

- Energy end-use efficiency
- Renewable energies
- Carbon Capture and Storage

- **Efficiency** and **Renewables** are **INSTRUMENTS** for addressing all the challenges at the same time!

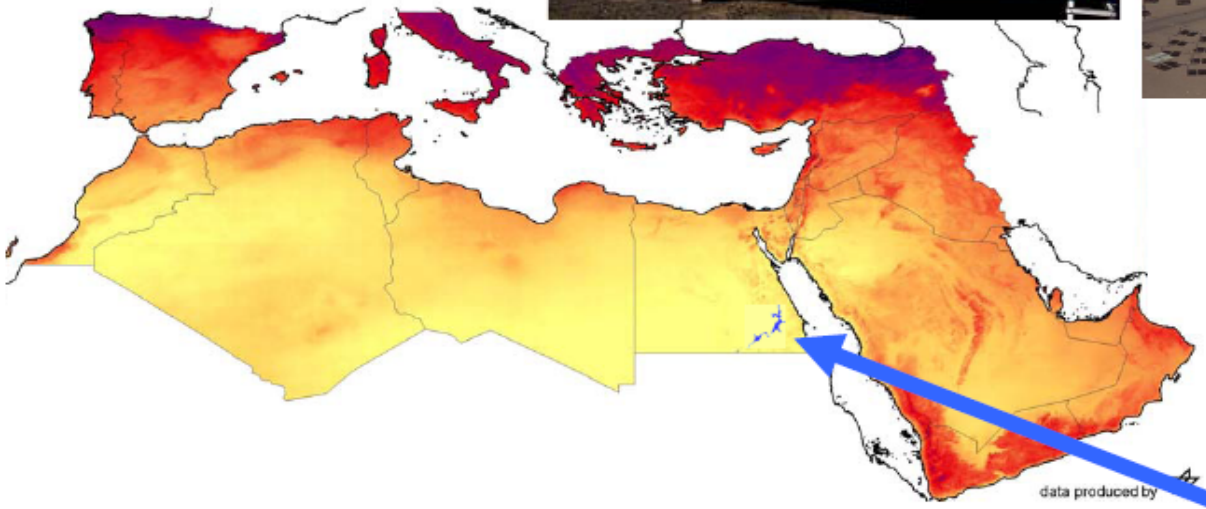
GLOBAL ENERGY BALANCE AND FLOWS WITHOUT ANTHROPOGENIC INTERFERENCE



Note: Energy flows are in thousands of exajoules a year. Numbers in parentheses are uncertain or rounded.

Source: Sørensen, 1979.

solar resources in the Middle East/North Africa region



a solar thermal power plant of the size of Lake Nasser (Aswan) could harvest energy equivalent to the annual oil production of the Middle East

