POTSDAM INSTITUTE FOR CLIMATE IMPACT RESEARCH

Prof. Dr. Ottmar Edenhofer

# The Economics of Atmospheric Stabilization

Beijing, 15th September 2009

**Tsinghua Environment Forum**

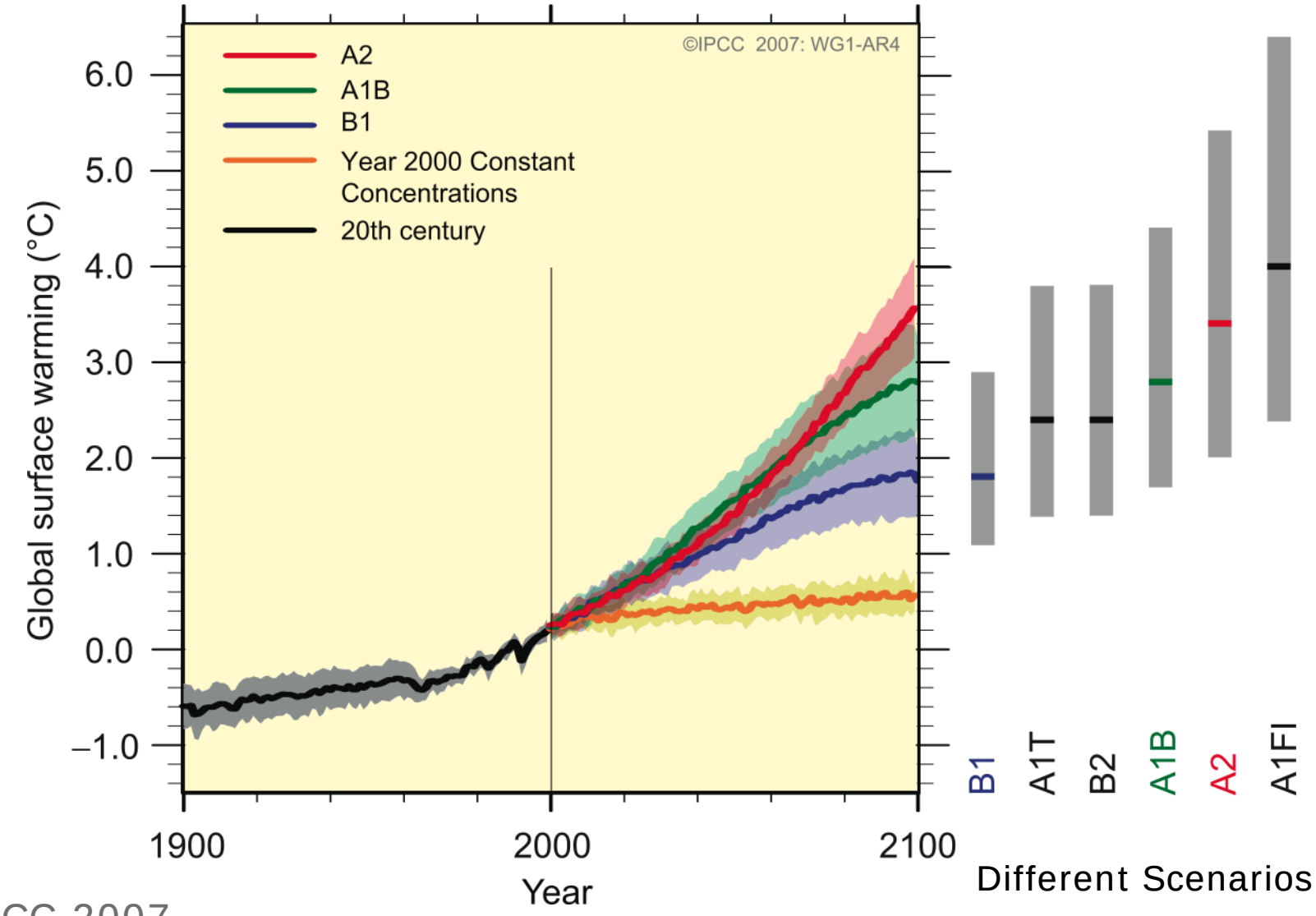
INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE

