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international centre for theoretical physics

SMR.1524 - 12

**College on Evaluation of Energy Technologies
and Policies for Implementation of Agenda-21**

10 - 28 November 2003

Trends in Energy Technology Development

Global Energy Scenarios for Sustainable Developments

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These are preliminary lecture notes, intended only for distribution to participants

Global Energy Scenarios for Sustainable Development

Manfred Strubegger

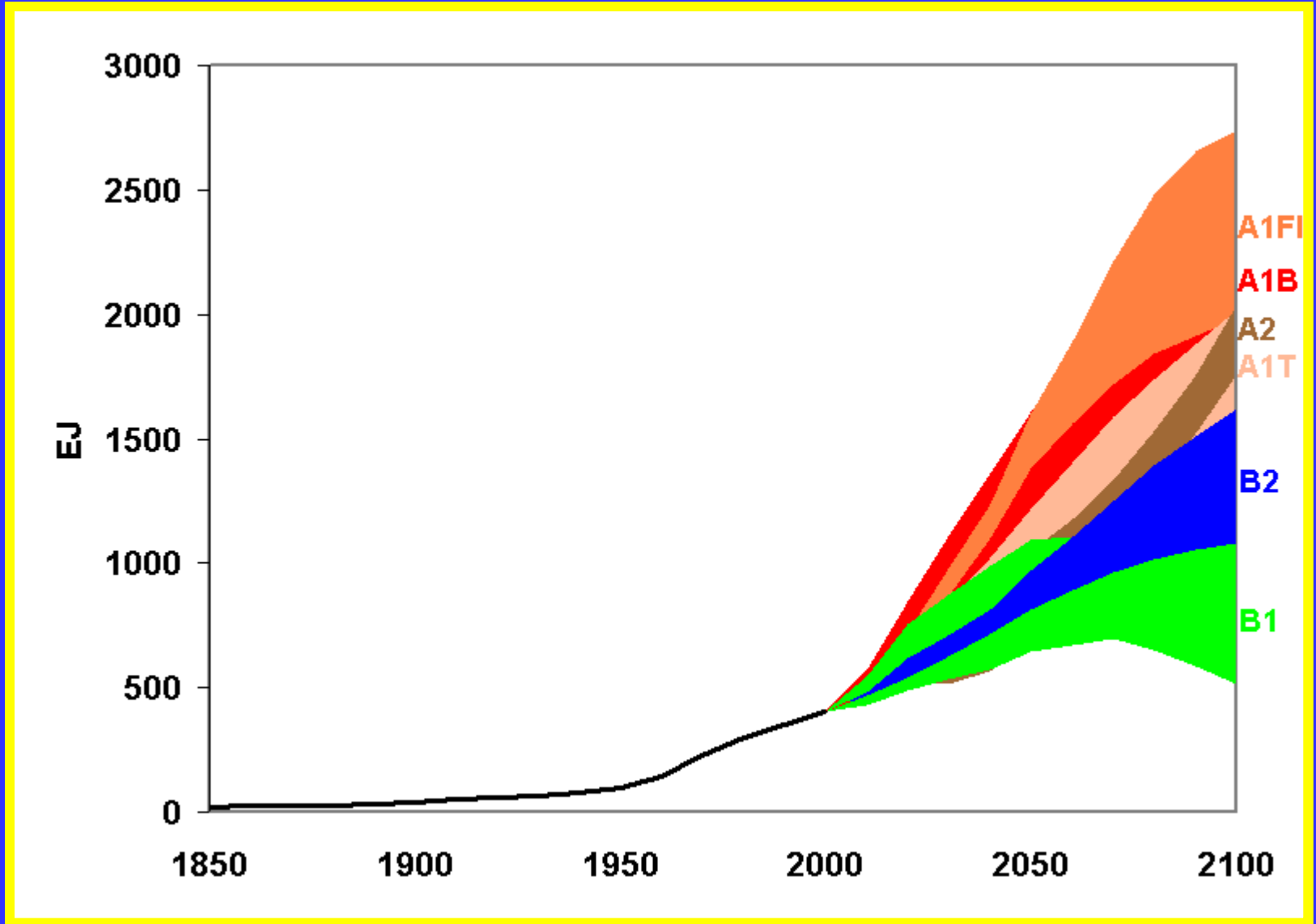
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(IIASA)

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Evaluation of Energy Technologies and Policies
for Implementation of Agenda 21

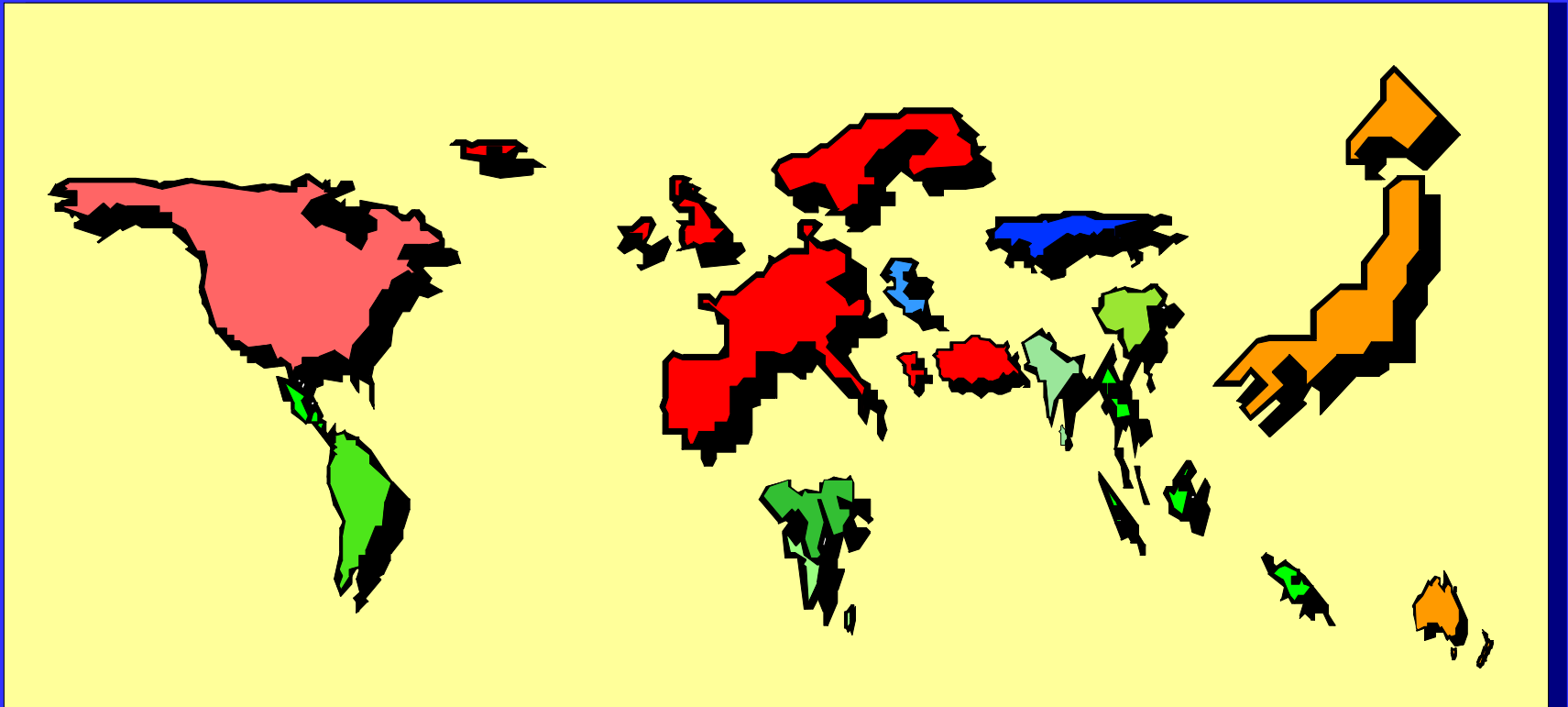
ICTP, Trieste, November 2003

Global Primary Energy Scenarios



World Economic Map

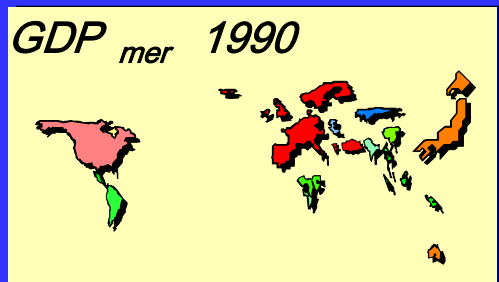
Areas of Regions Proportional to 1990 GDP
(mer)



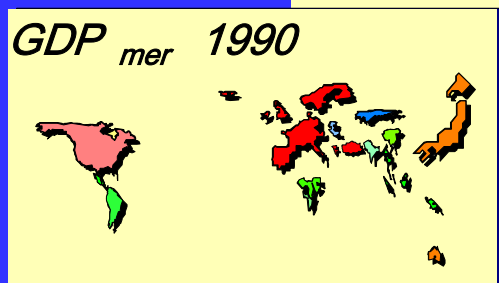
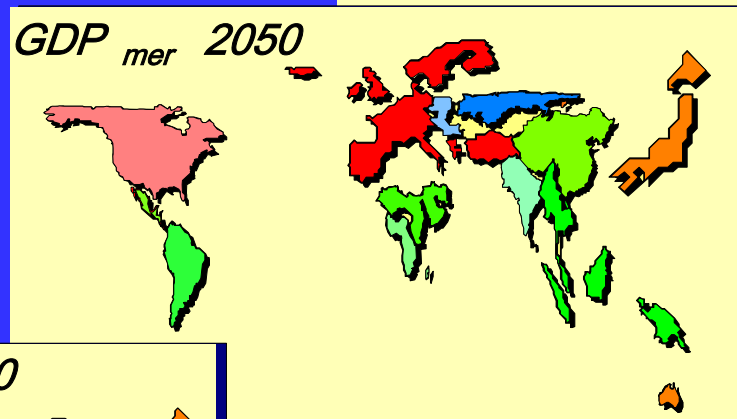
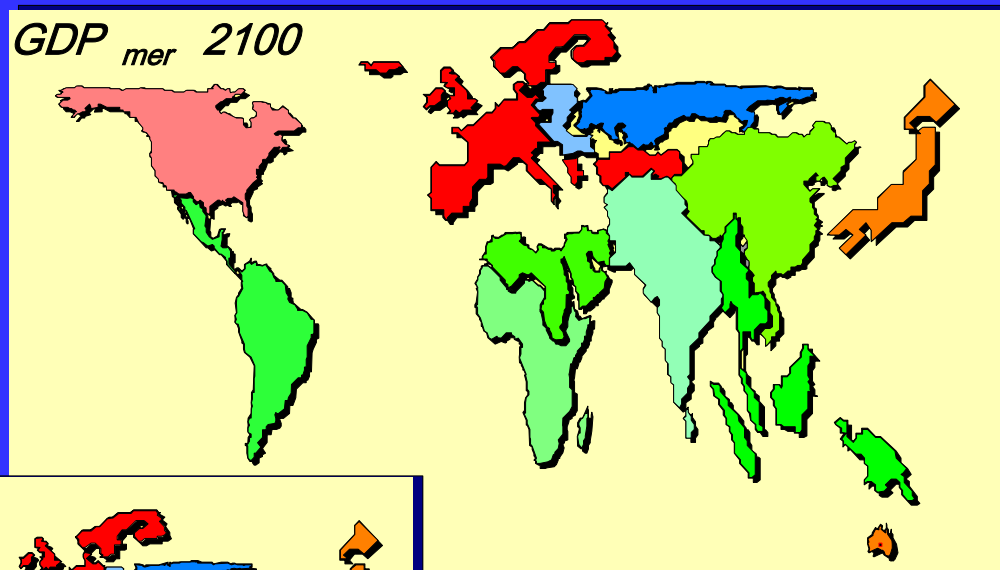
DCs = 16% of world GDP(mer); 35% of world GDP (ppp)