Part of Sahara needed

Area used for all agriculture

HVDC Light cable development

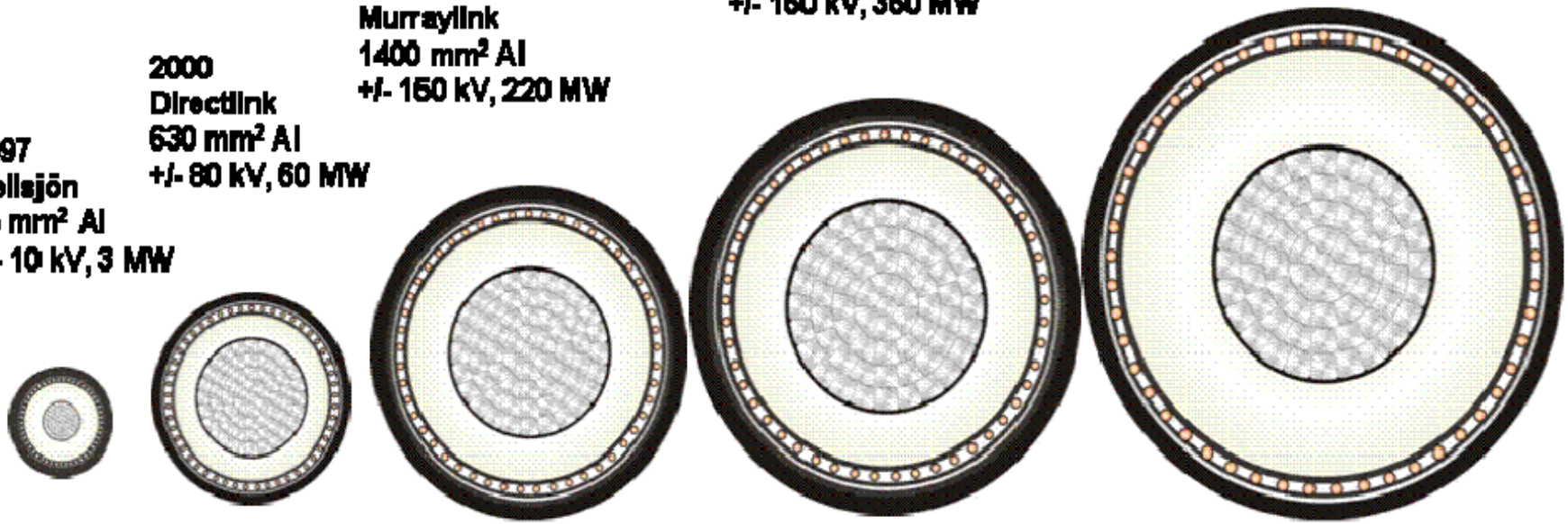
1997
Hellsjön
95 mm² Al
+/- 10 kV, 3 MW

2000
Directlink
630 mm² Al
+/- 80 kV, 60 MW

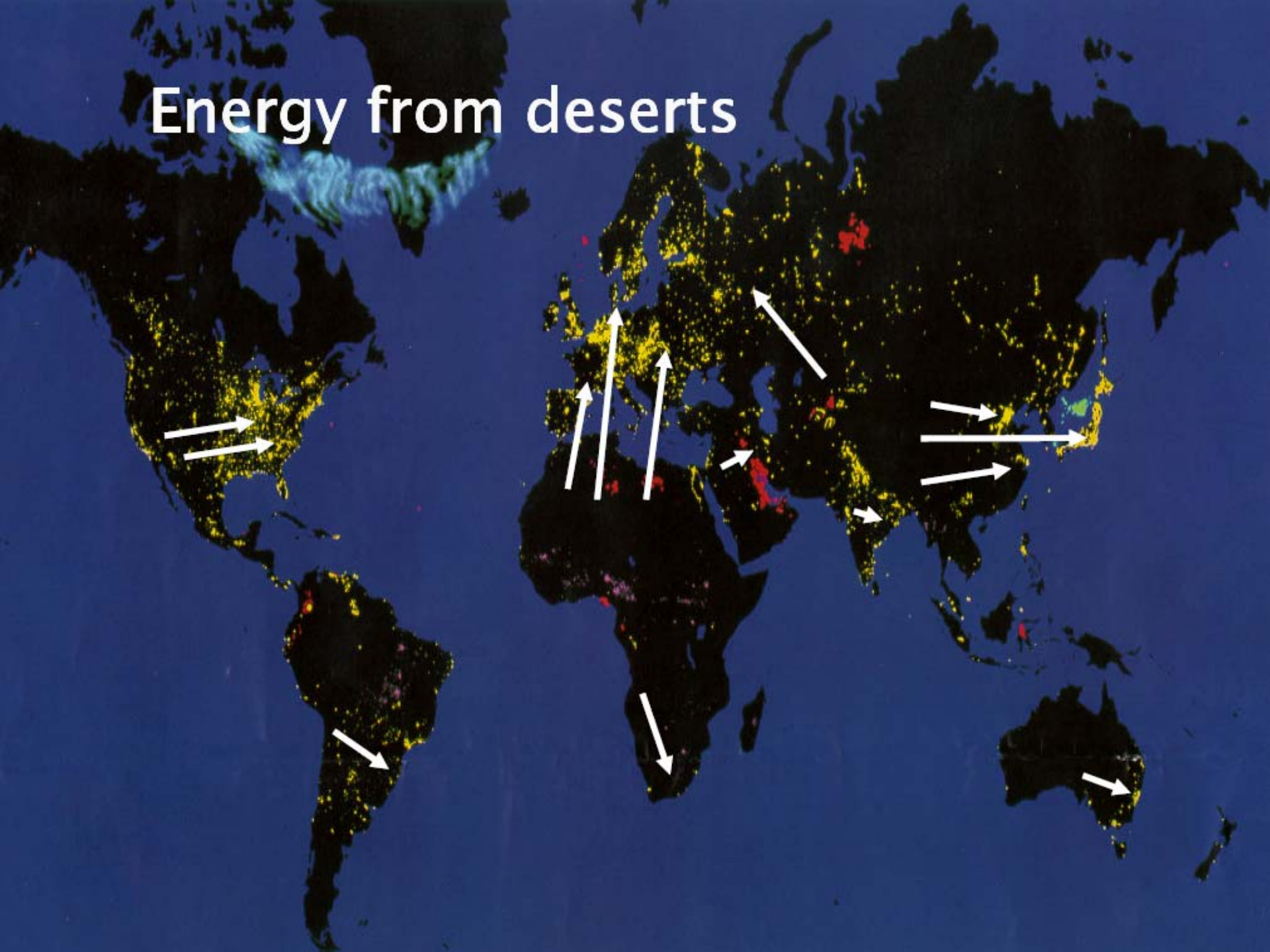
2001
Murraylink
1400 mm² Al
+/- 150 kV, 220 MW

2004
Estlink
2000 mm² Al
+/- 150 kV, 350 MW

2006 - 2007
1600 mm² Al (Cu)
+/- 300 kV, 700 MW (1100 MW)