Working Group III
Mitigation of Climate Change

WMO UNEP

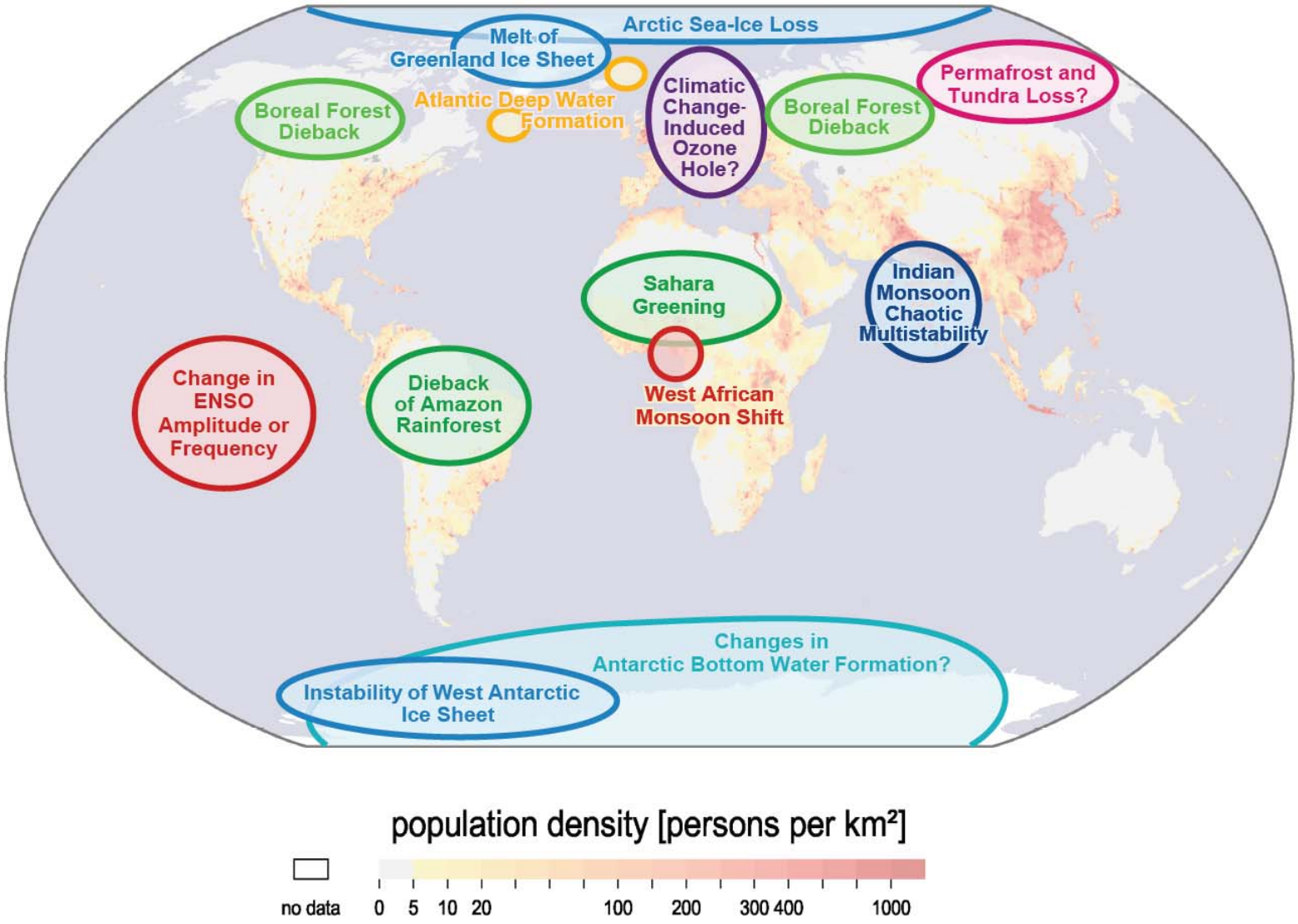
Technische Universität Berlin

# Projections of Global Mean Temperature



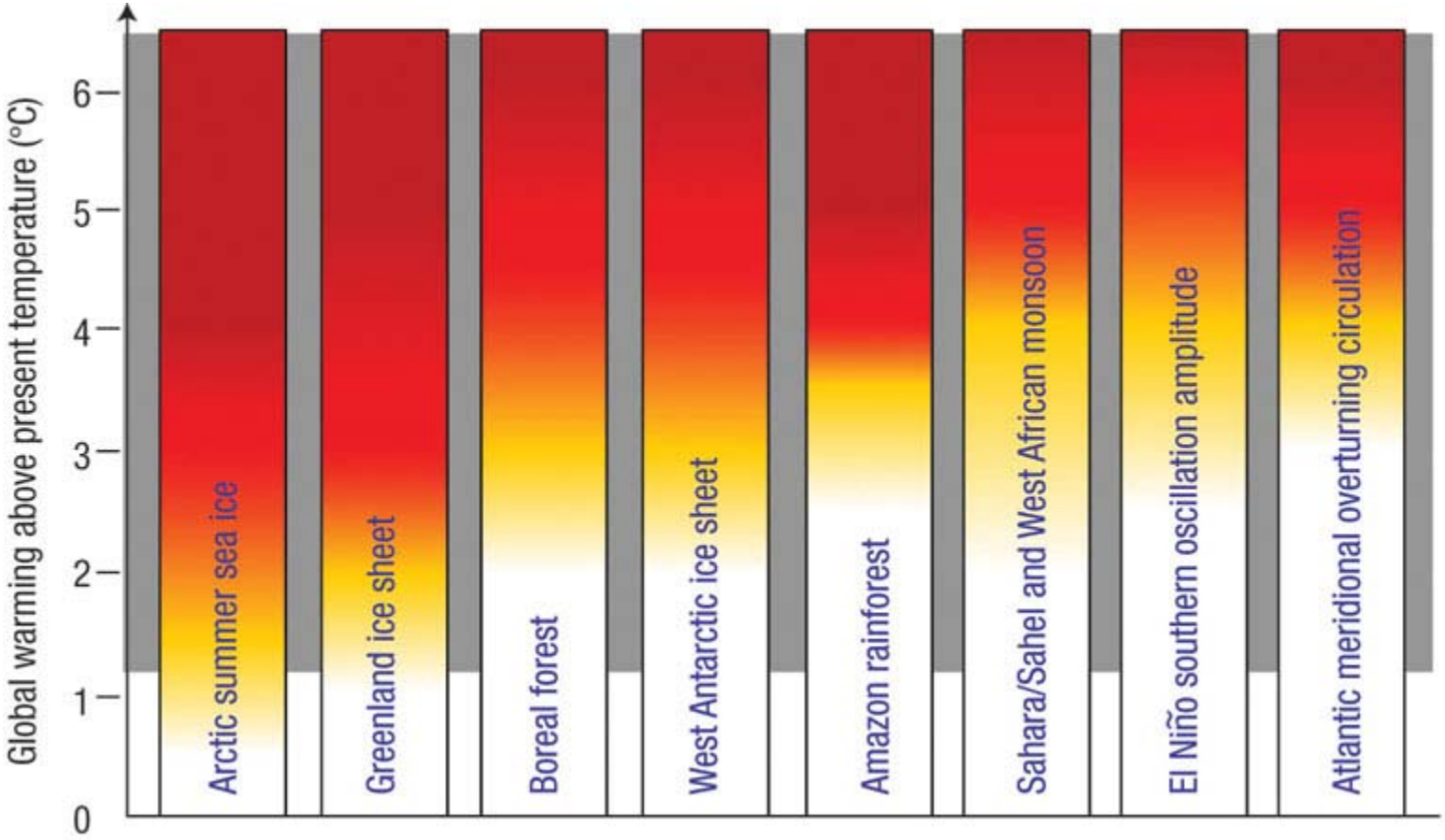

IPCC 2007

# Tipping Points in the Earth System




T. M. Lenton & H. J. Schellnhuber (Nature Reports Climate Change, 2007)

# Burning Embers

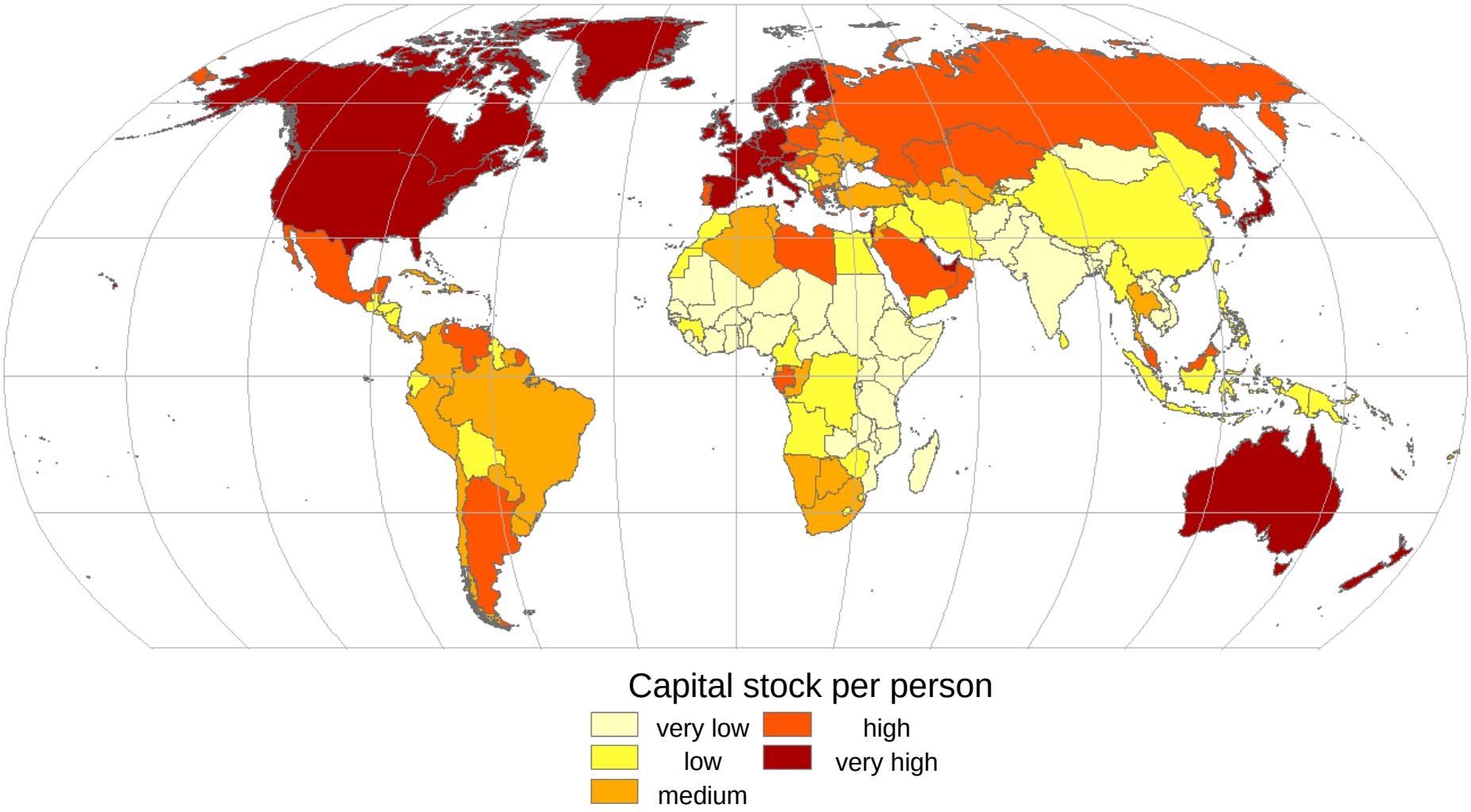



Year 2100 range (IPCC 2007)

**Potential policy-relevant tipping elements that could be triggered by global warming this century, with shading indicating their uncertain thresholds. For each threshold, the transition from white to yellow indicates a lower bound on its proximity, and the transition from yellow to red, an upper bound. The degree of uncertainty is represented by the spread of the colour transition.**

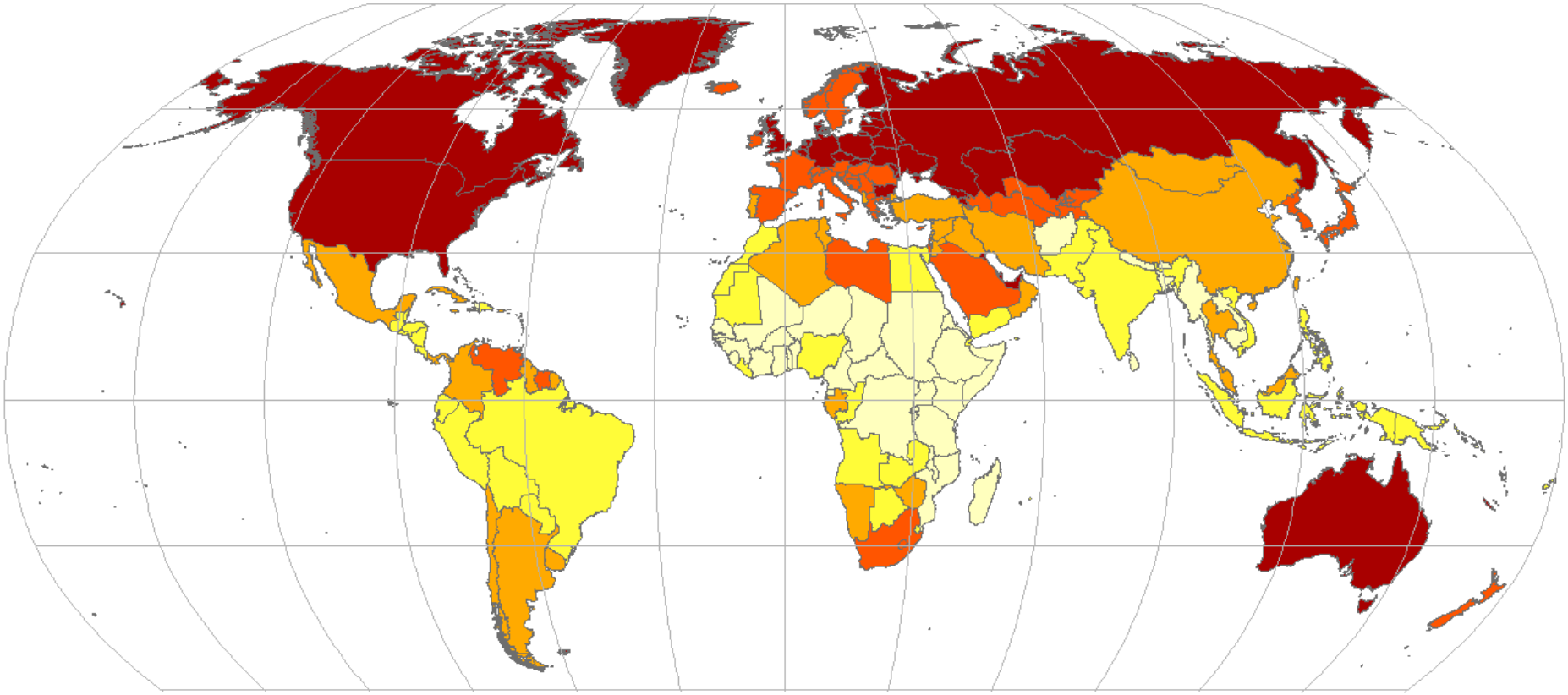
**T. M. Lenton & H. J. Schellnhuber (Nature Reports Climate Change, 2007)**

# World Map of Wealth




*Source: Füssel (2007)*

# World Map of Carbon Debt

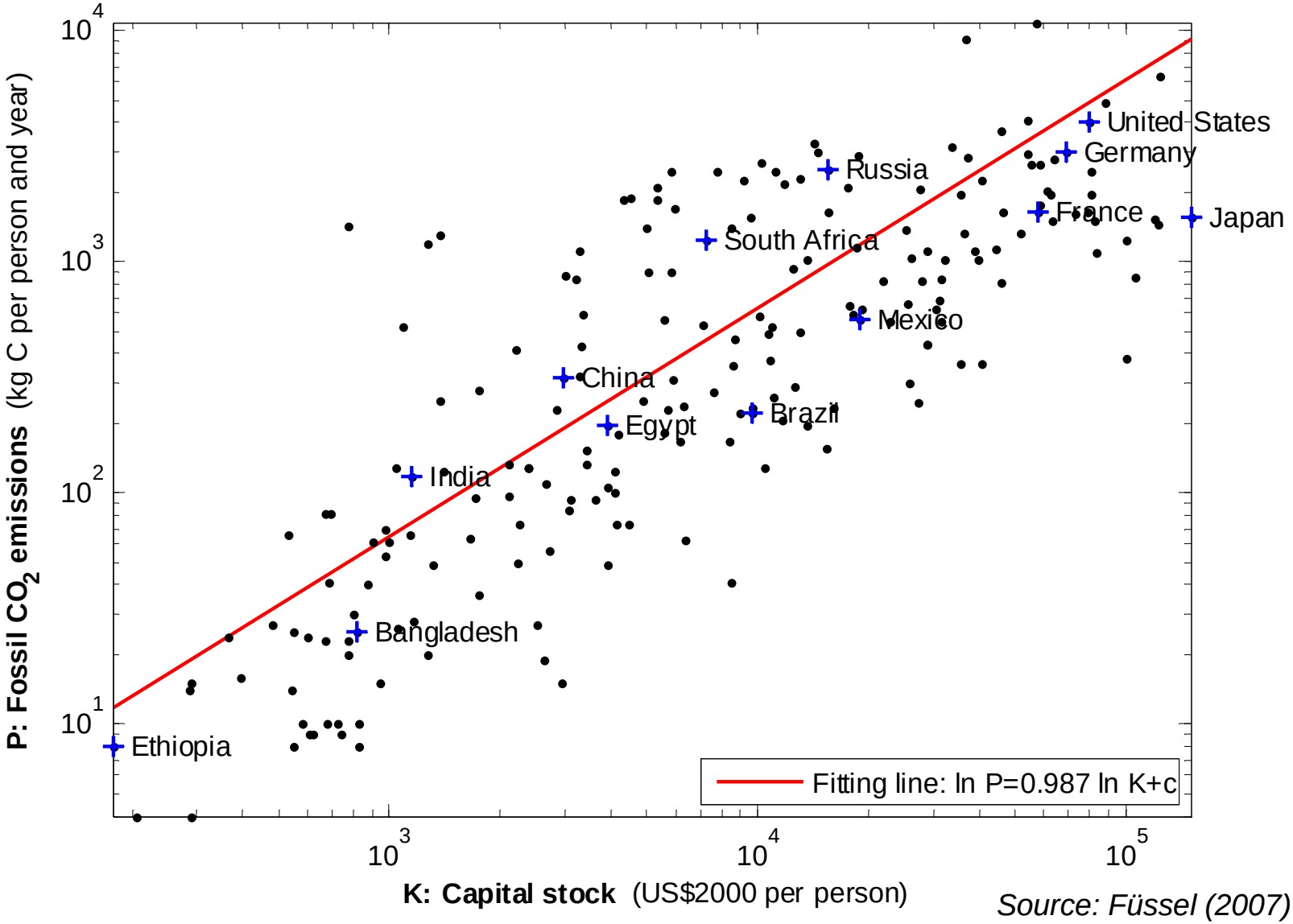


Carbon emissions per person from fossil fuel burning (1950-2003)