World Economic Map

Areas of Regions Proportional to 1990 GDP
(mer)

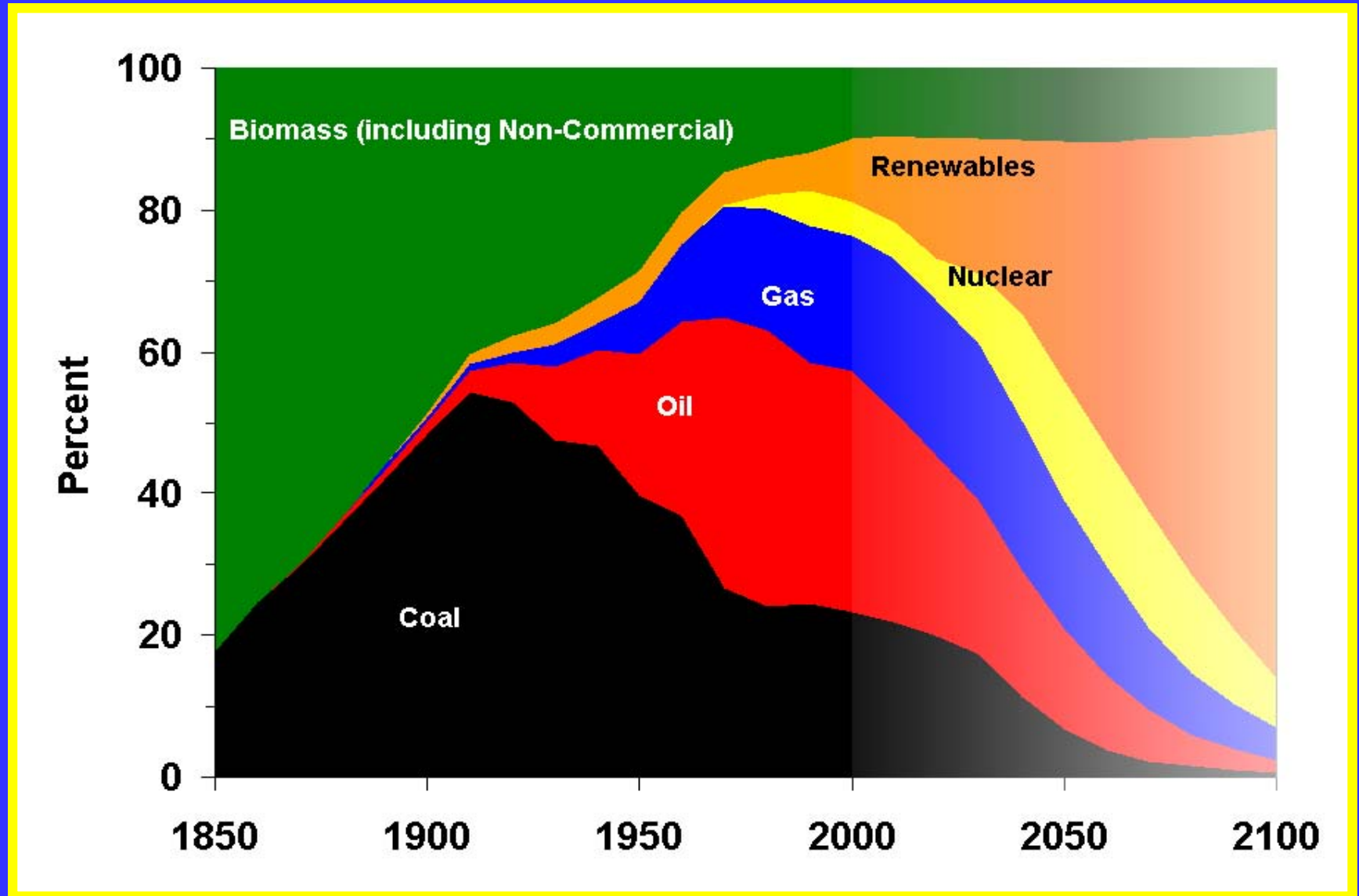


Area of Regions
Proportional
to 1990 GDP_{mer}



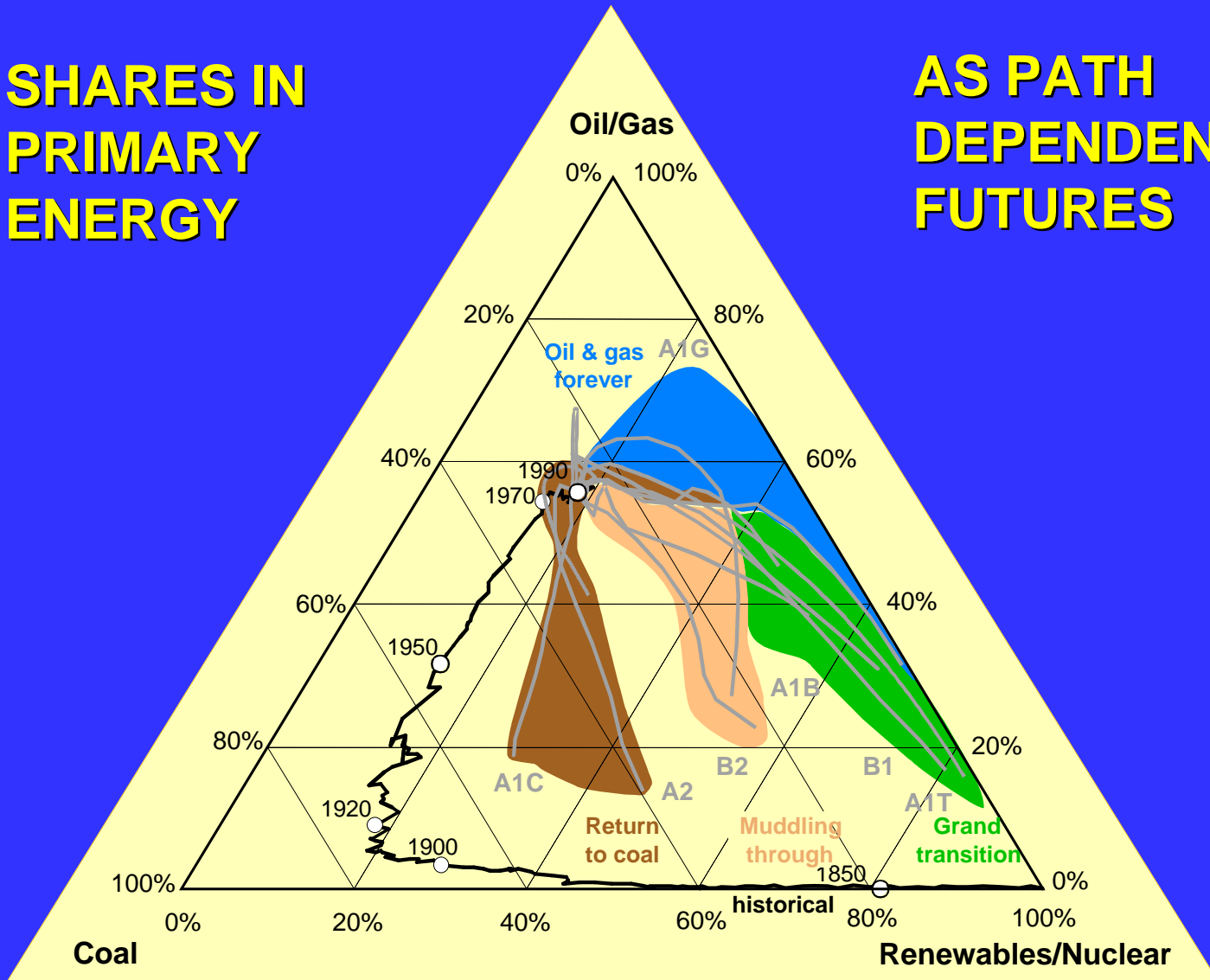
World Economic Map

Evolution of Global Primary Energy

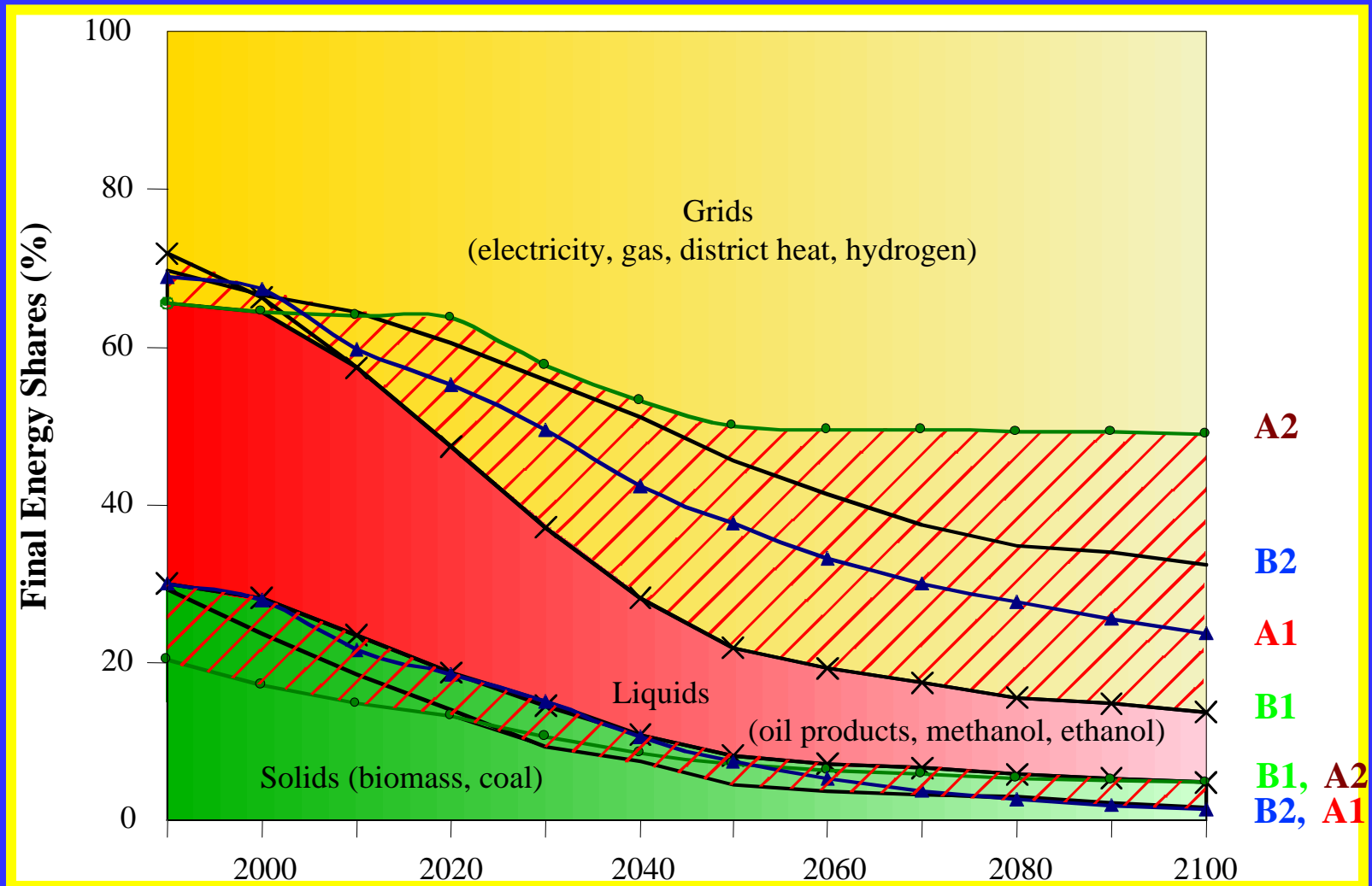


**SHARES IN
PRIMARY
ENERGY**

**AS PATH
DEPENDENT
FUTURES**



Global Final Energy by Form



Are we changing the world's climate?