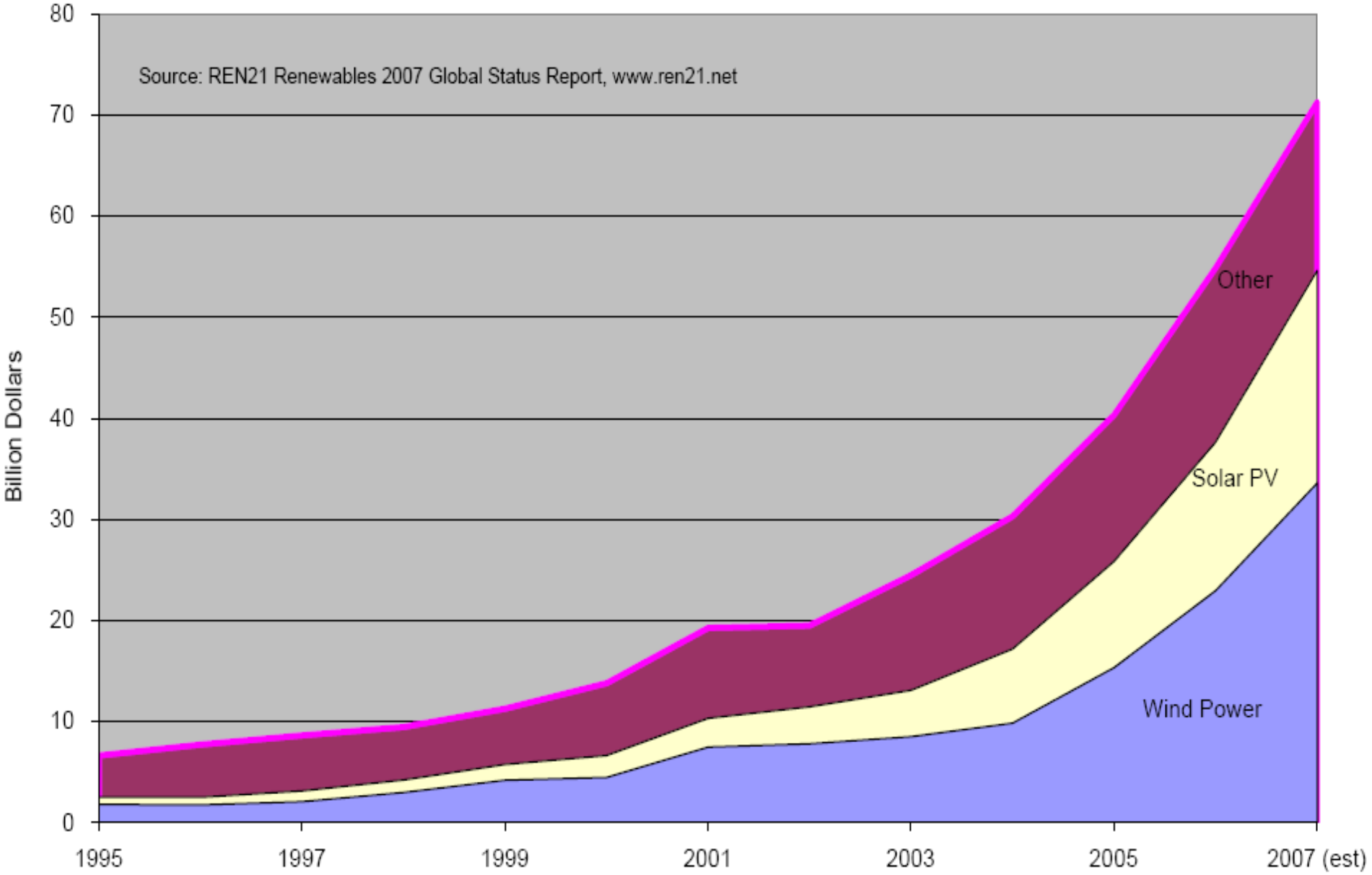
Energy from deserts



Now a sizeable industry!

- Investments 2007 about $70 billion
- Large hydro investments additonal $20-25 billion
- $500 million goes to developing countries (KfW, World Bank, GEF, etc…)
- 240 GW power capacity, ~6 % of global (+L hydro 740 GW)
- Policies in place in at least 66 countries, including 22 developing countries
- RE targets in at least 66 countries

Figure 11. Annual Investment in New Renewable Energy Capacity, 1995–2007



Note: Excludes large hydropower.