very low
low
medium
high
very high

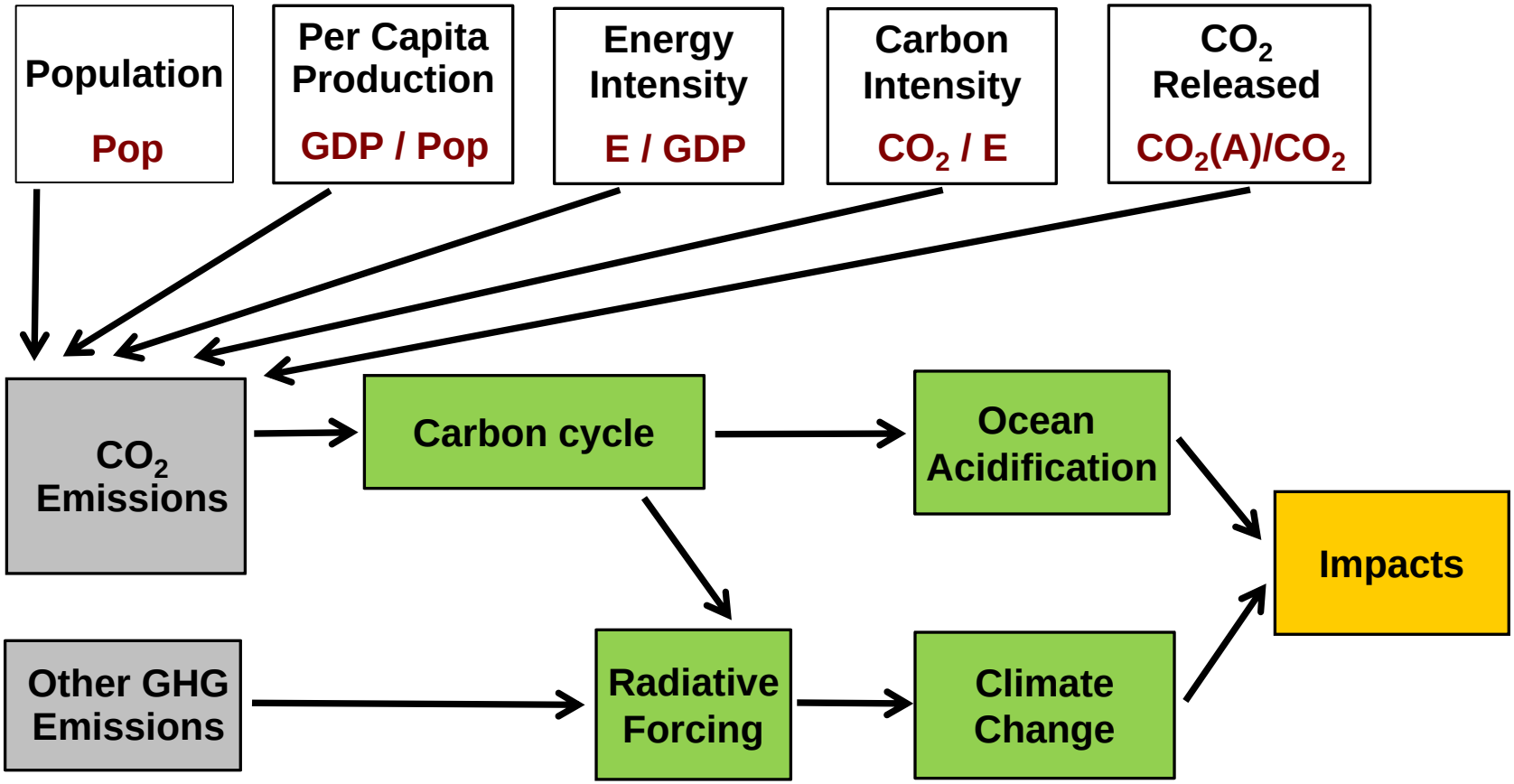
*Source: Füssel (2007)*

# Carbon Dept and Wealth

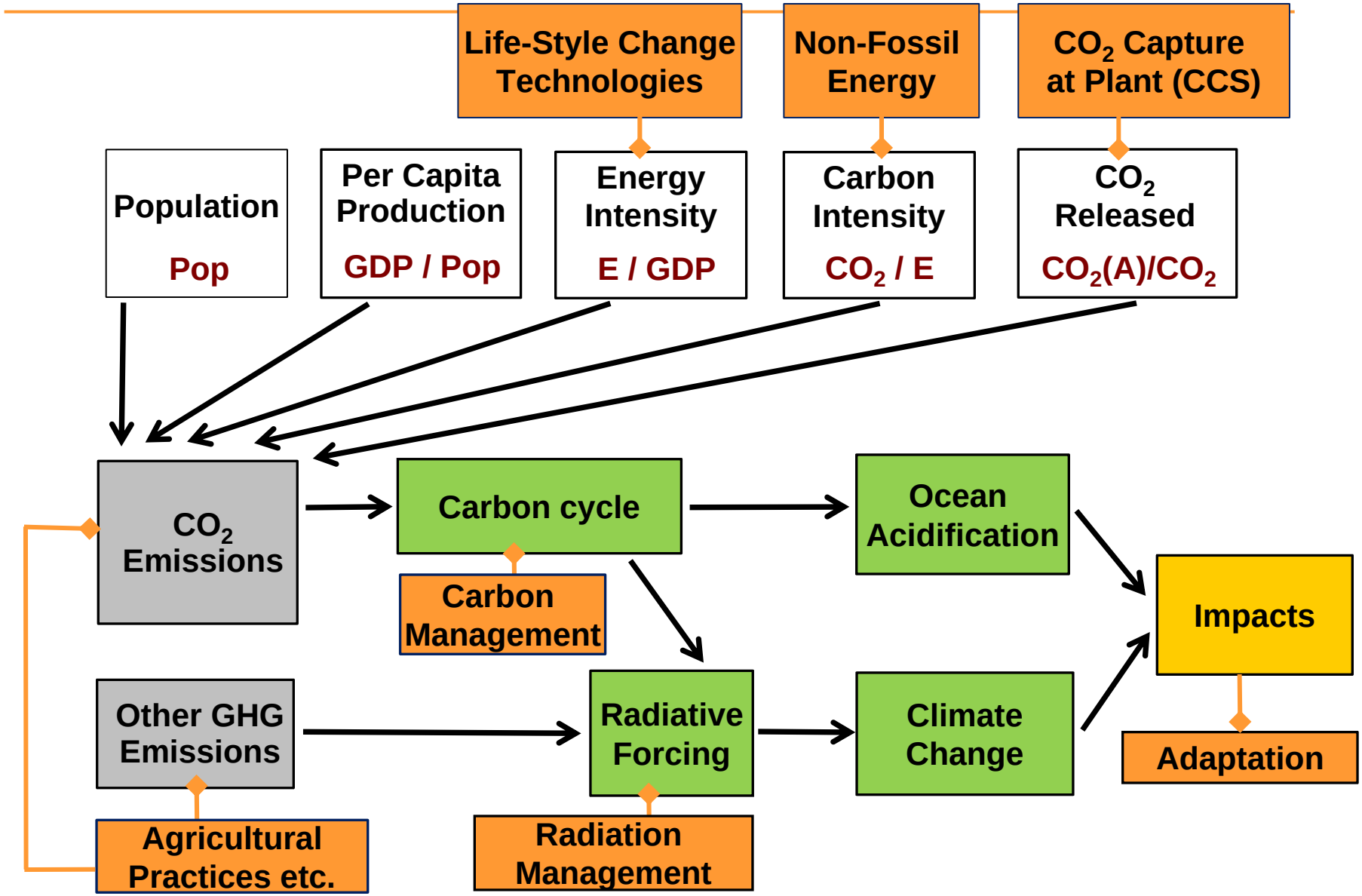



*Source: Füssel (2007)*

# Driving Forces



# Assessing the Solution Space



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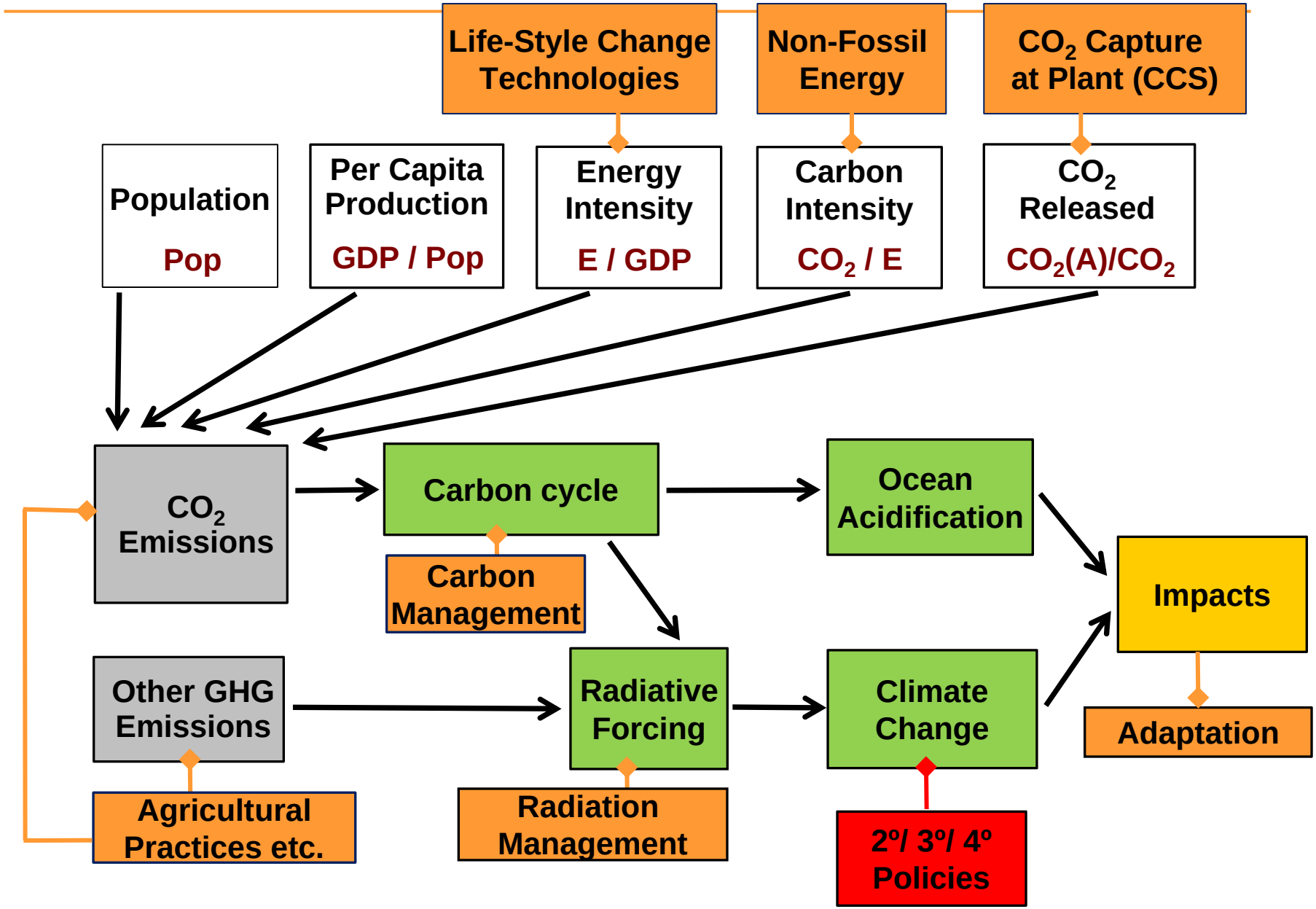
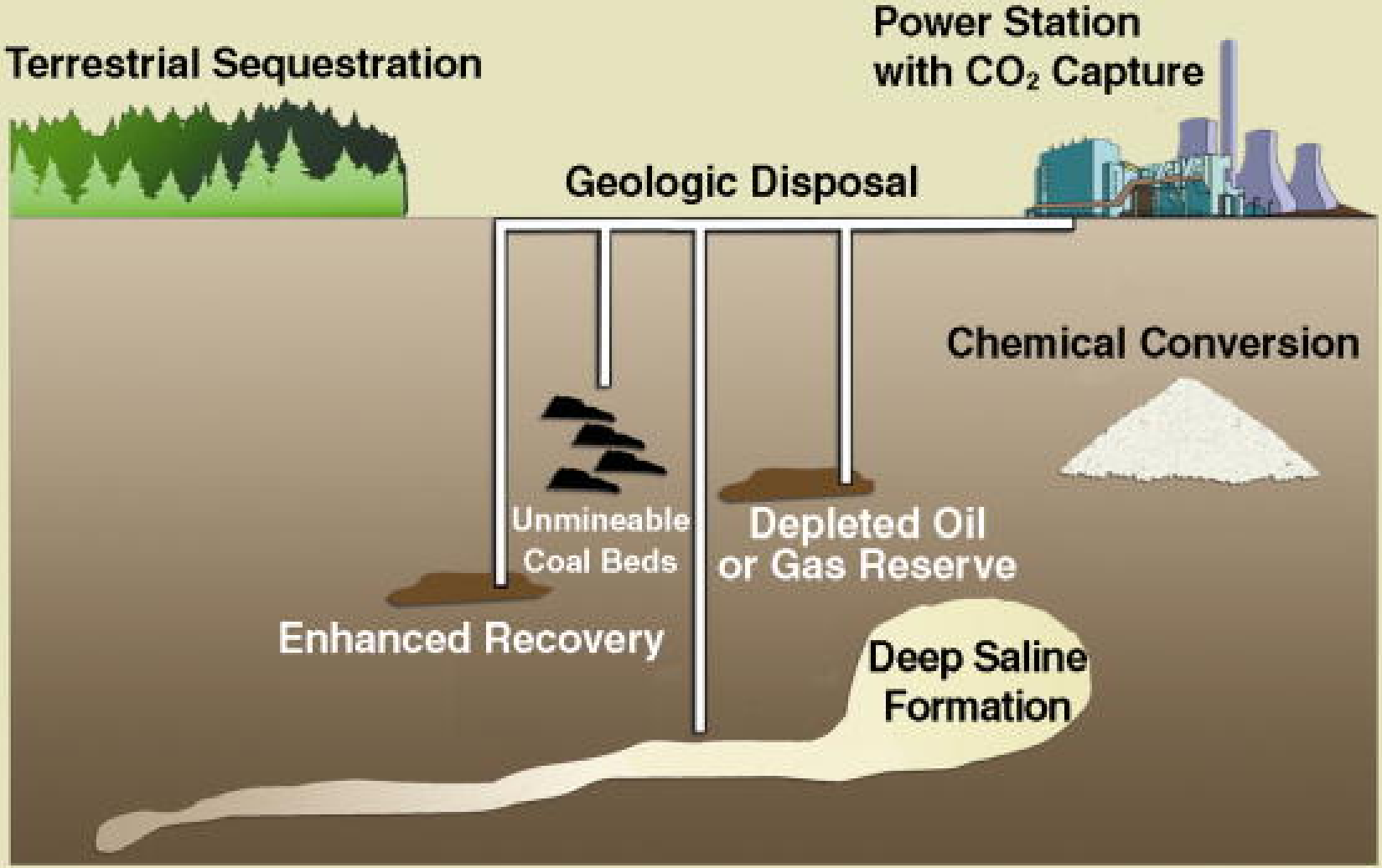