1. Greenhouse effect
The greenhouse effect is a natural process that warms the Earth's surface. When the Sun's rays hit the Earth, they heat the land and water. The heat is then absorbed by the air and the ground. This causes the air and ground to warm up. The warm air and ground then radiate heat back towards the Earth's surface, trapping the heat and making the Earth warmer.

2. Global warming
Global warming is the long-term heating of Earth's climate system over several decades or longer. It is caused by the increasing concentrations of greenhouse gases in the atmosphere, which trap more heat from the Sun. This leads to a rise in the average temperature of the Earth's surface and oceans.

3. Causes of global warming
The primary cause of global warming is the increase in greenhouse gases in the atmosphere. These gases are released by human activities, such as burning fossil fuels (coal, oil, and natural gas) for energy, and deforestation. Other natural causes include volcanic eruptions and changes in the Earth's orbit around the Sun.

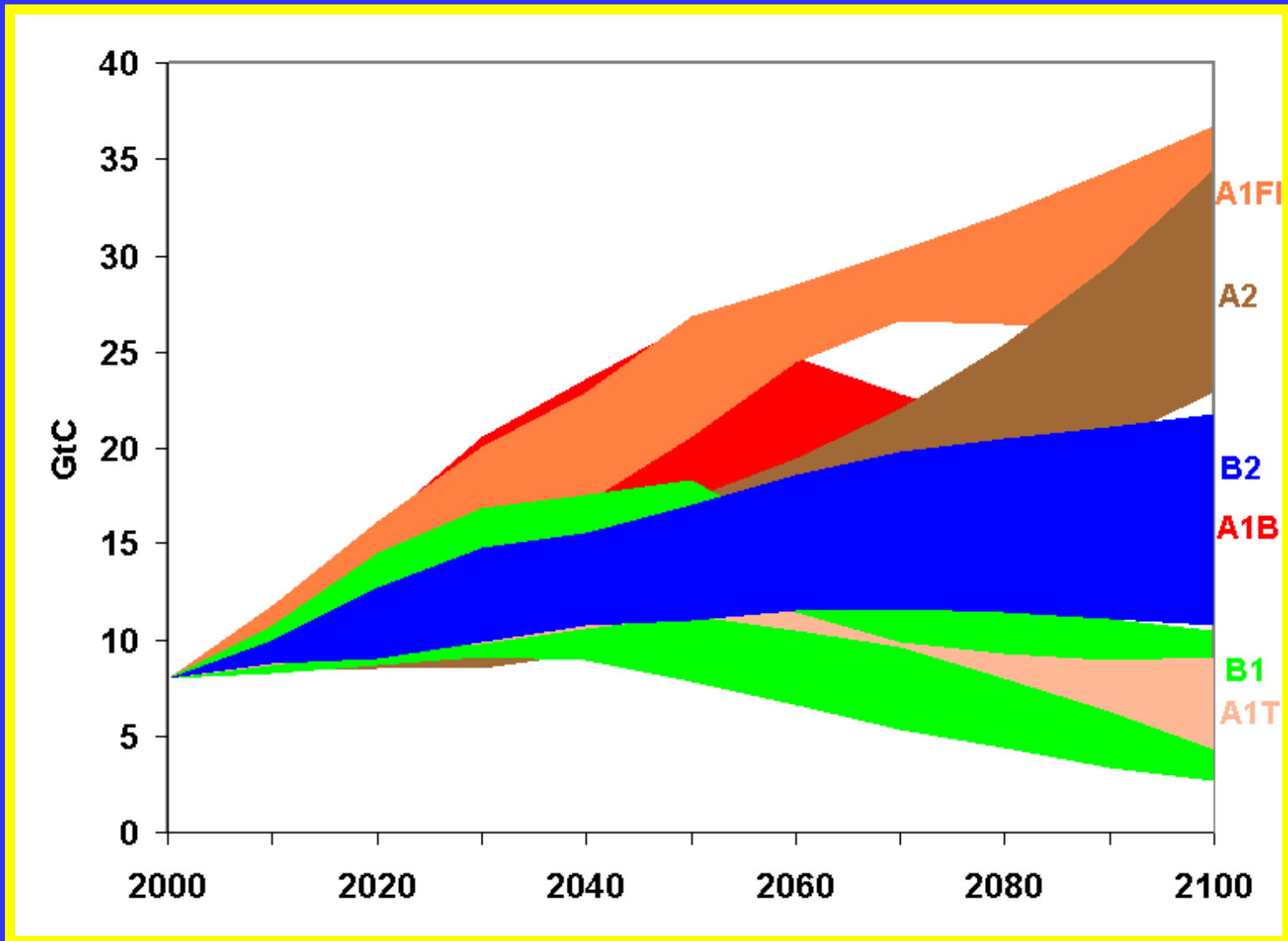
4. Effects of global warming
Global warming has a wide range of effects on the Earth's climate and environment. These include rising sea levels, more frequent and severe weather events (such as hurricanes, droughts, and heatwaves), and the melting of glaciers and ice sheets. It also leads to the loss of biodiversity and the disruption of ecosystems.

5. How to reduce global warming
There are several ways to reduce global warming. These include using renewable energy sources (such as solar, wind, and hydro), conserving energy, and reducing our carbon footprint. Other actions include planting trees, recycling, and supporting policies that aim to reduce greenhouse gas emissions.

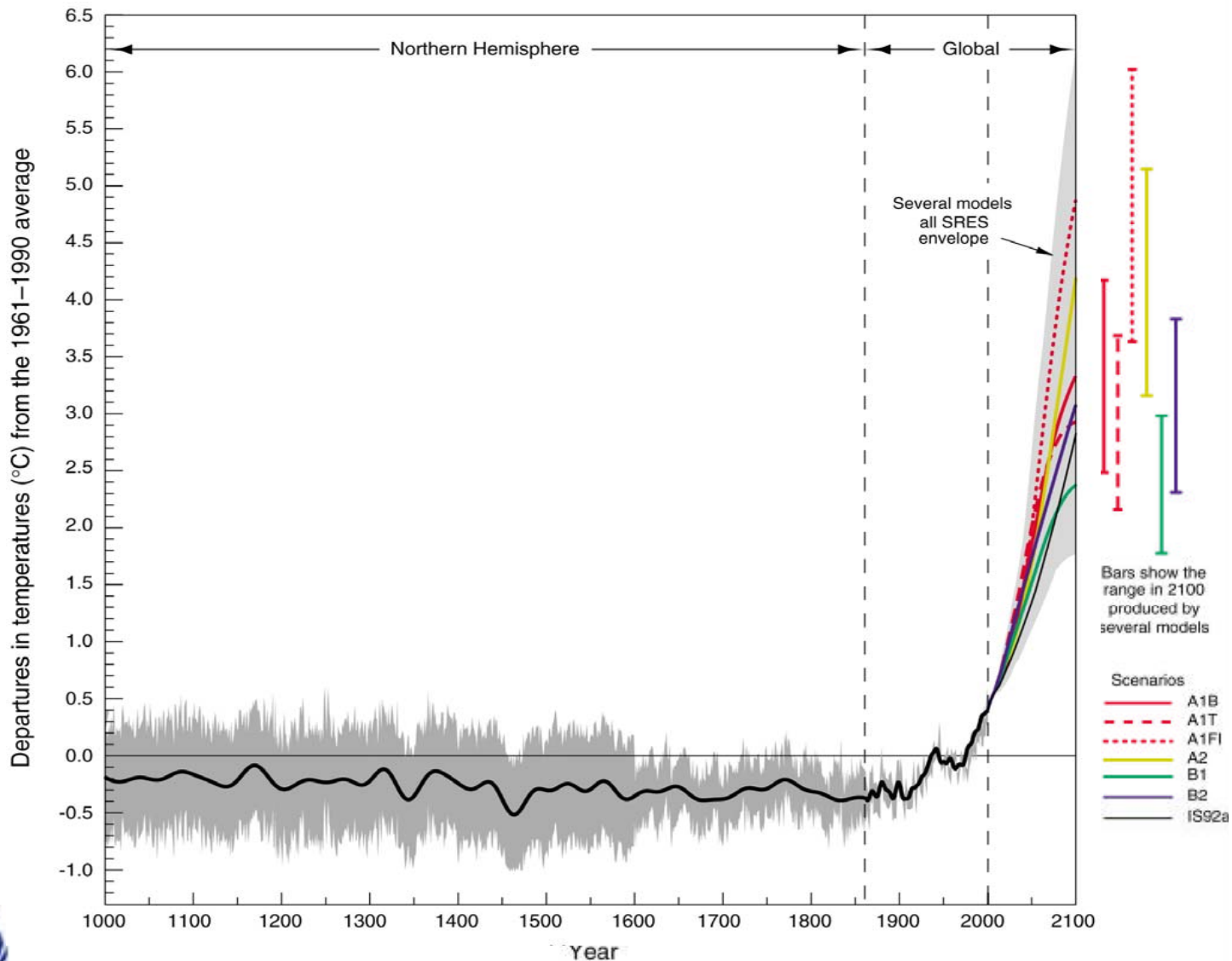
6. The greenhouse effect
The greenhouse effect is a natural process that warms the Earth's surface. It occurs when the Sun's rays hit the Earth and are absorbed by the land and water. The heat is then radiated back towards the Earth's surface by the air and ground, trapping the heat and making the Earth warmer.