Figure 5. Wind Power Capacity, Top 10 Countries, 2006

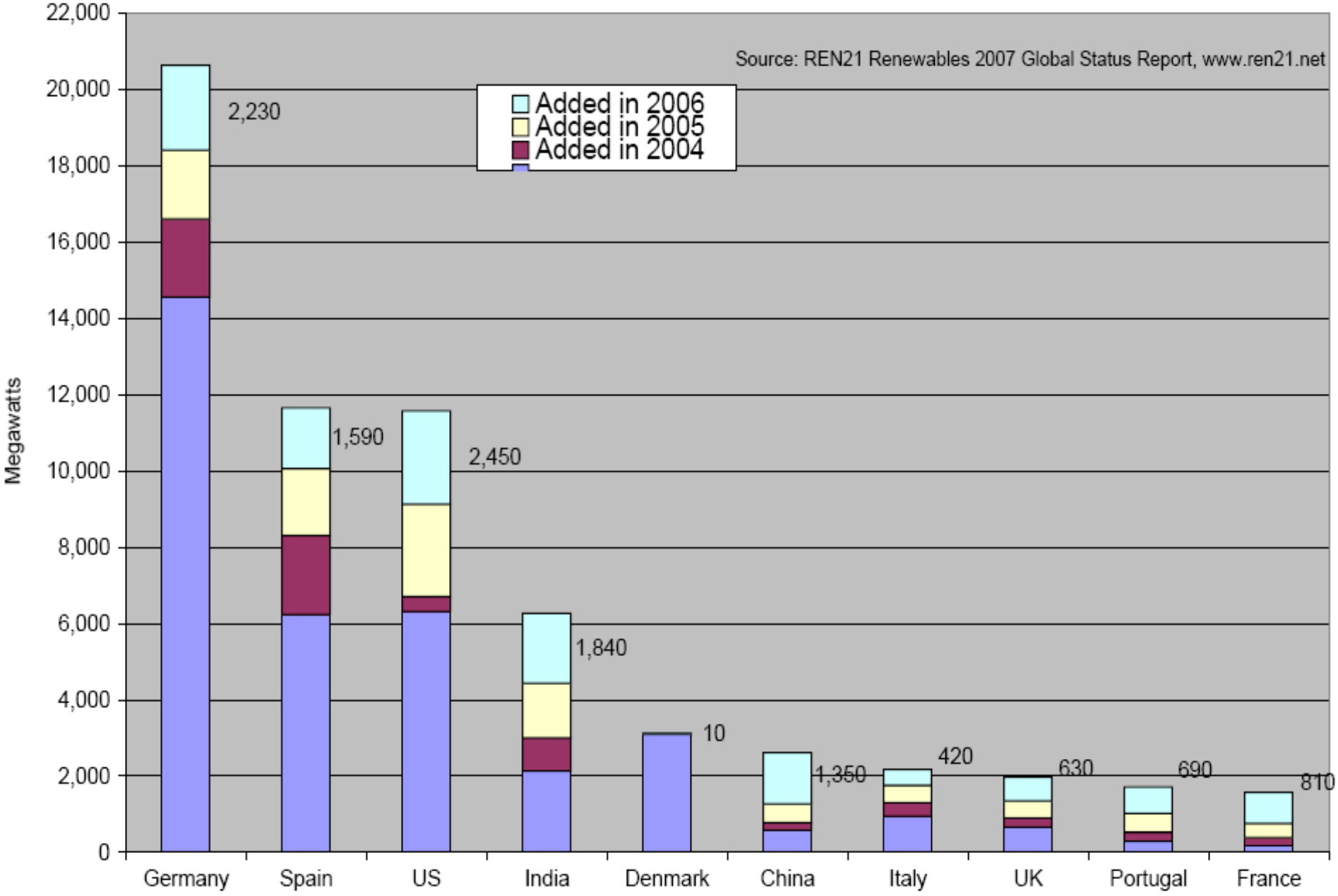
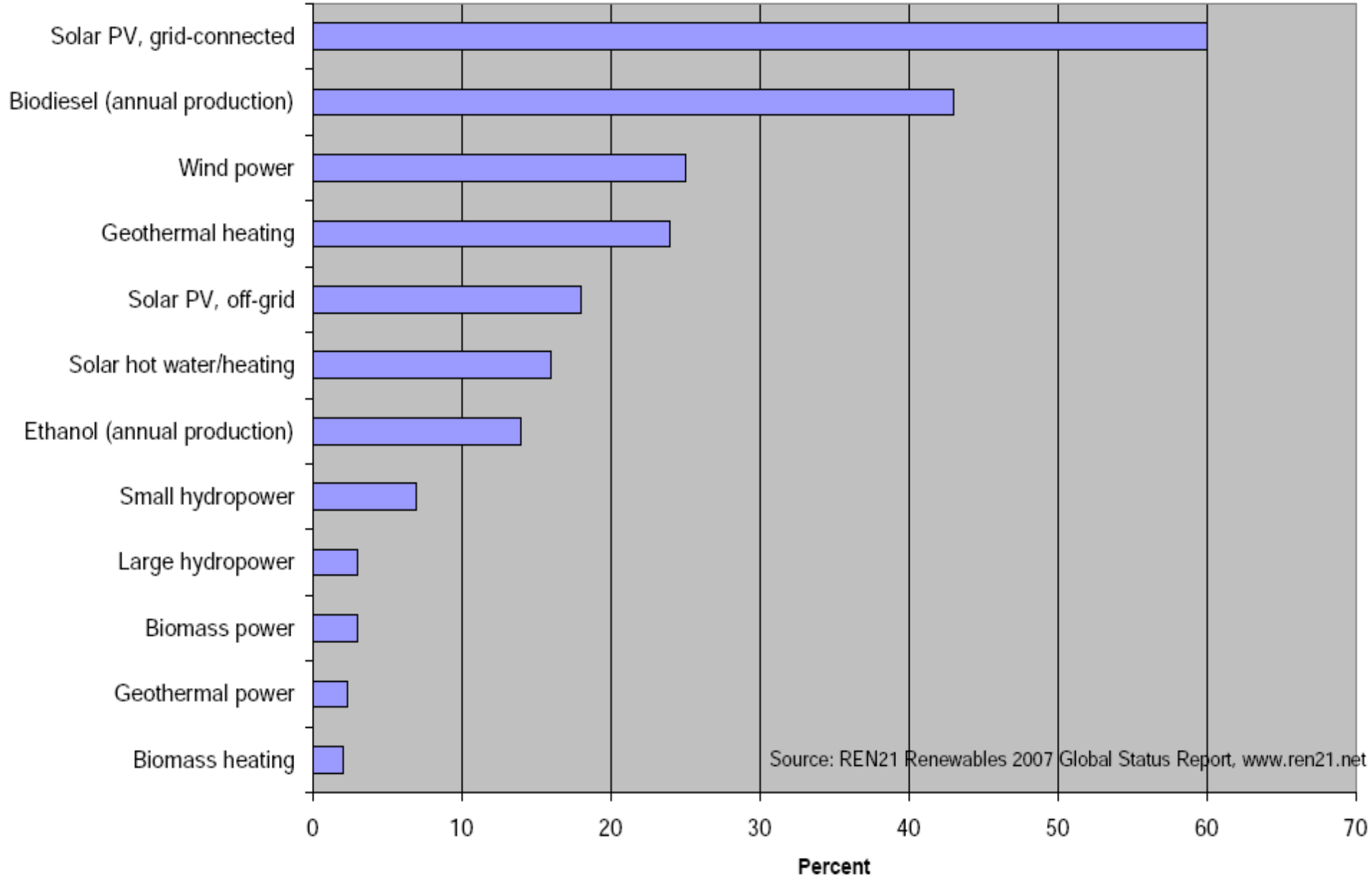