# New Storage Technology Increases Reliability and Integration

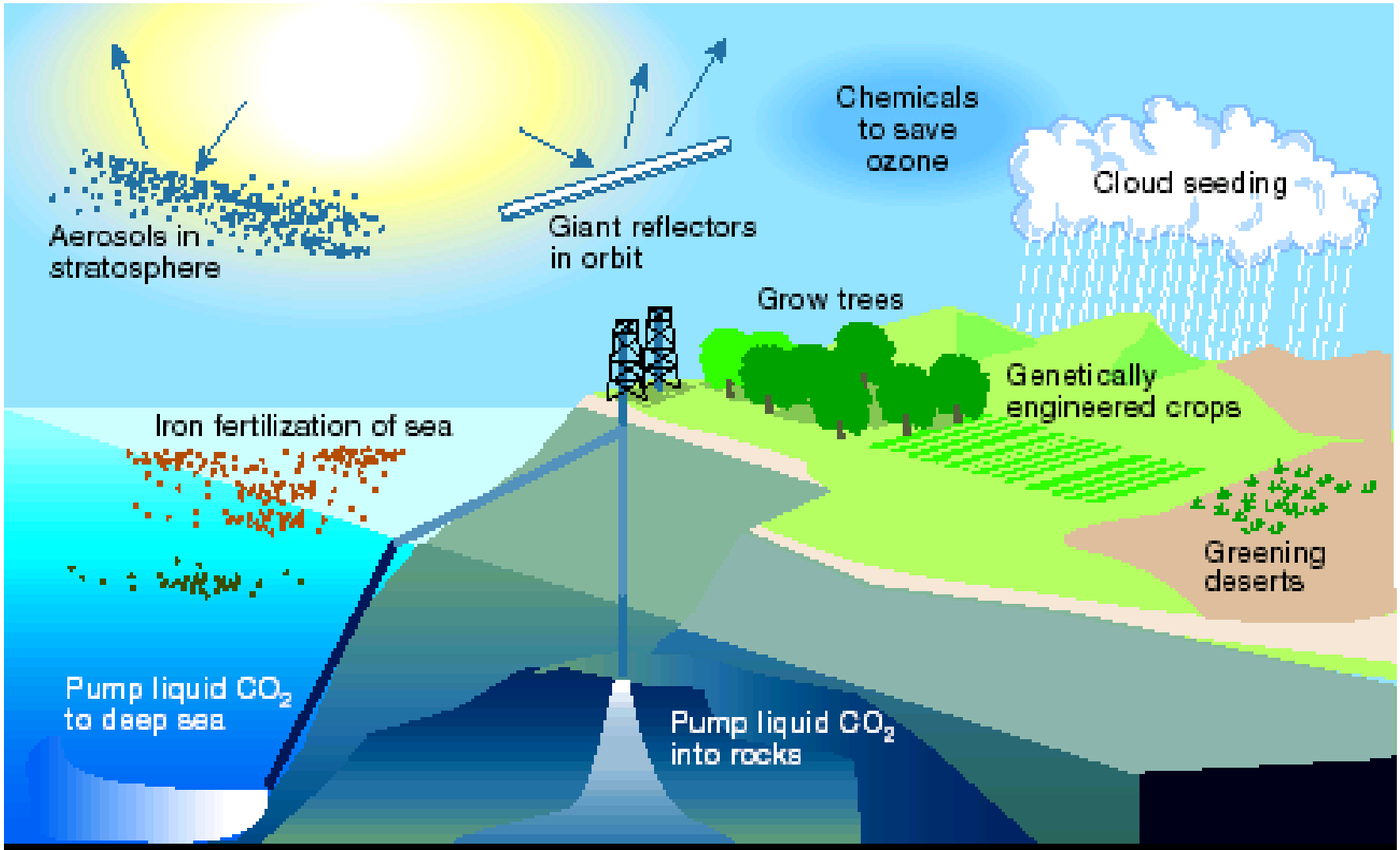
New storage technologies open new potentials to integration.

E.g. concentrating-solar-thermal-power-plant with molten salt thermal storage system with 7 hour capacity (bridging nights).

# Carbon Sequestration Options



# Geo-Engineering Options + Carbon Management




Schematic representation of various climate-engineering proposals (courtesy B. Matthews).

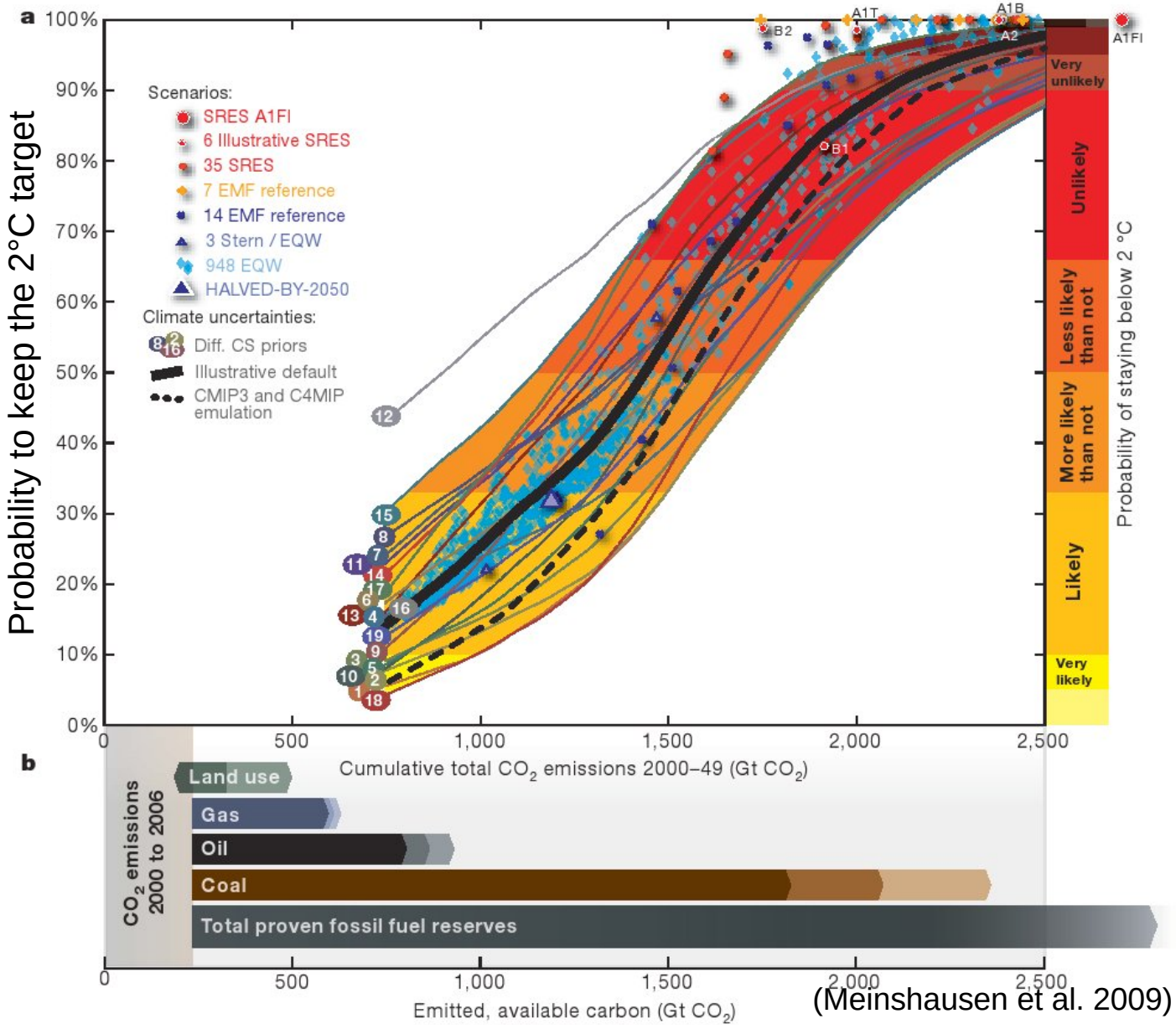
# Assessment of Controlling the Radiation Balance

- Science is not clarified yet
- If geo-engineering can work, it will transform the climate debate substantially: The climate problem can then be solved unilaterally
- However, geo-engineering might then resemble the arms race problem

# Are There Limits to Adaptation?

Dutch cow ready for sea-level rise?

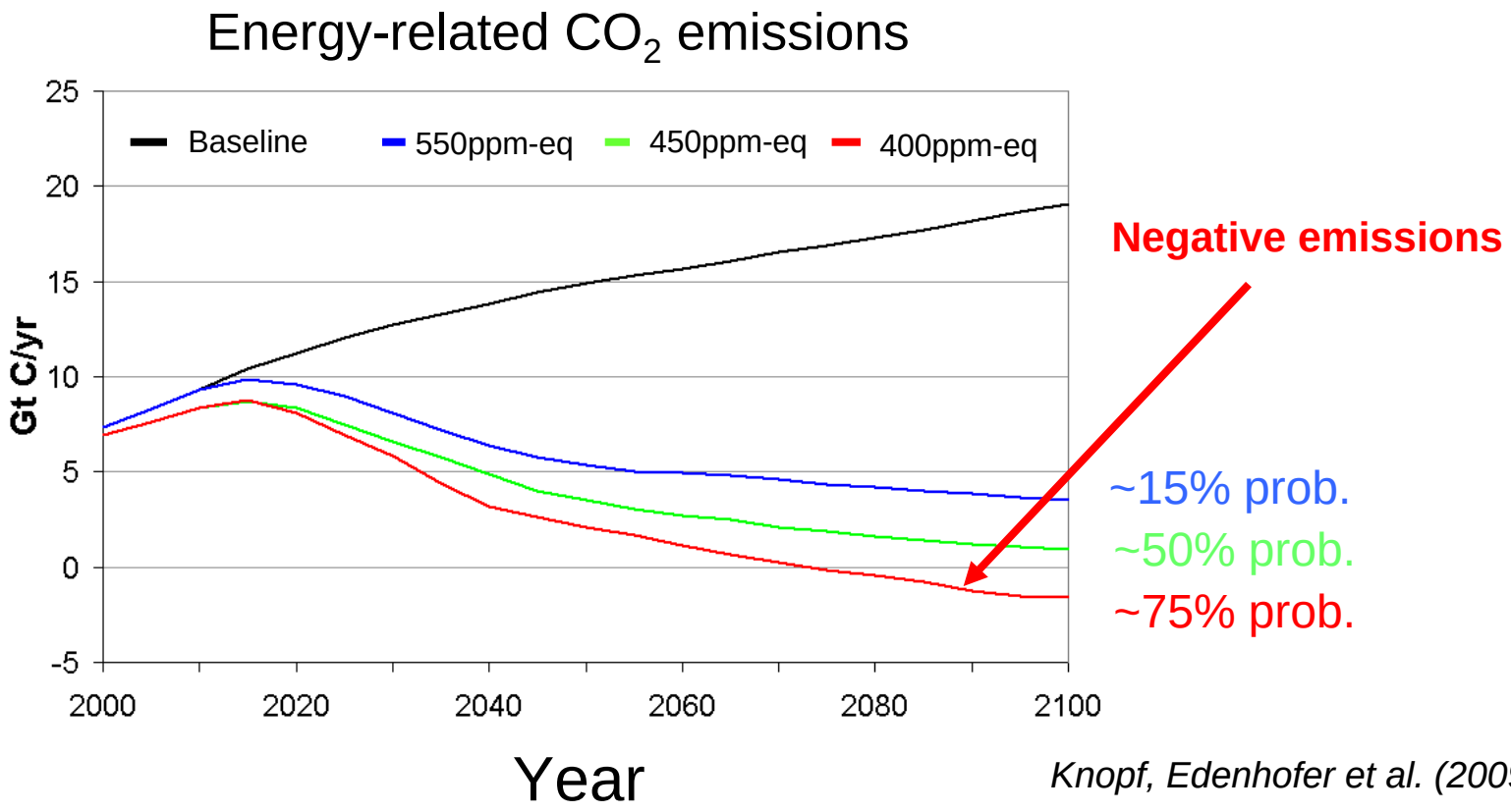
# Climate Protection Implies a Remaining Stock of Emissions