A GIFT FROM THE ORGANIZATION OF AMERICAN STATES

Global Carbon Dioxide Emissions



Global Mean Temperature Change



WMO

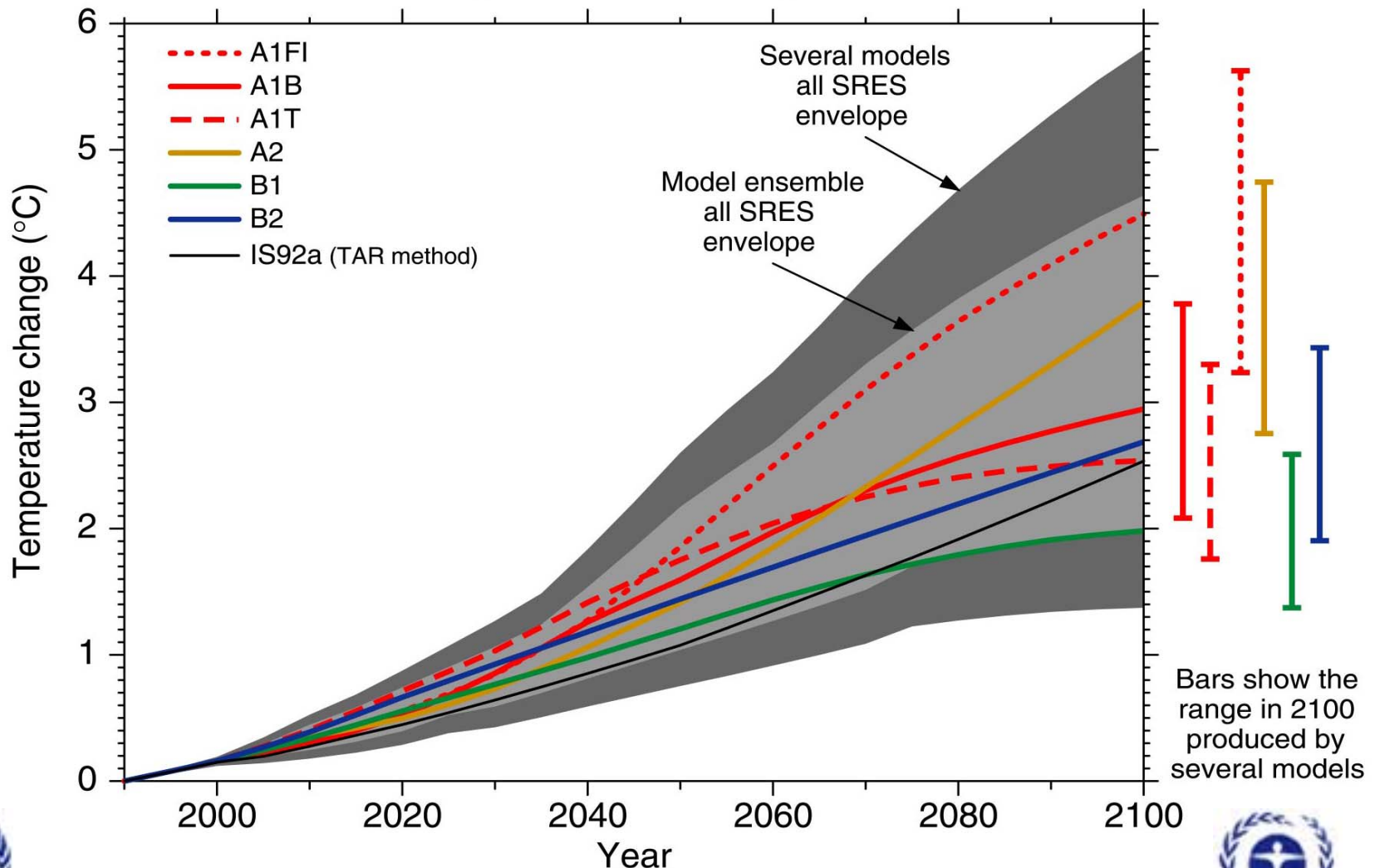
INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE (IPCC)



UNEP

Global Mean Temperature Change

Six illustrative SRES scenarios, full range



INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE (IPCC)