Figure 3. Average Annual Growth Rates of Renewable Energy Capacity, 2002–2006



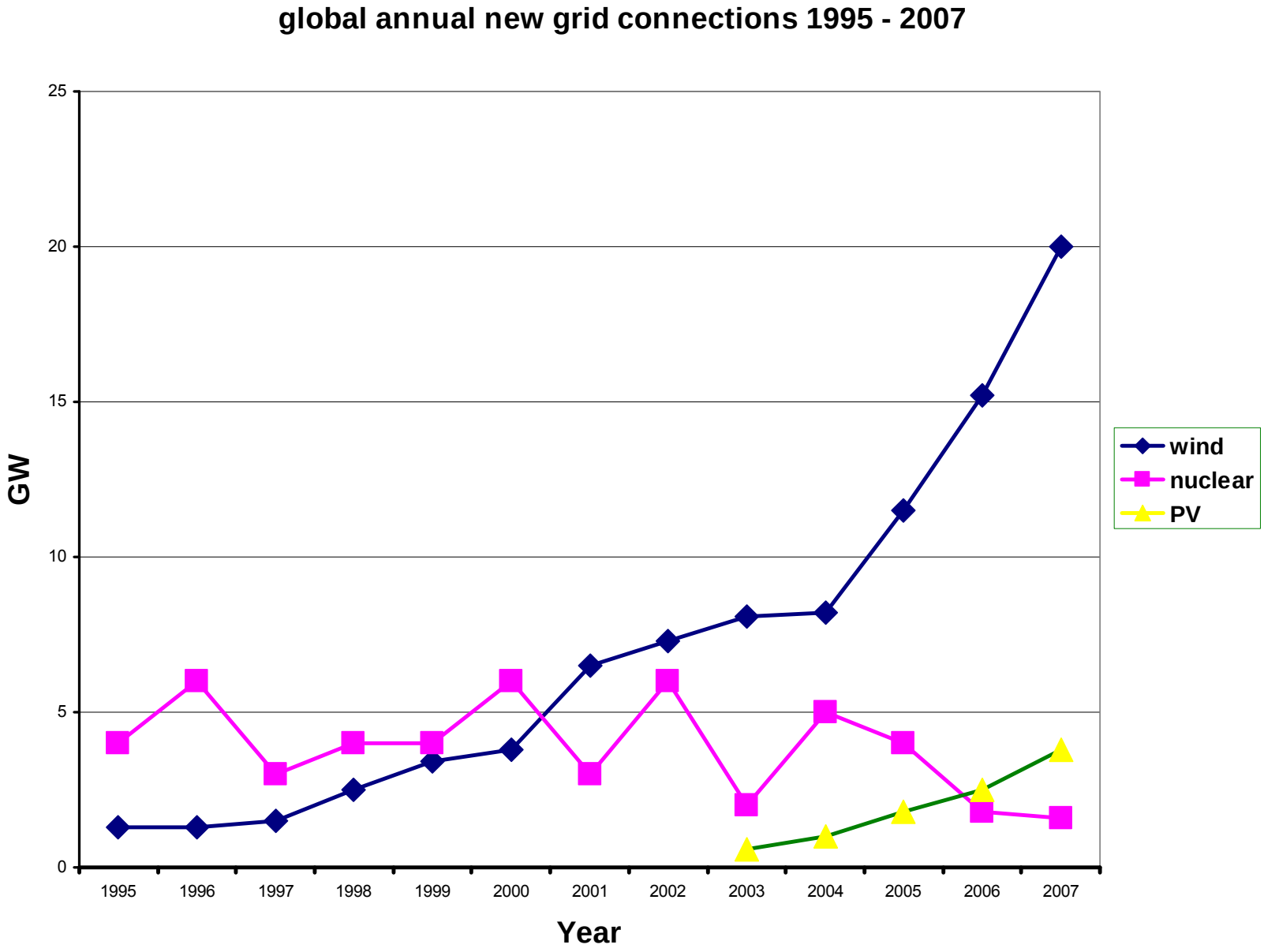

global annual new grid connections 1995 - 2007
GW
25
20
15
10
5
0