(Meinshausen et al. 2009)

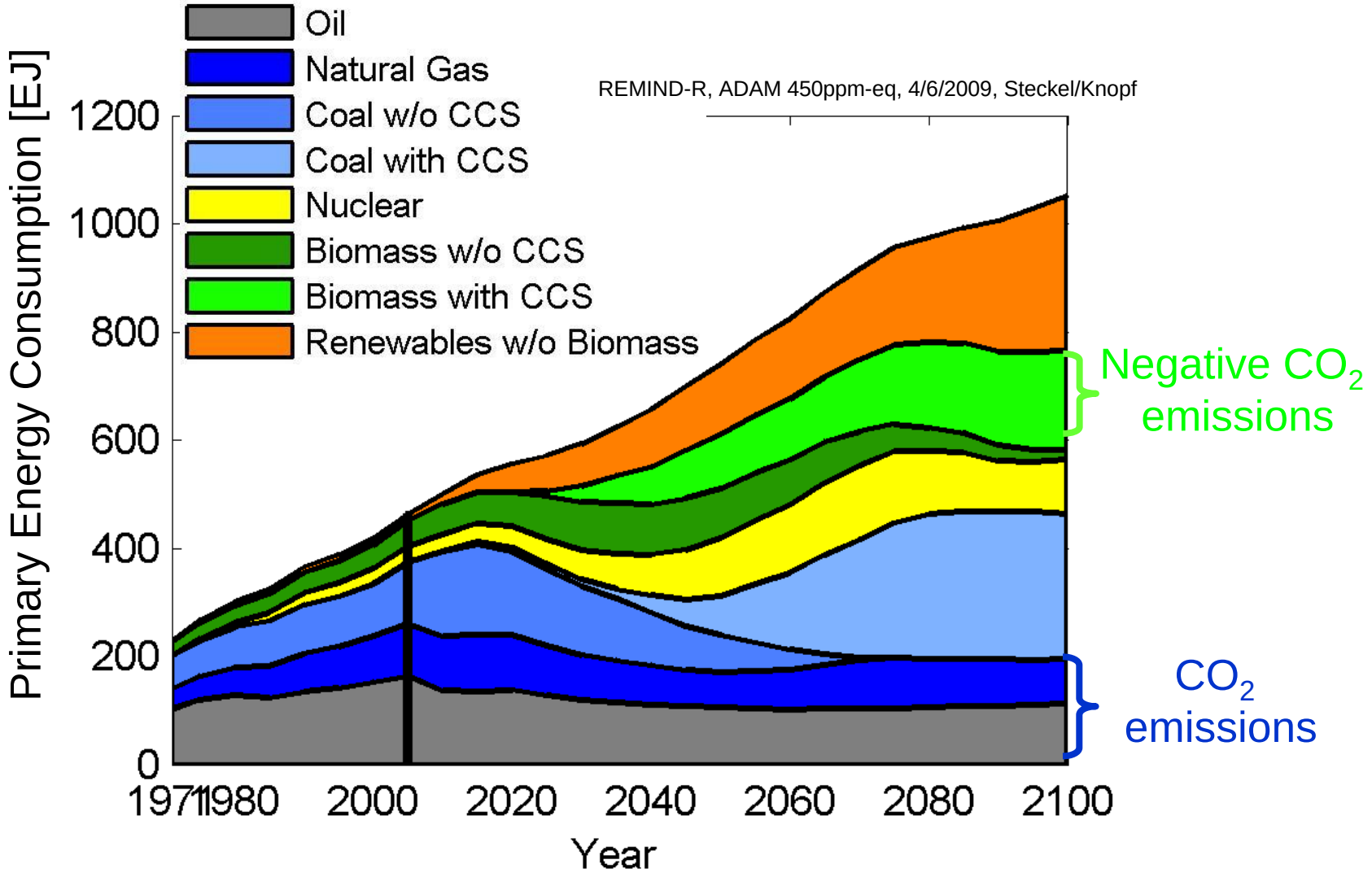
# The Economics of Atmospheric Stabilization

3 stabilisation targets with different probabilities to reach the 2° target:
550ppm-eq, 450ppm-eq, 400ppm-eq



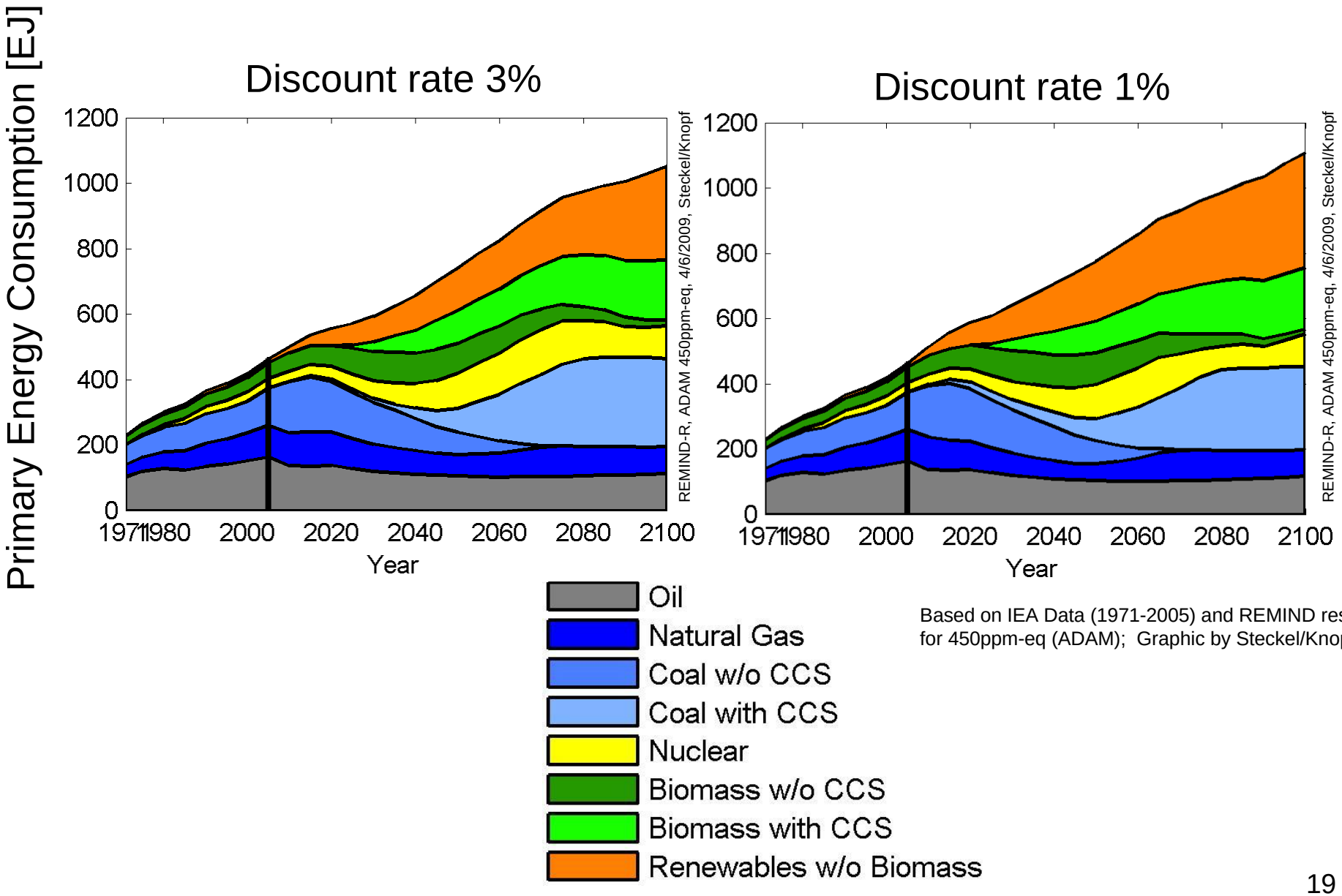

*Knopf, Edenhofer et al. (2009)*

# The Great Transformation




Based on IEA Data (1971-2005) and REMIND-R results for 450ppm-eq (ADAM); Graphic by Steckel/Knopf (PIK)

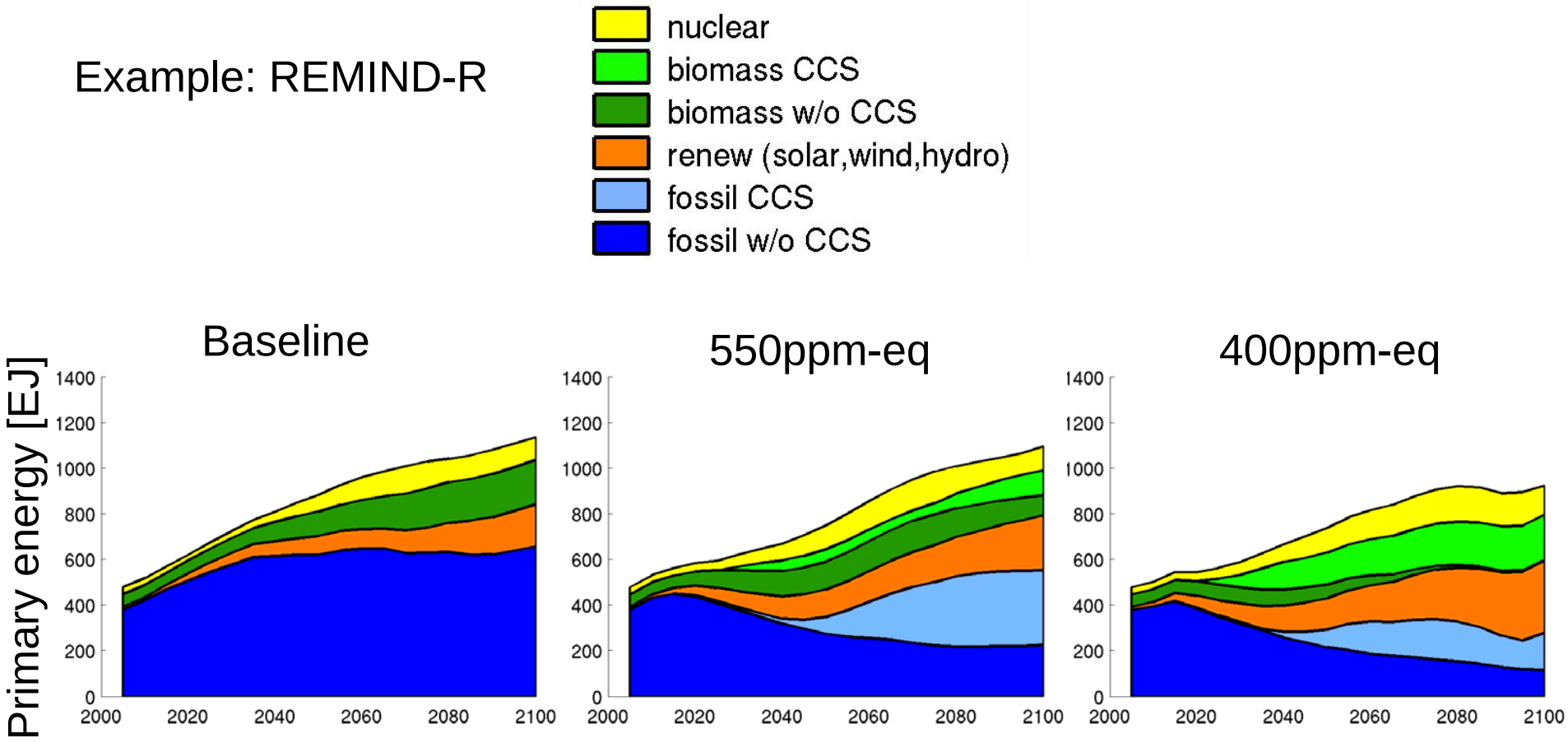
# Discounting and Technological Change




Based on IEA Data (1971-2005) and REMIND results for 450ppm-eq (ADAM); Graphic by Steckel/Knopf