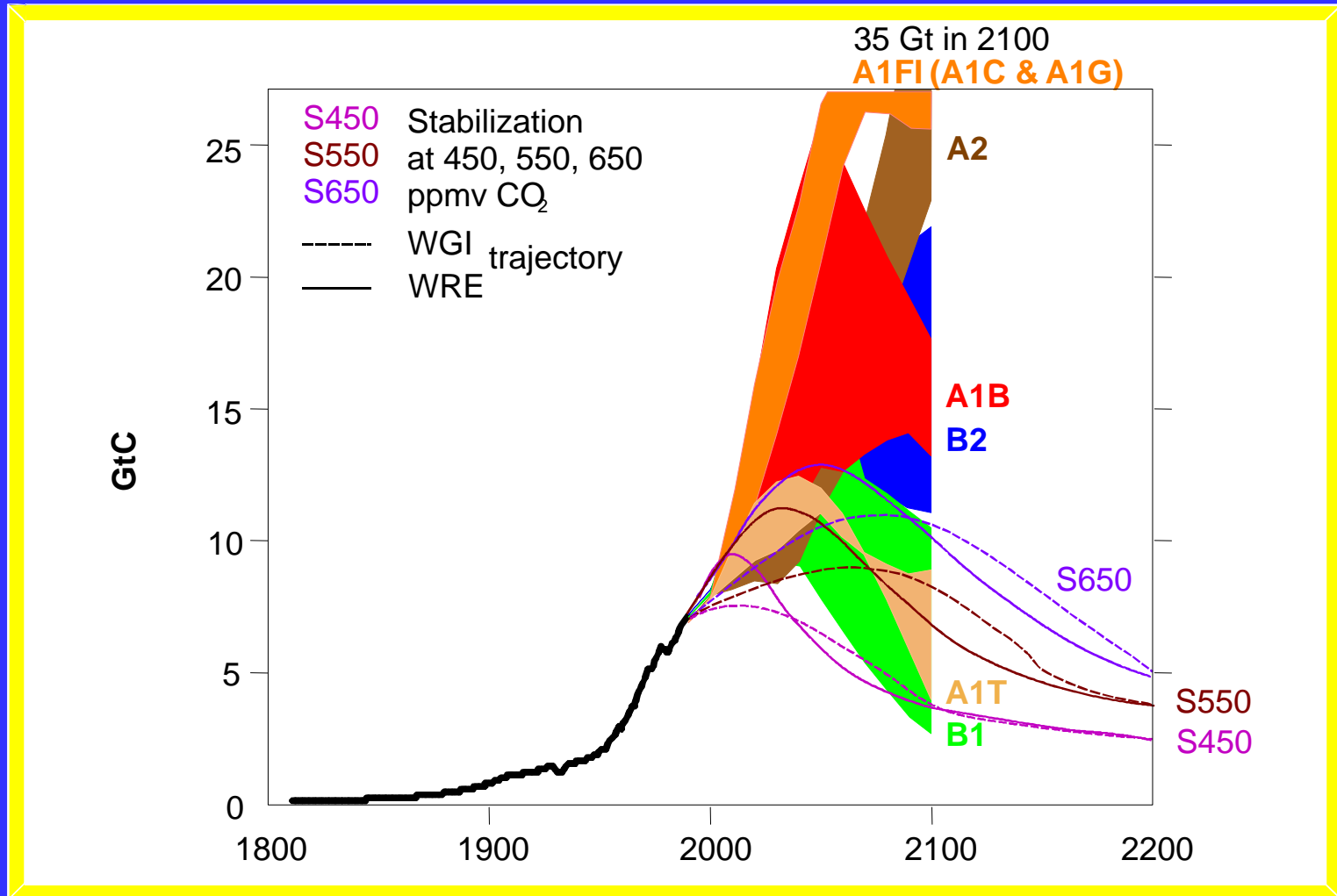


WMO

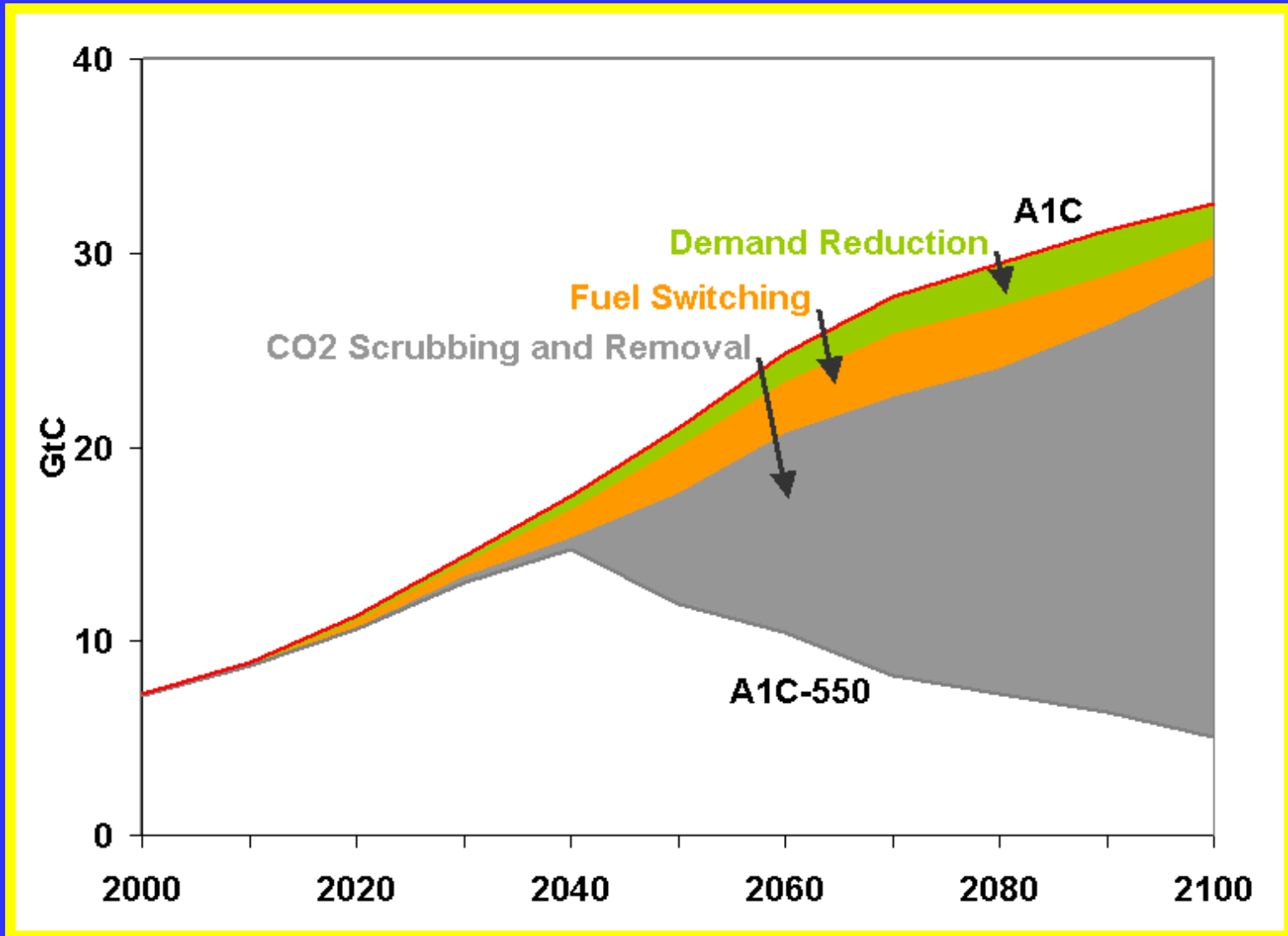


UNEP

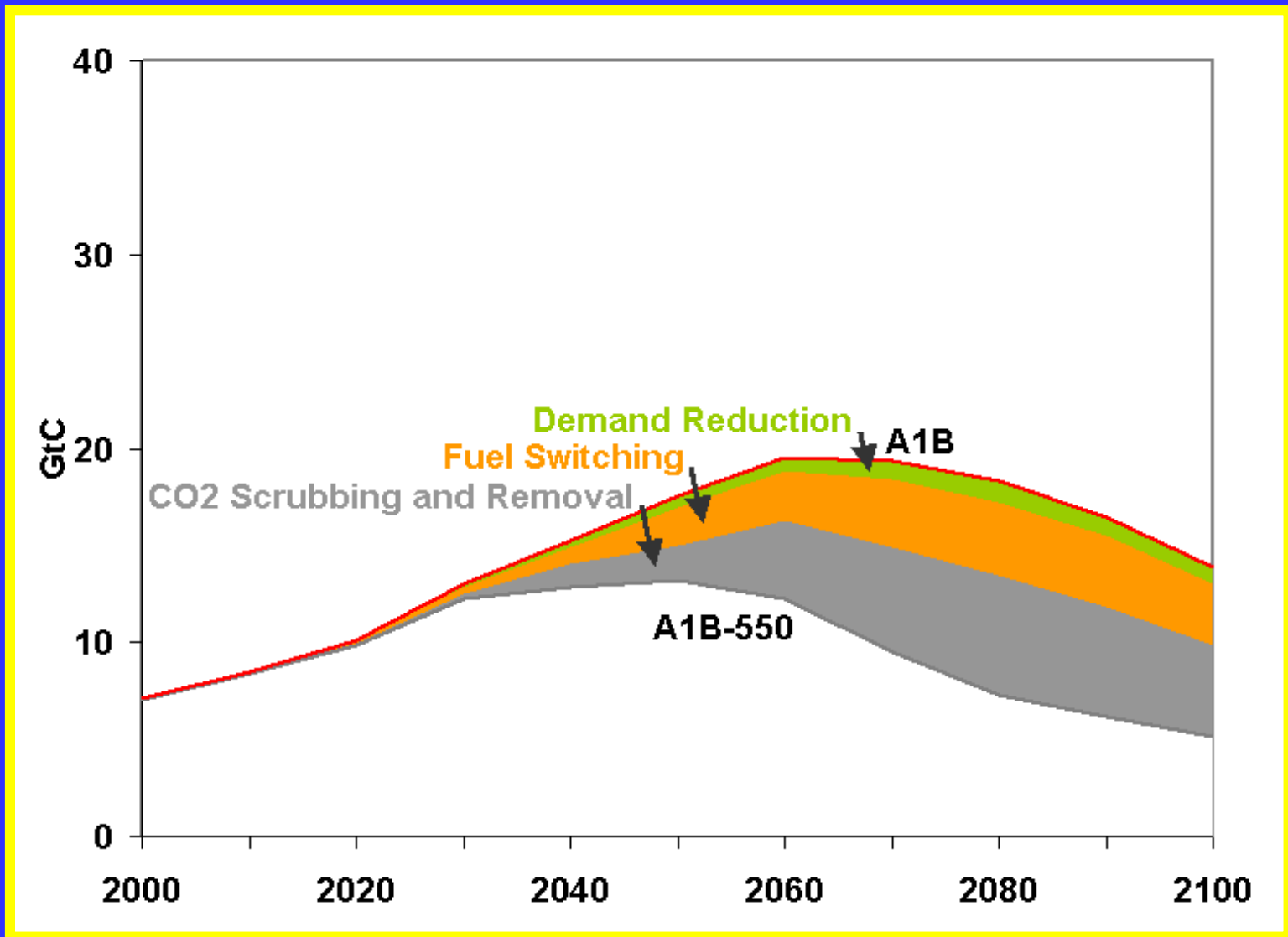
Carbon Emissions: Scenarios and Stabilization Profiles



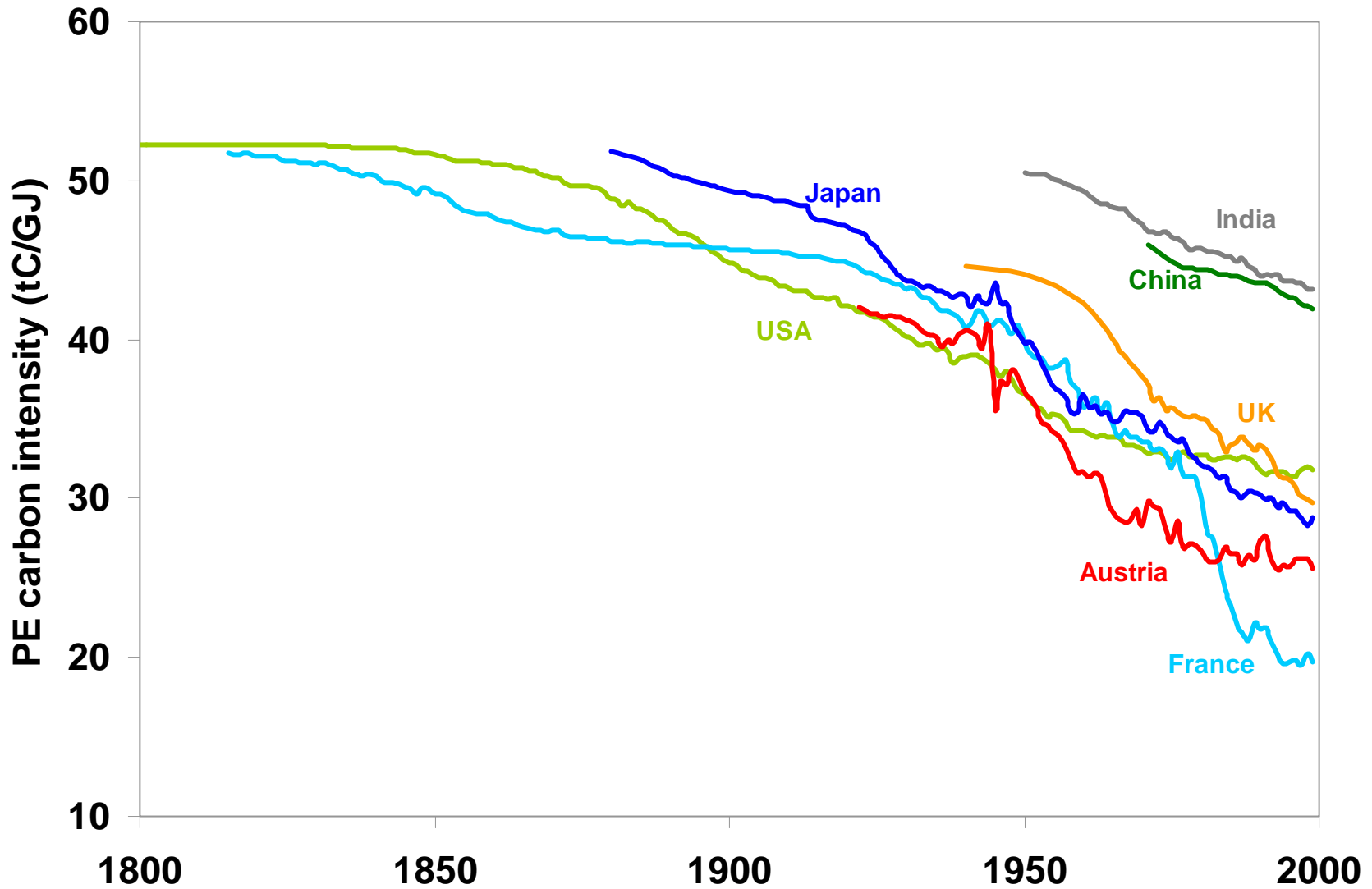
Global Carbon Dioxide Emissions



Global Carbon Dioxide Emissions



Carbon Intensity of Primary Energy





Technical Options for a more Sustainable Future

World Energy Assessment

<http://www.undp.org/seed/eap/activities/wea>

- **Improved Energy Efficiency** - especially at the point of end-use in buildings, electric appliances, vehicles, and production processes.
- **More Renewable Energy:** such as biomass, wind, solar, hydro, and geothermal
- **Advanced Energy Technologies:**
 - next generation fossil fuel and carbon sequestration technologies
 - nuclear technologies, if the issues can be resolved.