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
Year
wind
nuclear
PV

Figure 1. Renewable Energy Share of Global Final Energy Consumption, 2006

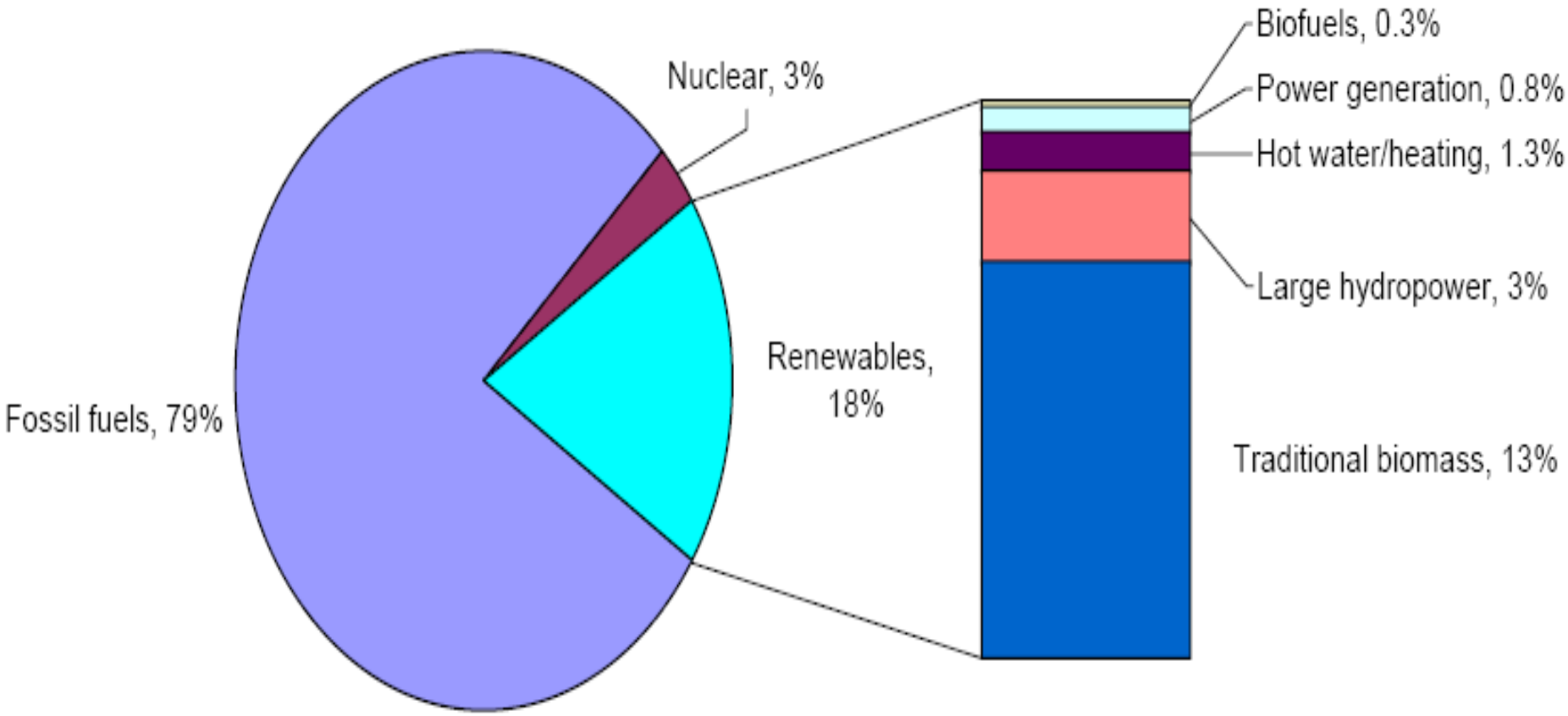
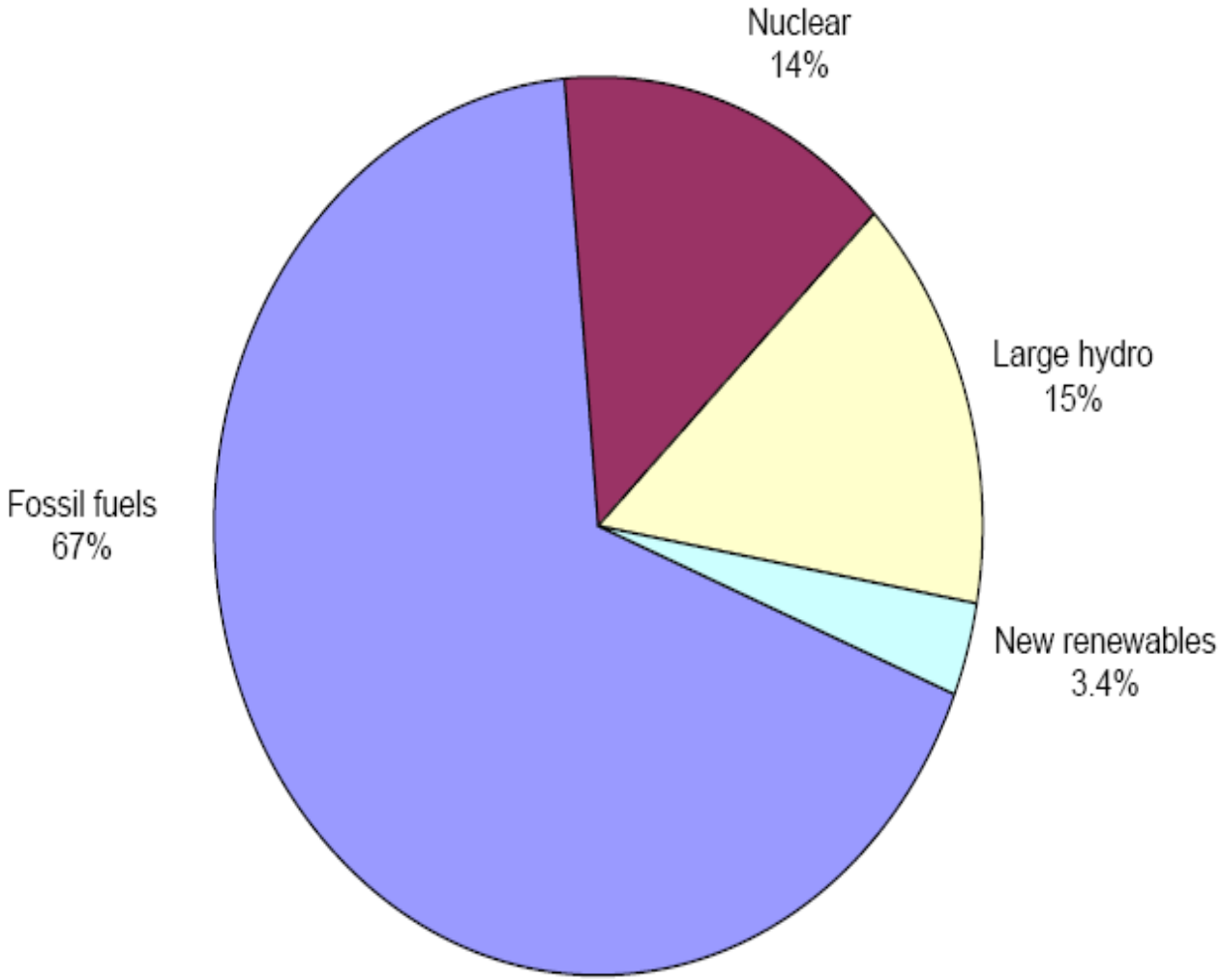