# Energy Mix of a Decarbonized Future

Example: REMIND-R




*Knopf, Edenhofer et al. (2009)*

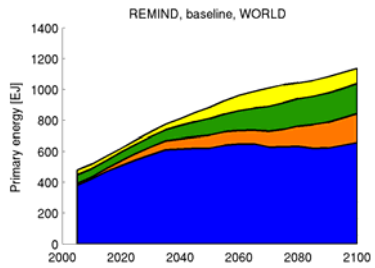
# There is more than one path towards a carbon-free economy

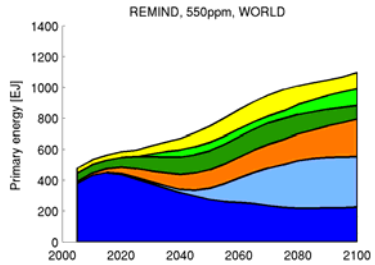
MERGE TIMER POLES REMIND E3MG

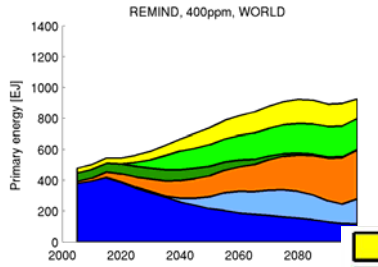
baseline

550 ppm

400 ppm





*Knopf, Edenhofer et al. (2009)*

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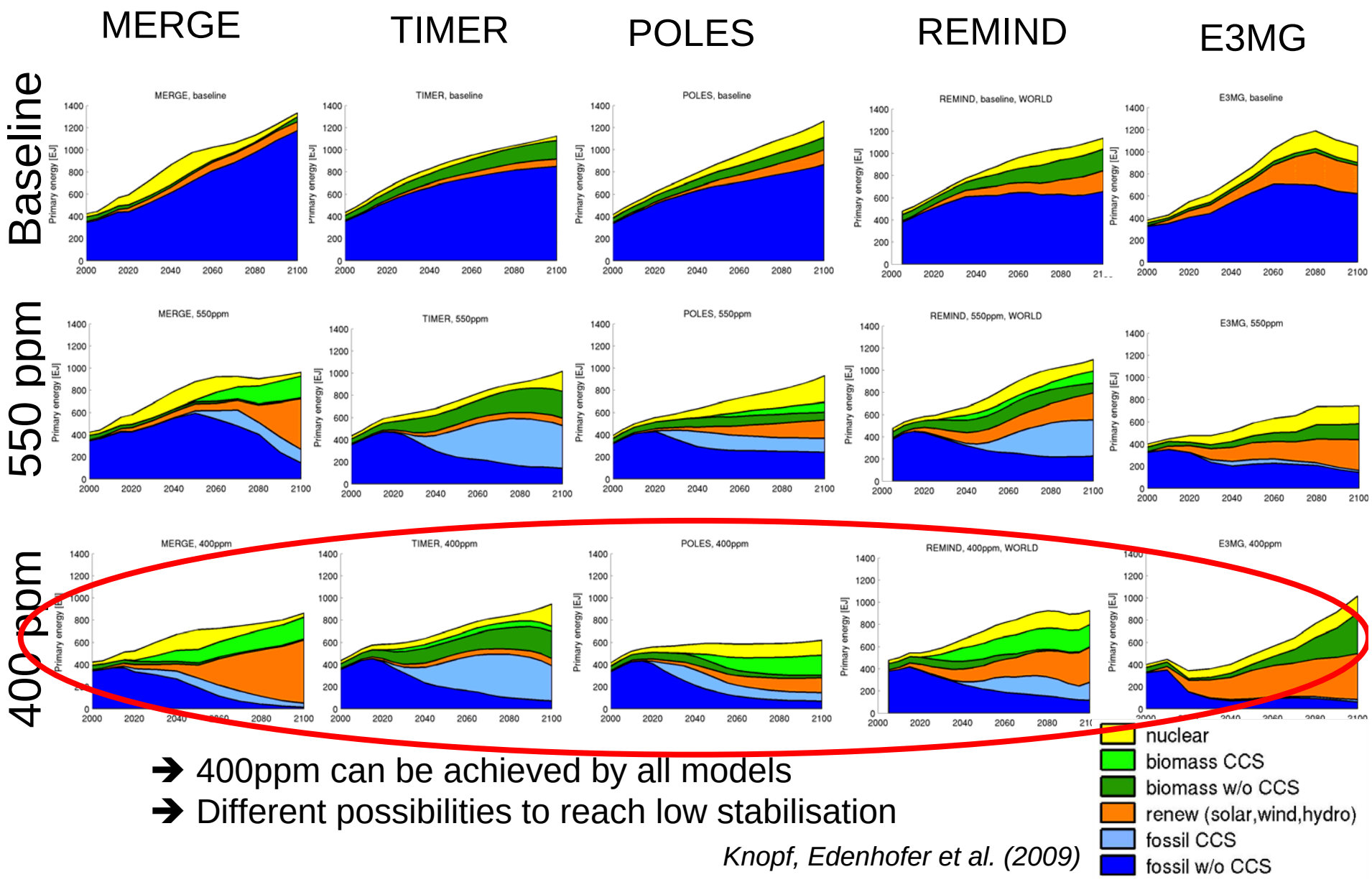
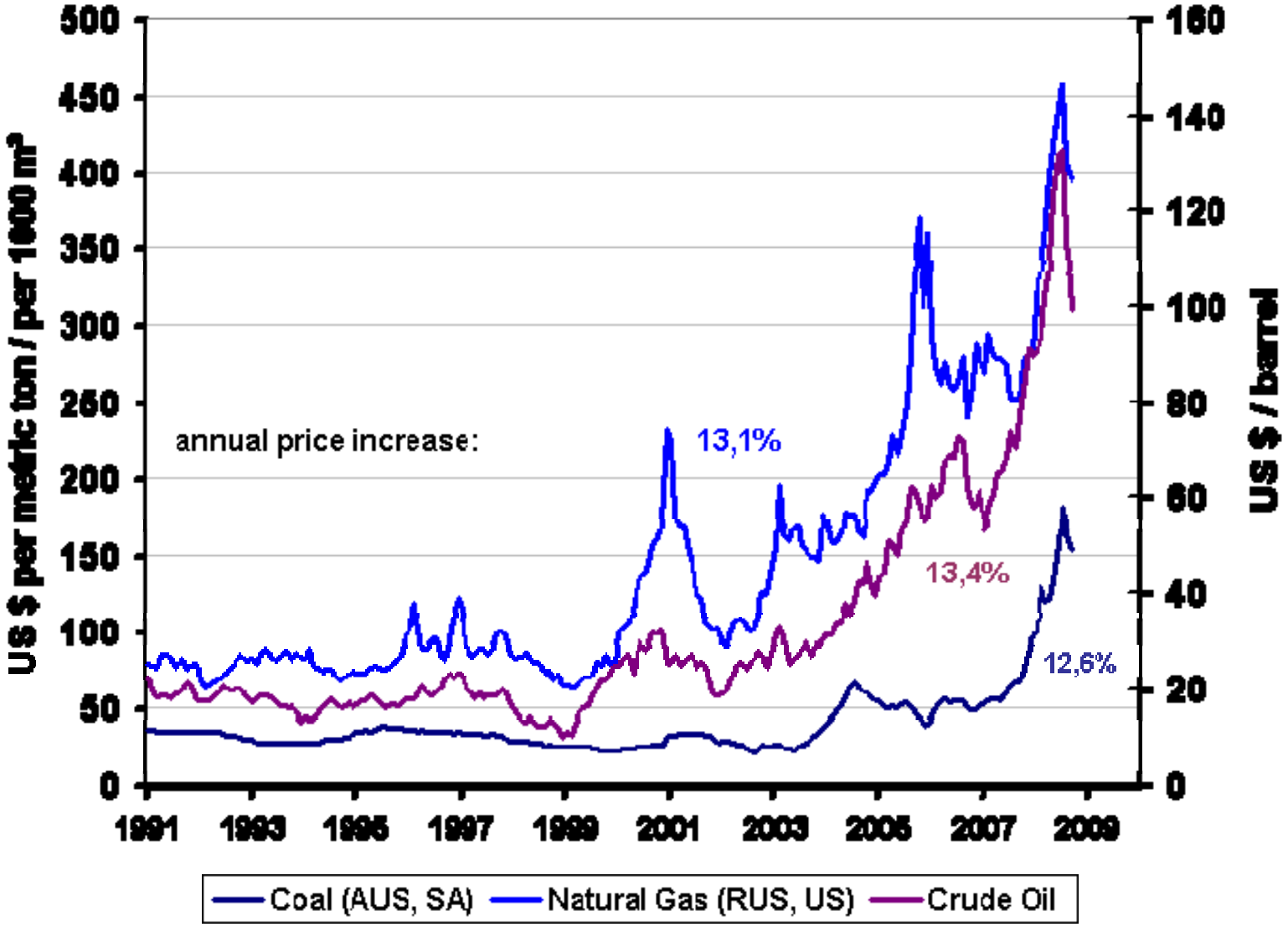