United Nations Development Programme

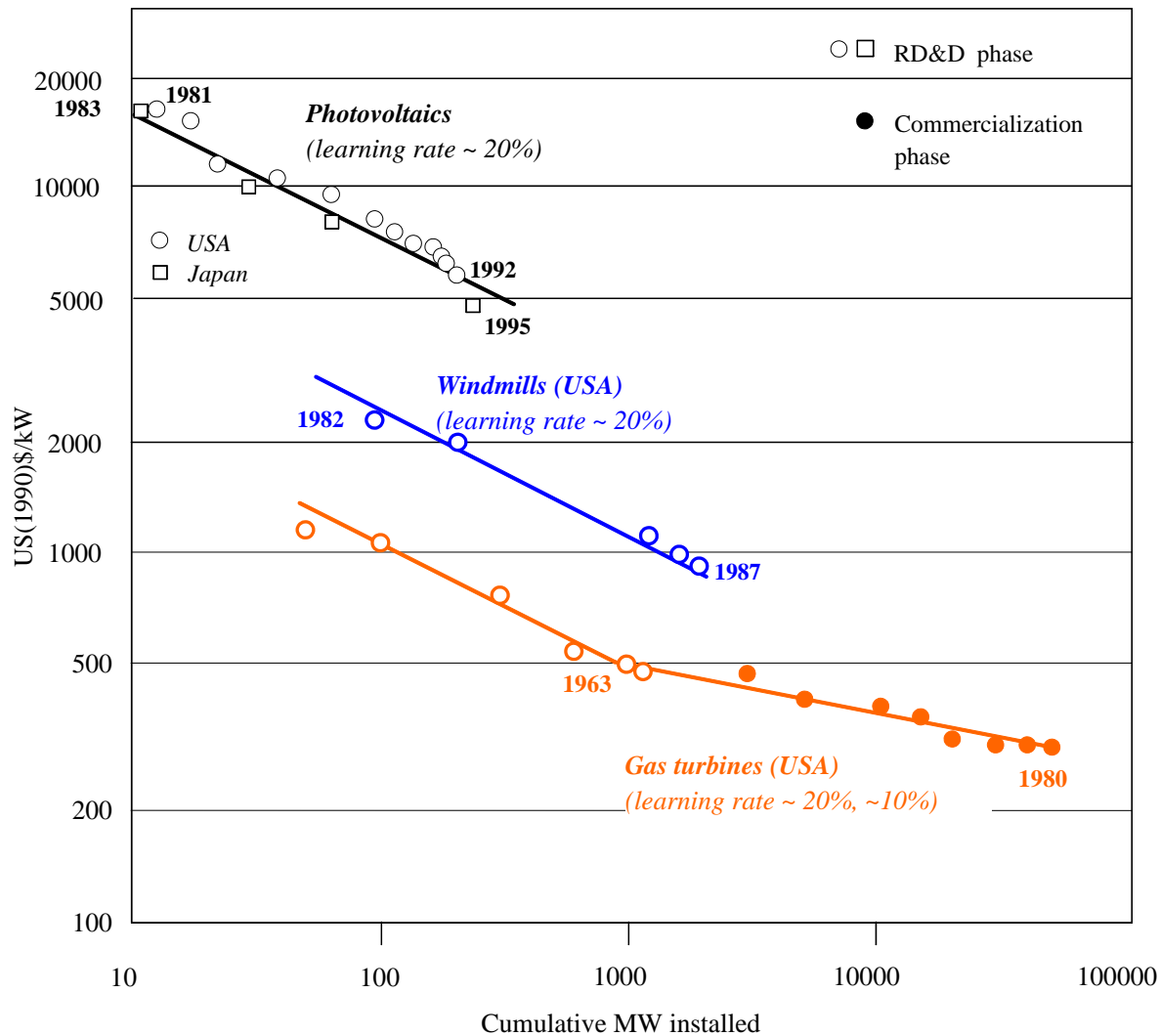


United Nations Department of Economic and Social Affairs

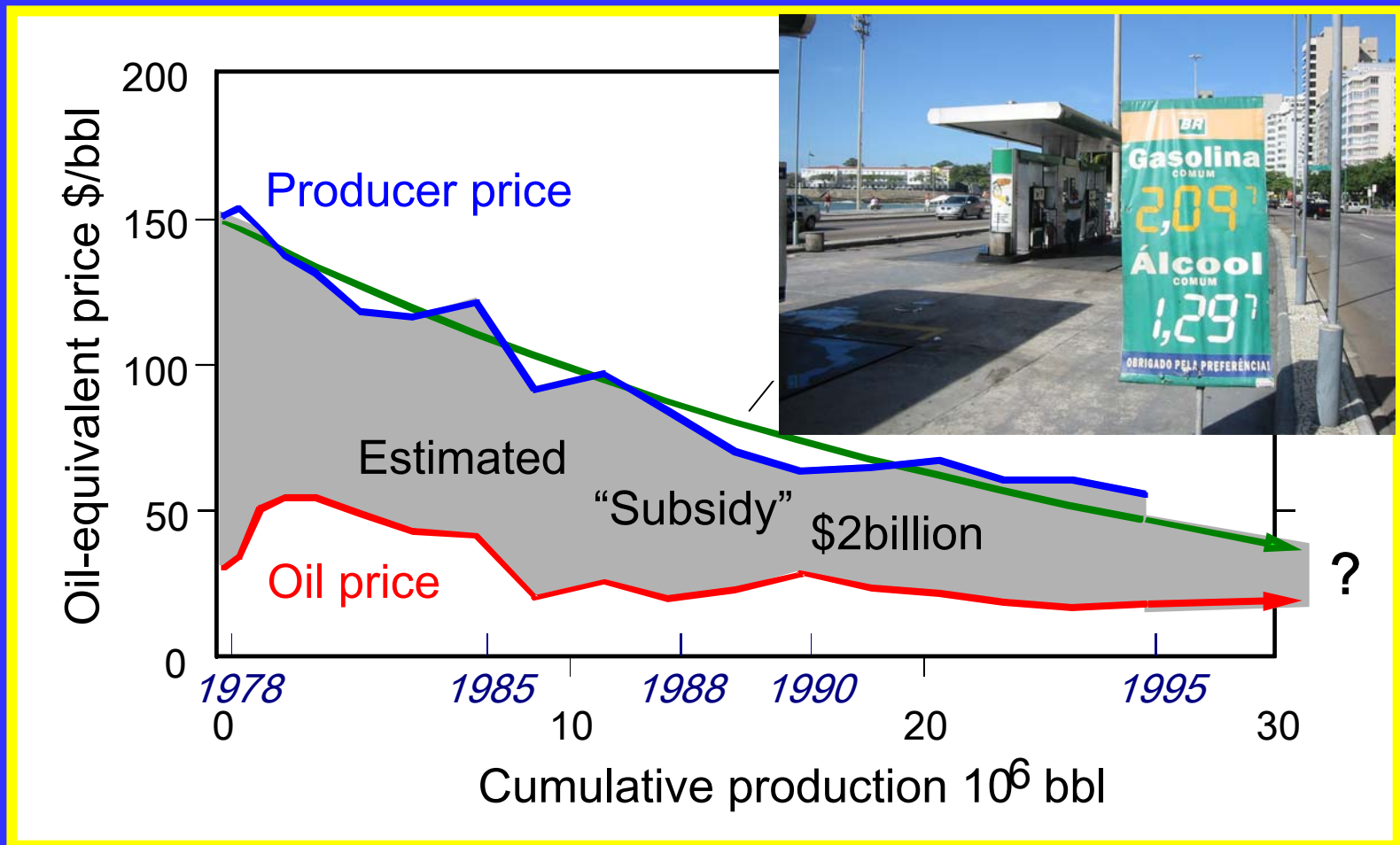


World Energy Council

Learning Curves