Figure 2. Share of Global Electricity from Renewable Energy, 2006



Source: REN21 Renewables 2007 Global Status Report, www.ren21.net

Costs and Benefits?

- Traditional ($) costs and benefits mostly seen for investor/owner
- Some renewables have costs < benefits
- However, there are additional benefits: improvements in security, peace, poverty, jobs, indoor and urban air pollution, climate change mitigation, etc….
- These also have value, esp. for society!
- These values need to be reflected in the marketplace for more renewables to be adopted!
- This is a major role of public policy

Policy Challenges

- Commensurate with magnitude of issues
- Integrated approaches required
- Prevention is better than cure: design systems and guide investments

- **Think of Energy as an Instrument!**

Policies for Sustainable Energy

An energy future compatible with sustainable development will not happen by itself, thus policy change is required, including:

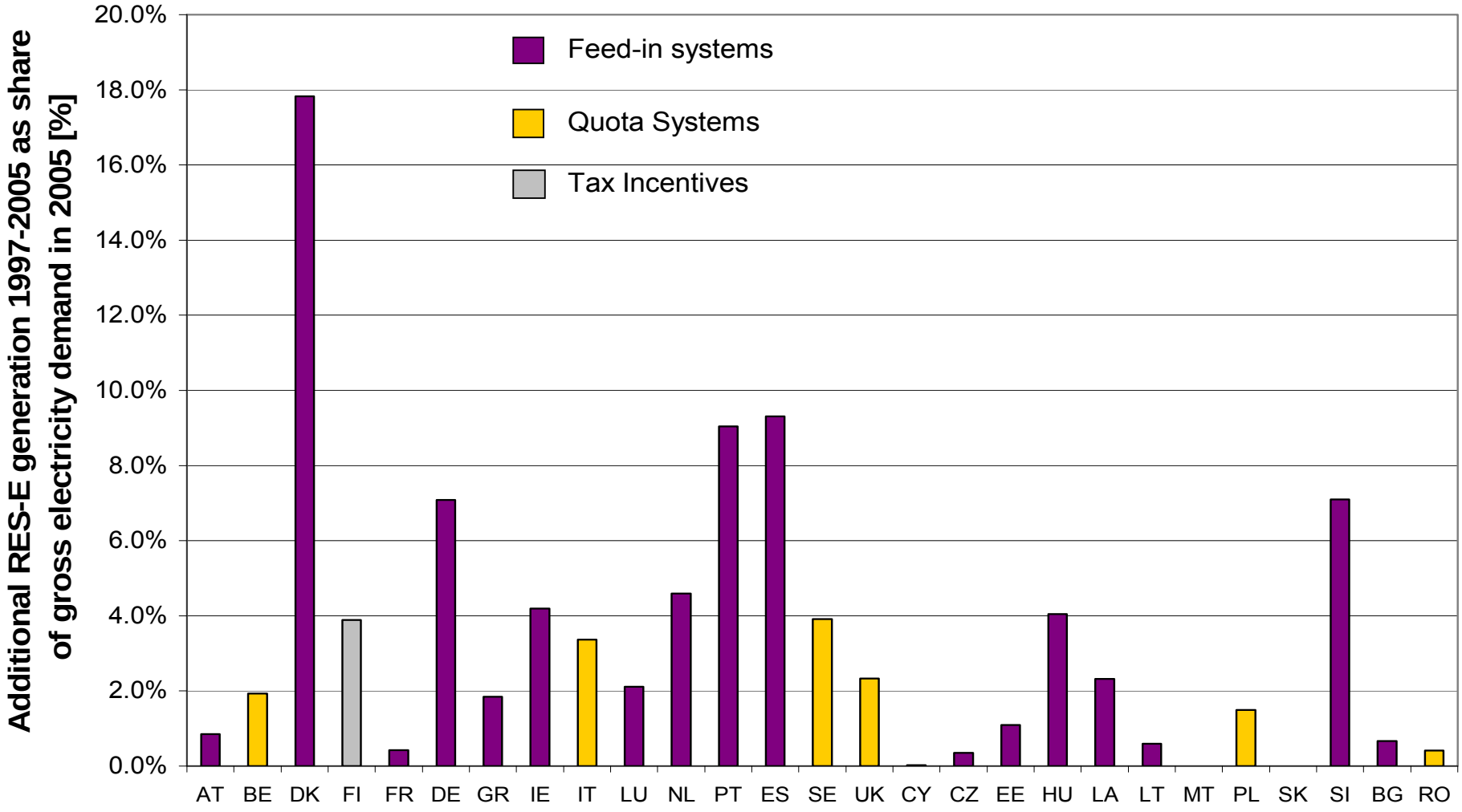
- Making markets work better, including mobilizing investments
- Focusing on the innovation chain
- Reforming the power sector
- Increasing capacity to support policy and institution building, and transfer of technology

certificate markets or feed-in tariffs?

- Certificates provide payment on the basis of supply and demand
- Payment (price) is therefore uncertain
- Projects hard to justify on basis of such payments
- Ambitious targets/caps hard to agree on

- Feed-in-tariffs lead to impressive activity, if generous!

Additional RES-E penetration 1997 - 2005



Source: Fraunhofer ISI

Energy R&D

- IEA countries allocate for energy R&D
  - ~ 8% for RE (2% on bioenergy),
  - ~ 12% for energy efficiency
  - > 50% for nuclear
- EU
  - Energy in 7th RTD totals €3 billion
  - Nuclear €4.8 billion from Euratom (€3.4 for fusion)

Vision!

- A local and global energy system advancing sustainability for all is conceivable
- However, this is a major challenge!
- Renewable resources are abundant!
- Technologies exist to tap into RE flows and to use the energy efficiently
- Societal benefits >>> costs
- Policies are needed, urgently and ambitiously!

Need for an Energy Assessment

- The world is at a critical juncture for energy policy – new challenges have emerged, while old challenges remain

- Previous studies do not identify the strategies and solutions needed to ***comprehensively address*** today's major energy and energy-related challenges in an ***integrated*** way

GEA Objectives include:

- Scientifically based, comprehensive, integrated, and **policy-relevant analysis** of issues and options, covering
  - Energy and sustainability challenges
  - Resource and technology options, demand and supply
  - System issues, scenarios
  - Policy options
- Local, Regional, and Global dimensions
- Provide basis for policy formulation


energy
and the challenge of sustainability