➔ 400ppm can be achieved by all models

➔ Different possibilities to reach low stabilisation

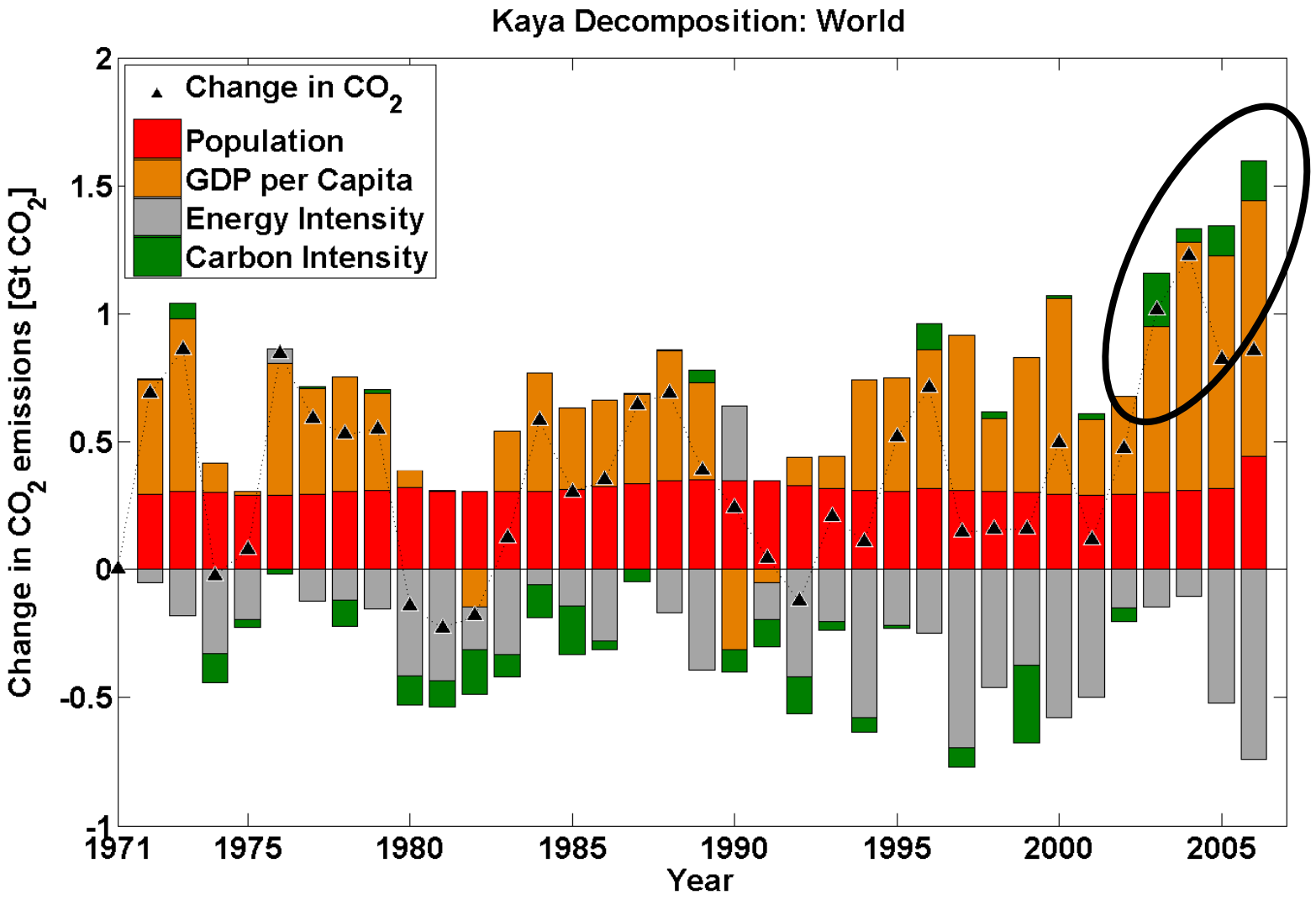
*Knopf, Edenhofer et al. (2009)*

# Global Fossil Fuel Prices 1991 - 2008

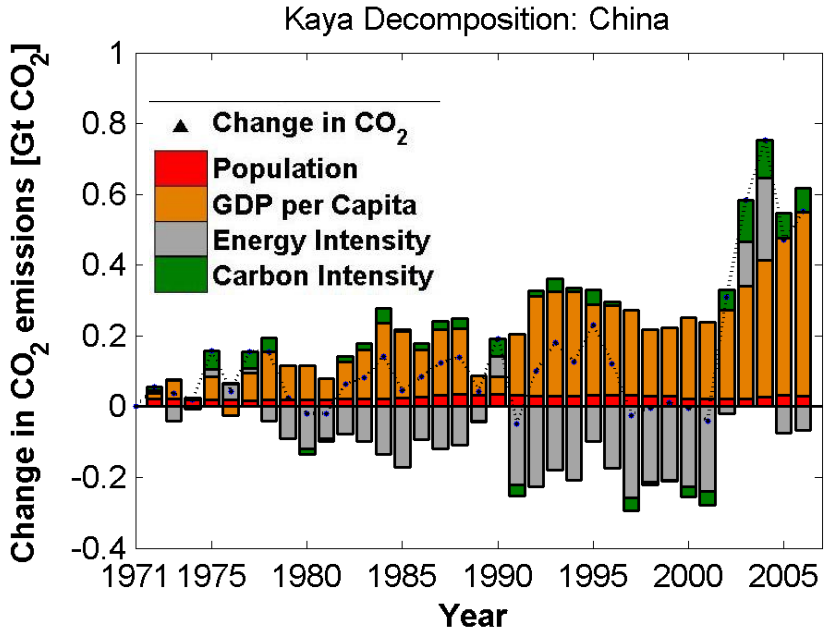


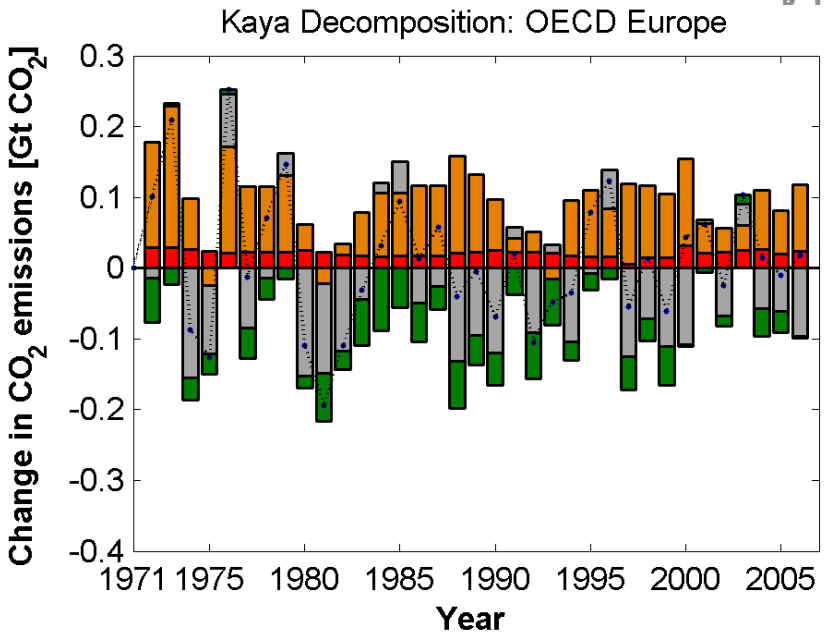

**Source: IMF International Commodities Database**

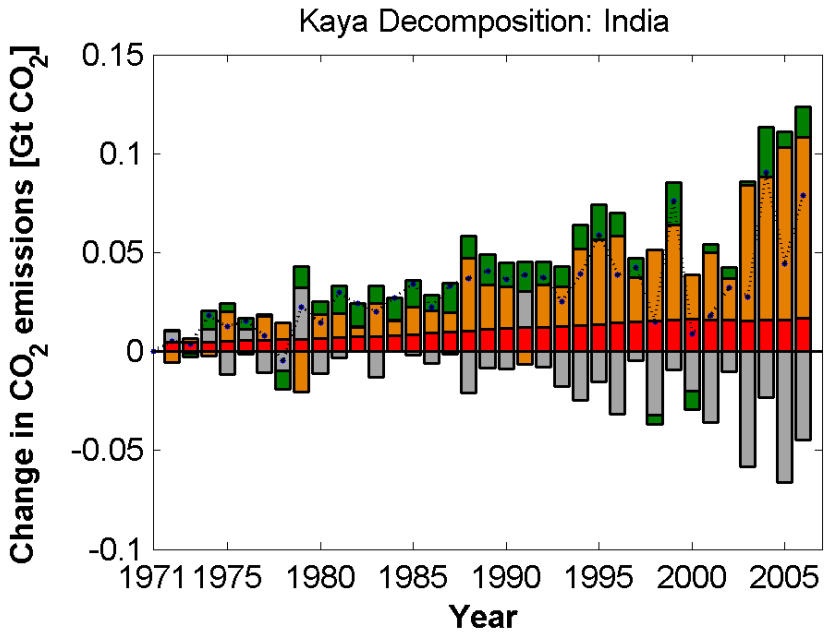
# Renaissance of Coal

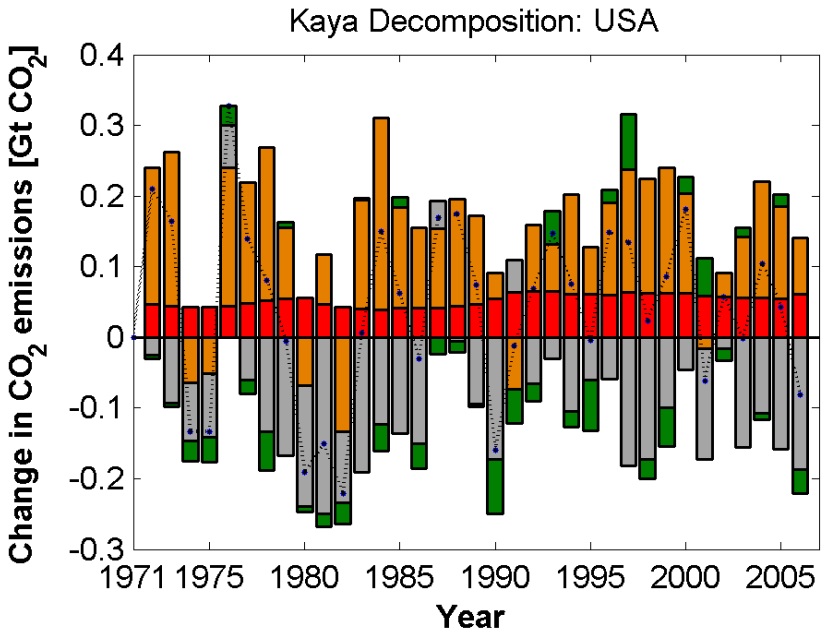


# Carbonization Pathways



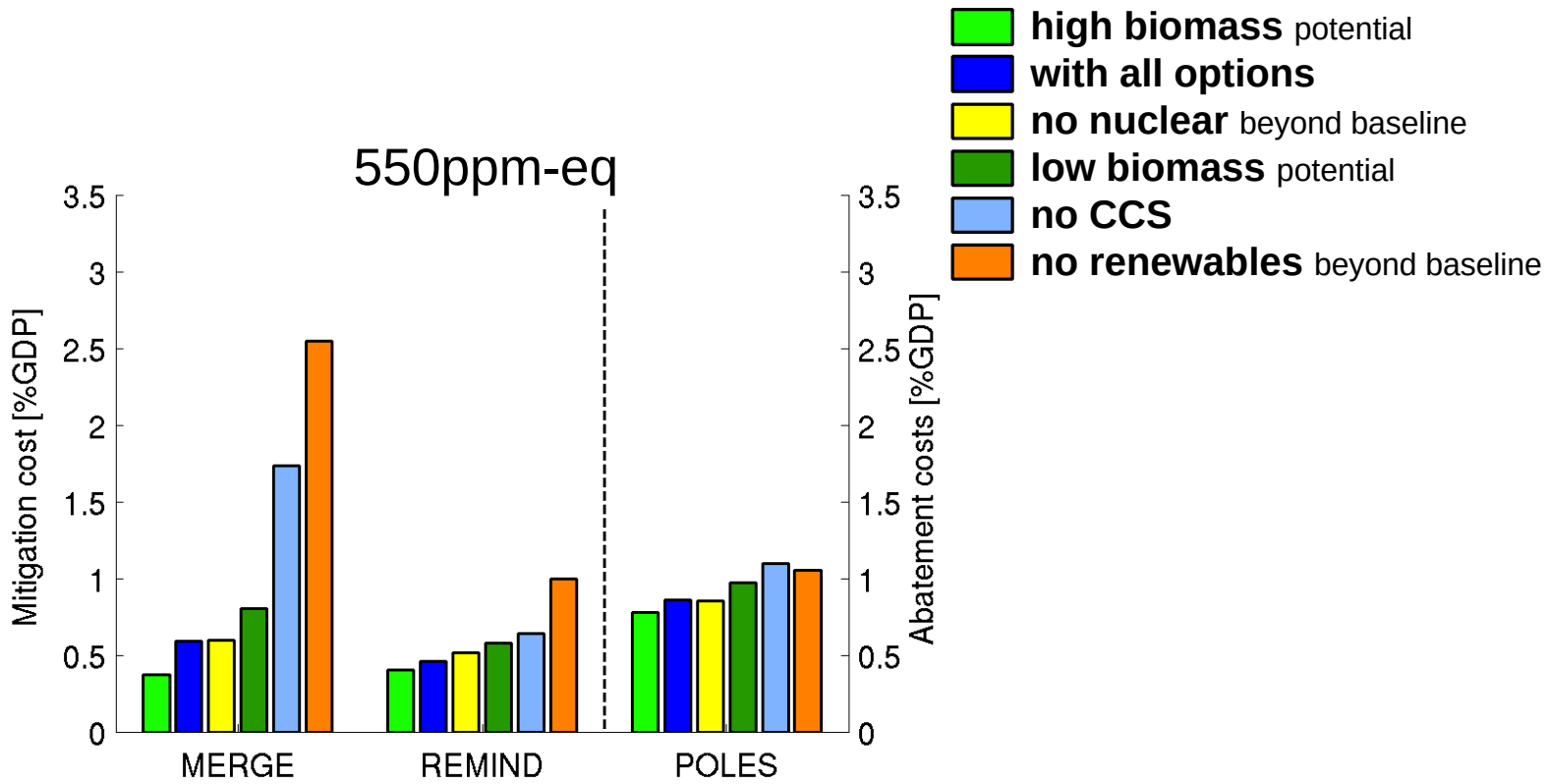




PIK 2009 (Jan Steckel)