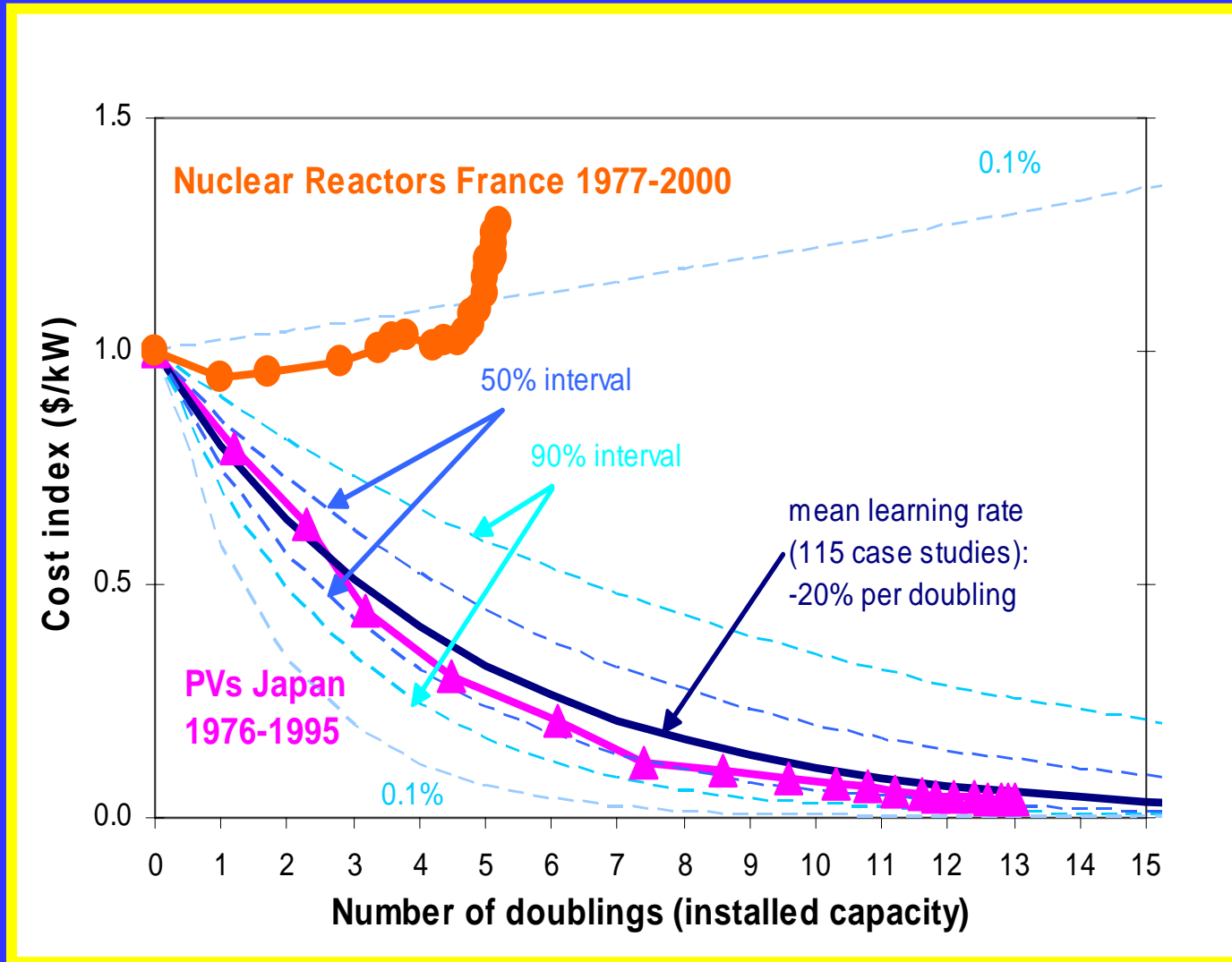


Brazil – Ethanol Learning Curve

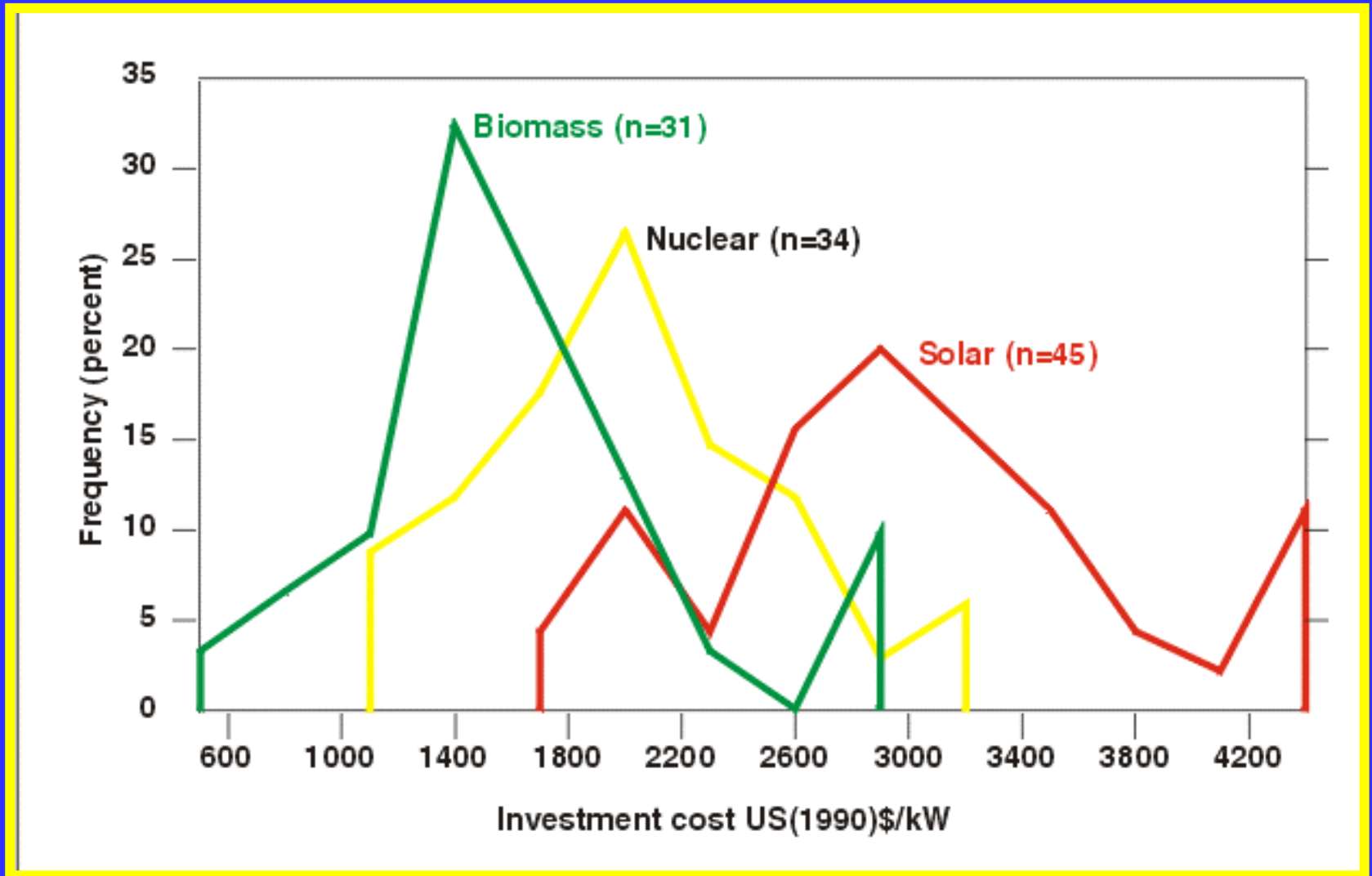


Technological Uncertainties

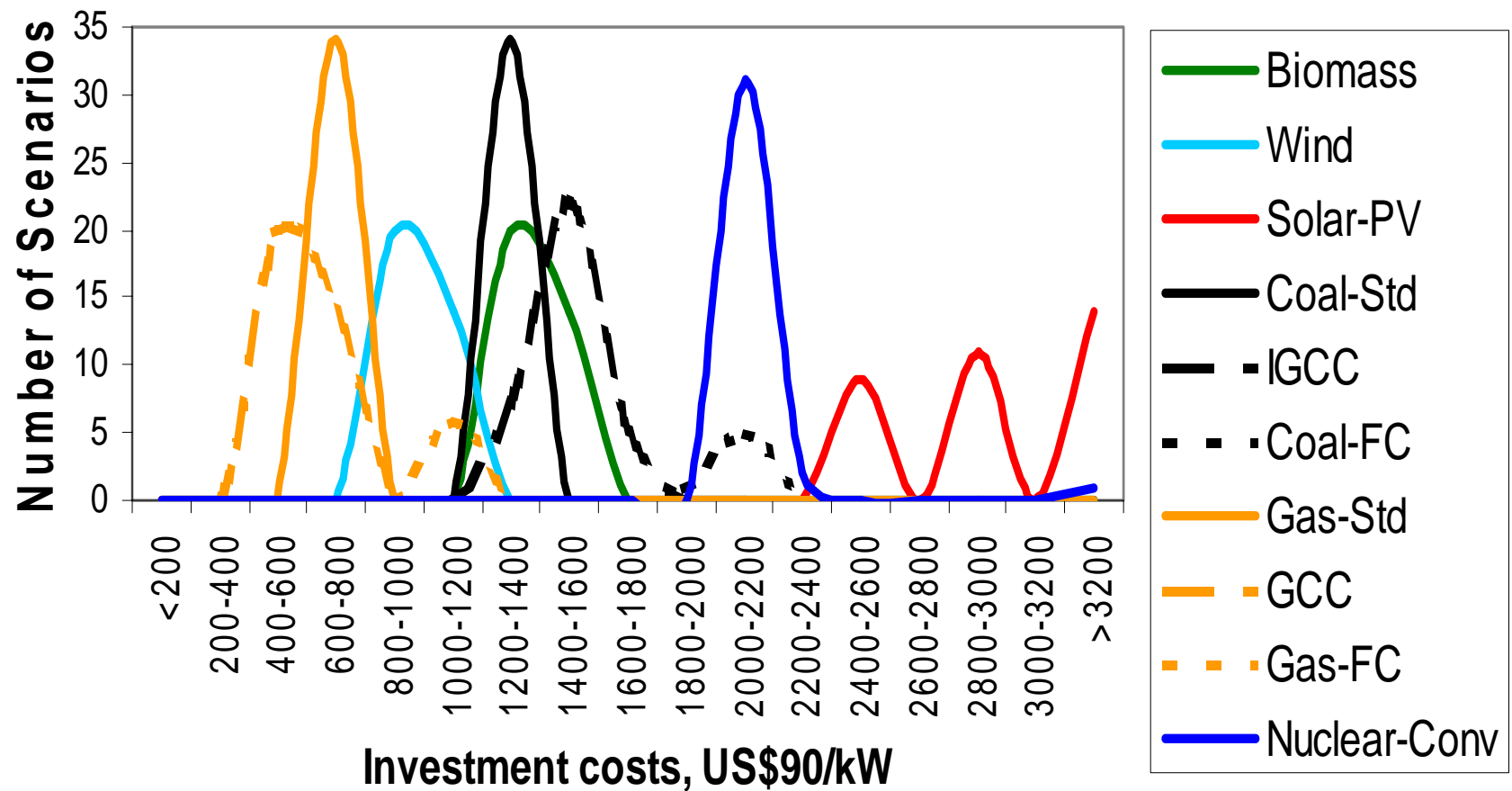
Learning rates (push) and market growth (pull)



Energy Investment Costs from Literature

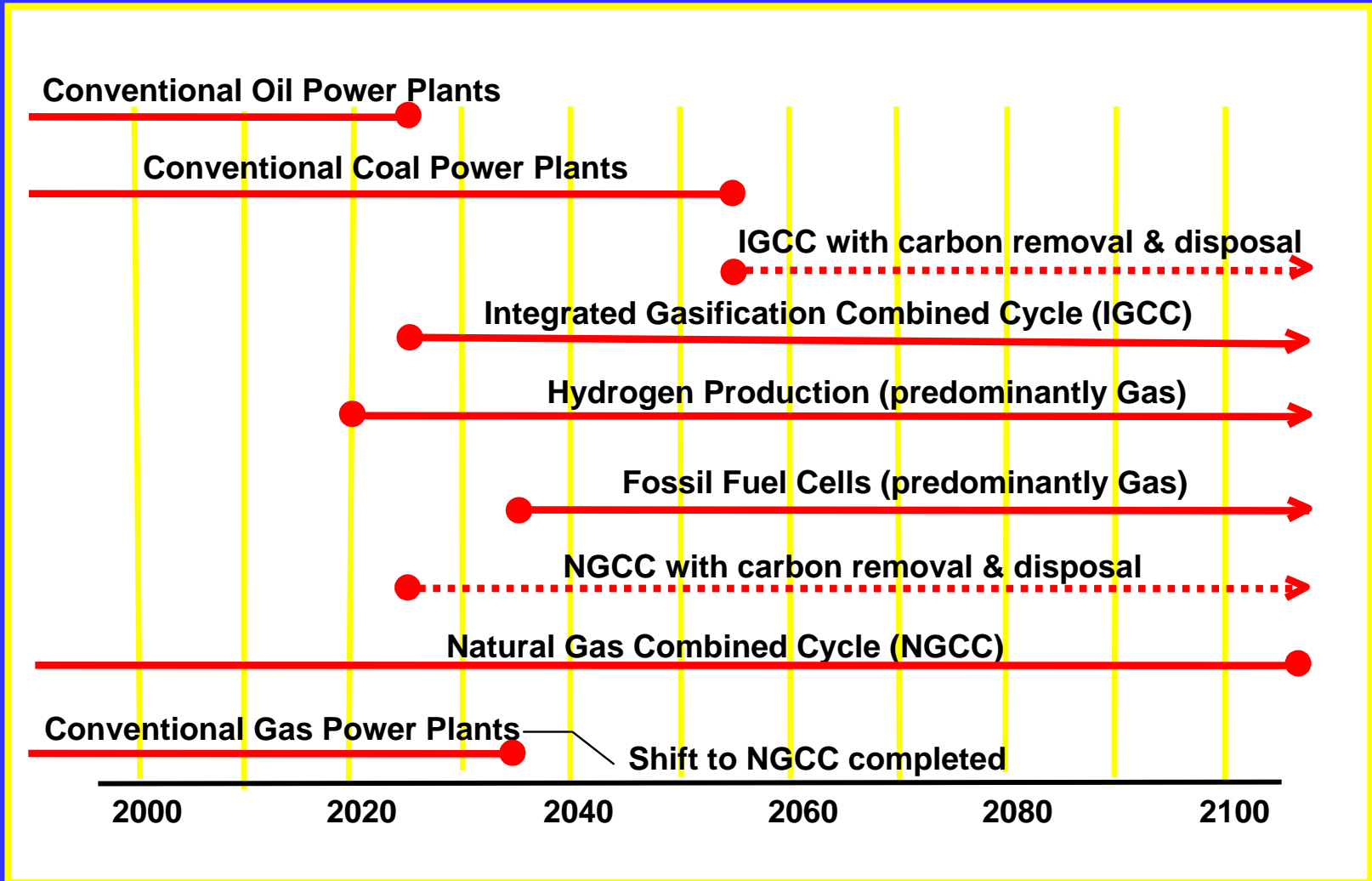


Distribution of Investment Costs in 2020

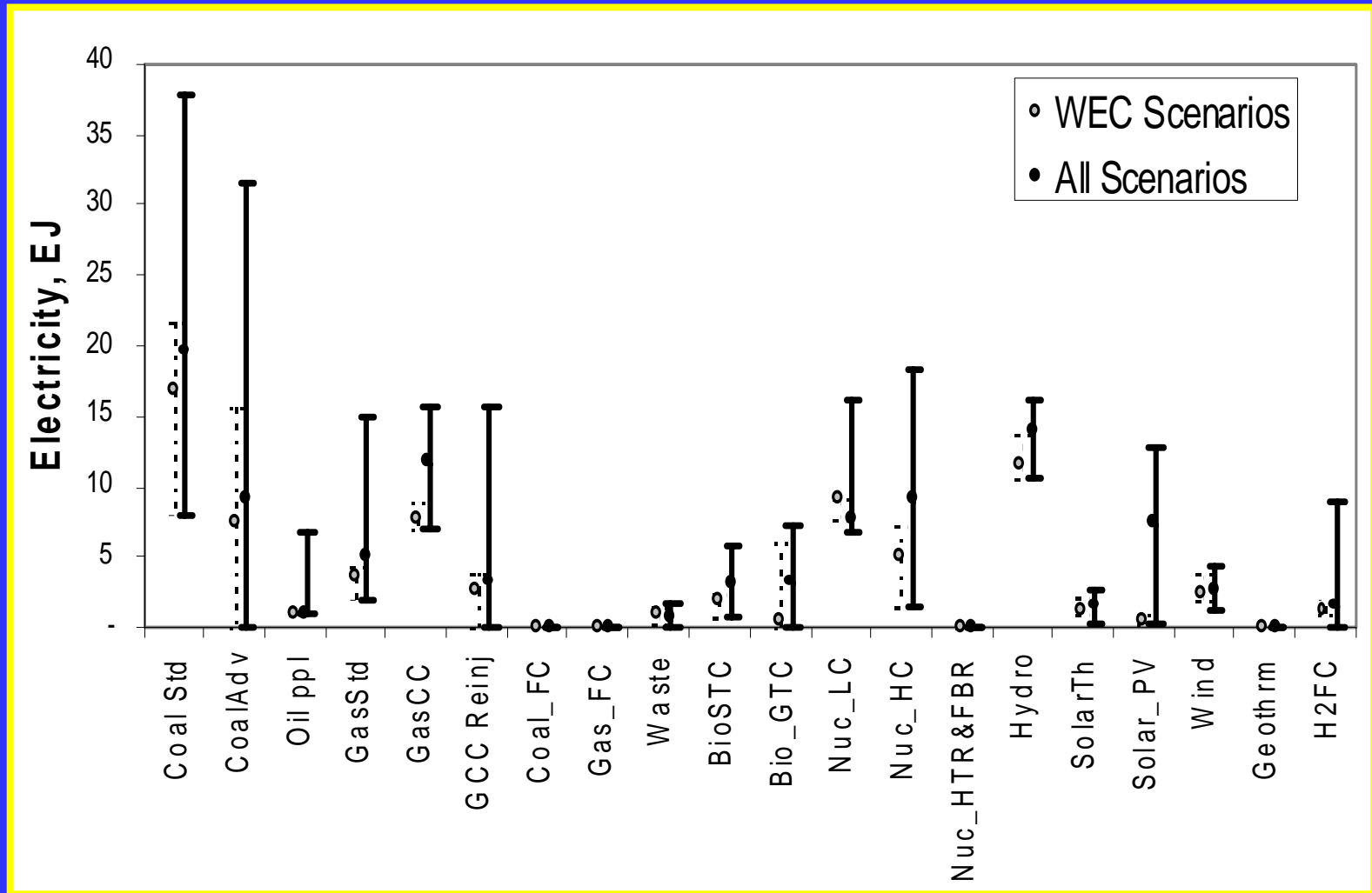


Diffusion of Fossil Technologies

IIASA IPCC SRES and Post-SRES Scenarios



Electricity Generation in 2020





- Research and development
- Demonstration projects
- Early deployment (cost buy down)
- Widespread diffusion



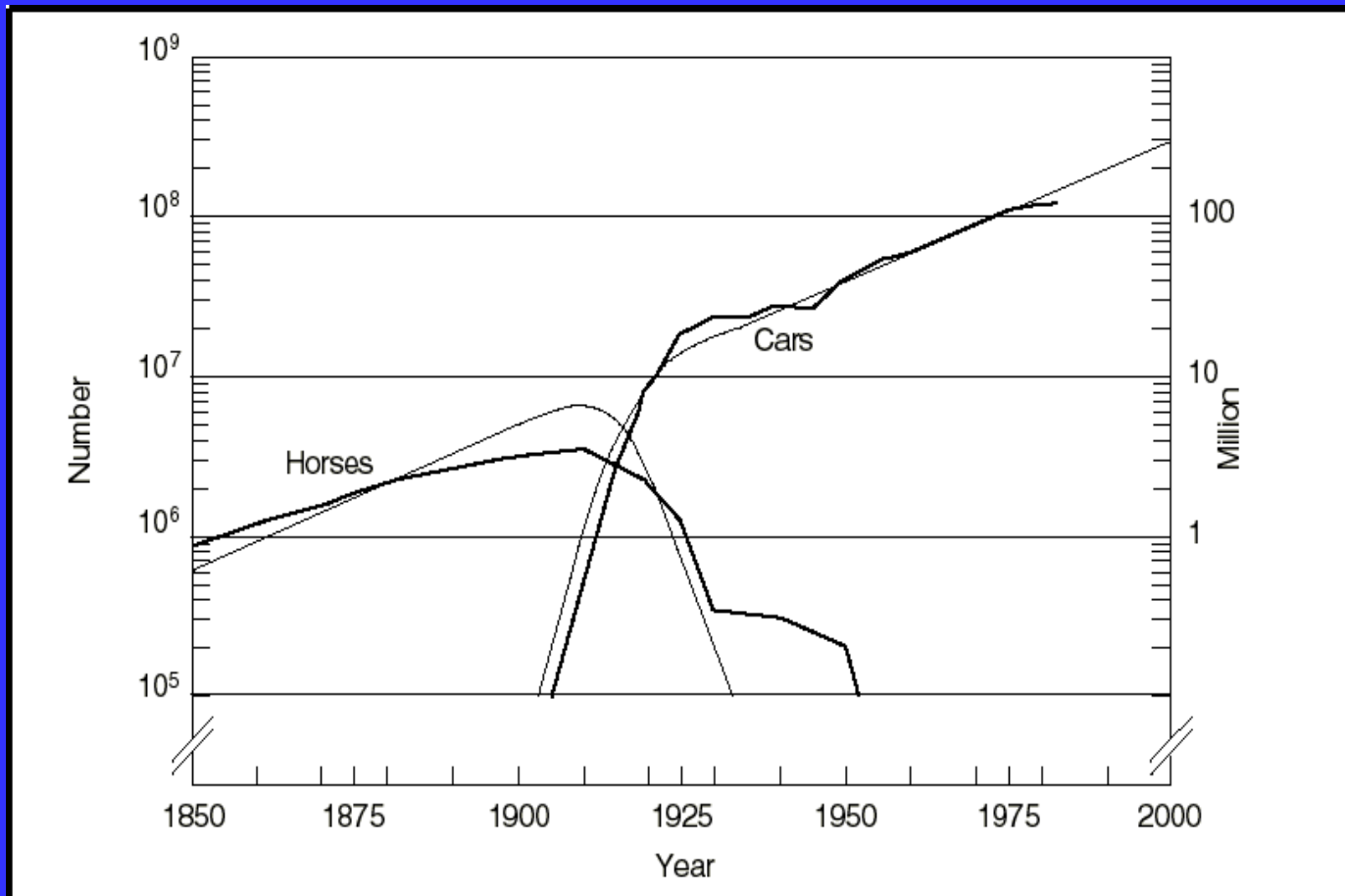
Issue: Mobilization of capital for energy supply investments

- Investment in energy supply projected at \$300-500 billion per year for the next 20 years, depending on path chosen
- Less than 10% of total overall investments

TIME FOR A CHANGE

- Typical diffusion time constraints for replacing 80% of energy capital stock are 20 to > 50 years
- Premature replacement of capital by new technologies is too costly
- Start experimentation and technological learning now to prepare for future capital replacement

Number of Draft Animals and Automobiles in the USA

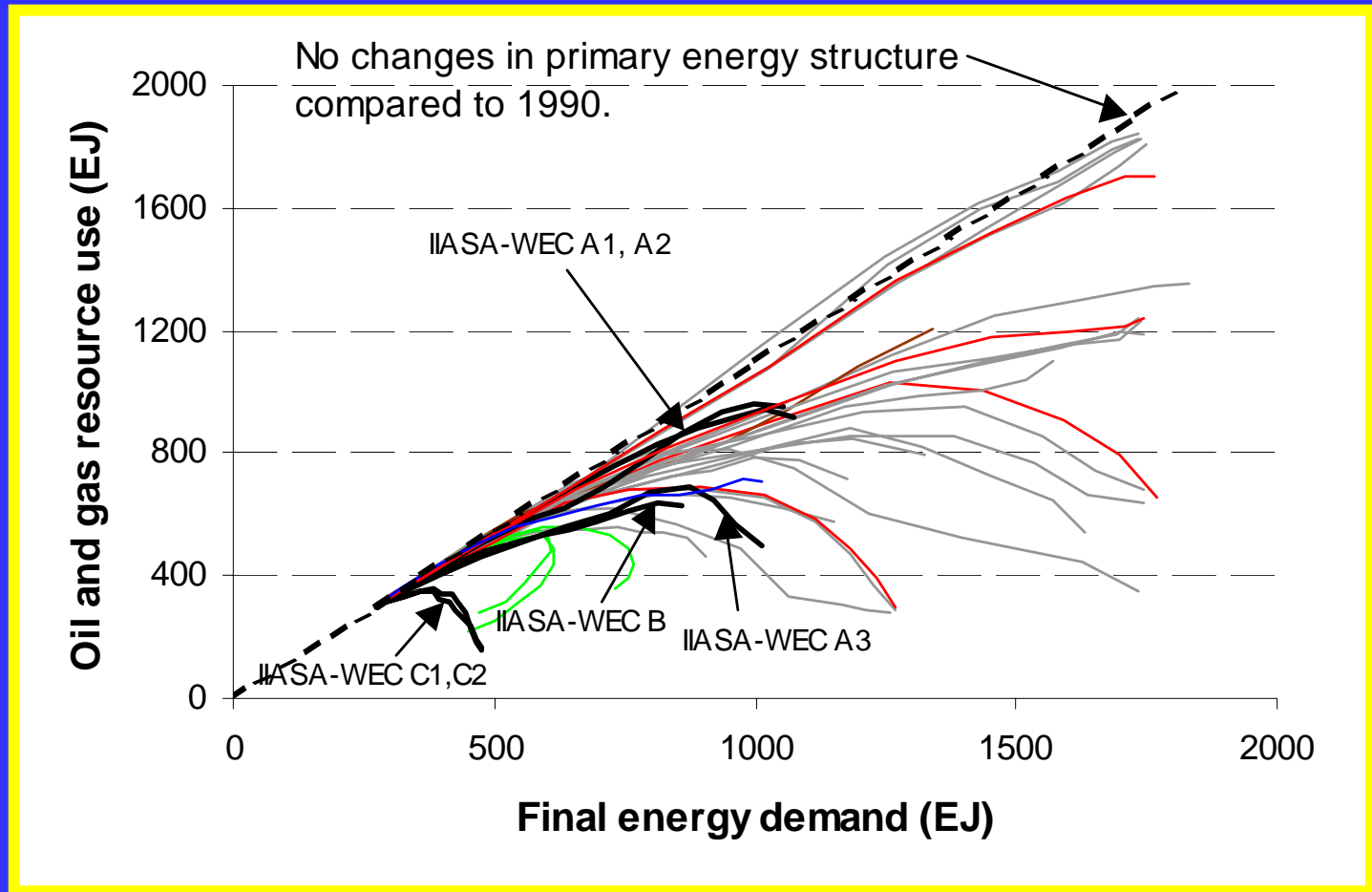


Global Hydrocarbon Reserves and Resources in ZJ (10^{21} J)

	Consumption		Reserves	Resources	Resource base	Additional Occurrences
	1860-1998	1998				
Oil						
Conventional	4.85	0.13	6	6	12	
Unconventional	0.29	0.01	6	16	22	60
Gas						
Conventional	2.35	0.08	6	11	17	
Unconventional	0.03	--	9	26	35	800
Coal	5.99	0.09	21	179	200	140
Total	13.51	0.31	48	238	286	1000

Source: Nakicenovic *et al.*, 1996; Nakicenovic, Grübler and McDonald, 1998; WEC, 1998; Masters *et al.*, 1994; Rogner *et al.*, 2000

Relationship between resource use and energy demand



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