# Mitigation Costs: Technology Options, 550ppm

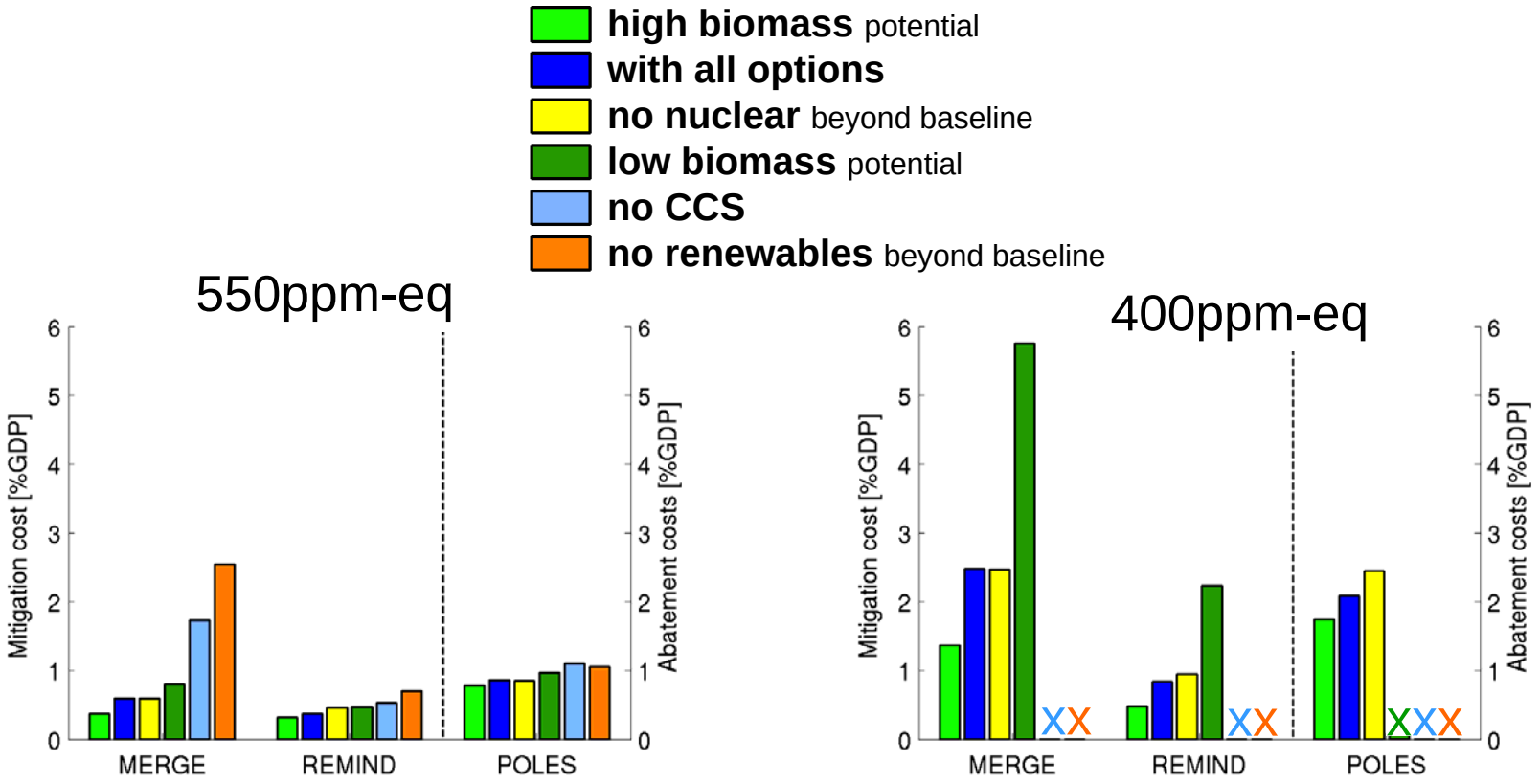



*Knopf, Edenhofer et al. (2009)*

➔ Renewables and CCS are the most important options

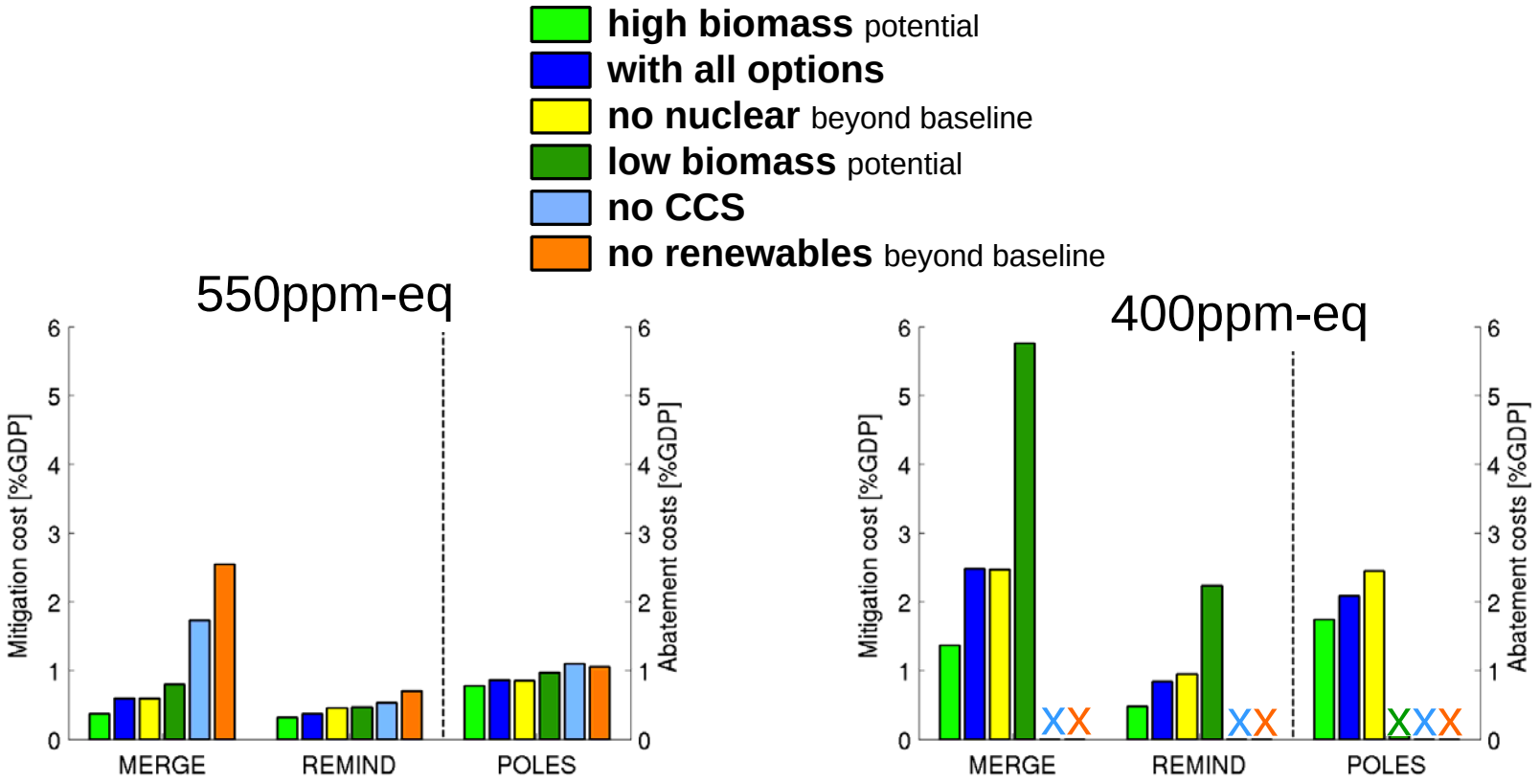
➔ Ranking of options: Robust picture throughout all models

# Technology Options for Low Stabilization




*Knopf, Edenhofer et al. (2009)*

# Technology Options for Low Stabilization



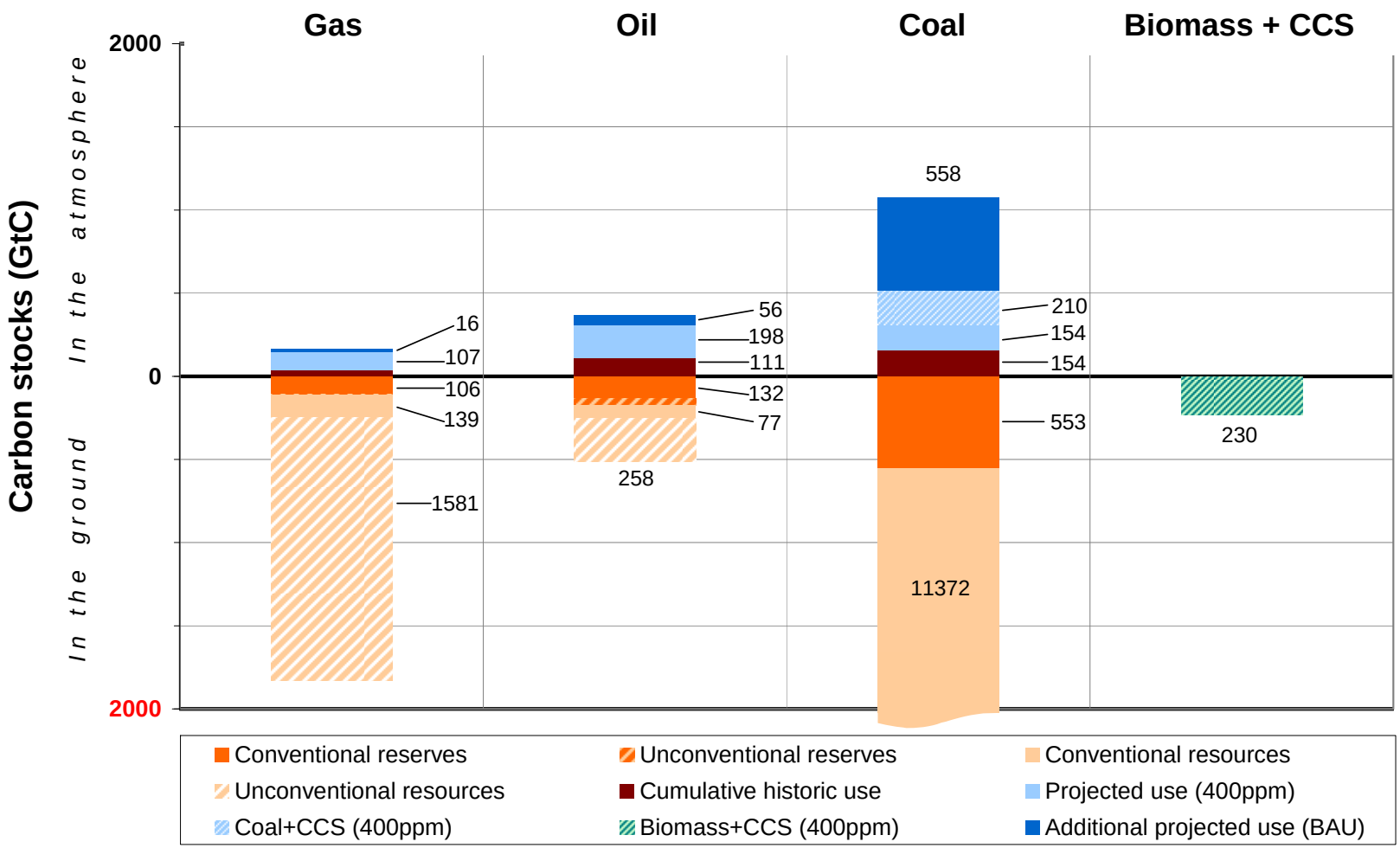

*Knopf, Edenhofer et al. (2009)*

➔ 400 ppm neither achievable without CCS nor without extension of renewables

➔ Biomass potential dominates the mitigation costs of low stabilisation

➔ Nuclear is not important beyond its (high) use in the baseline

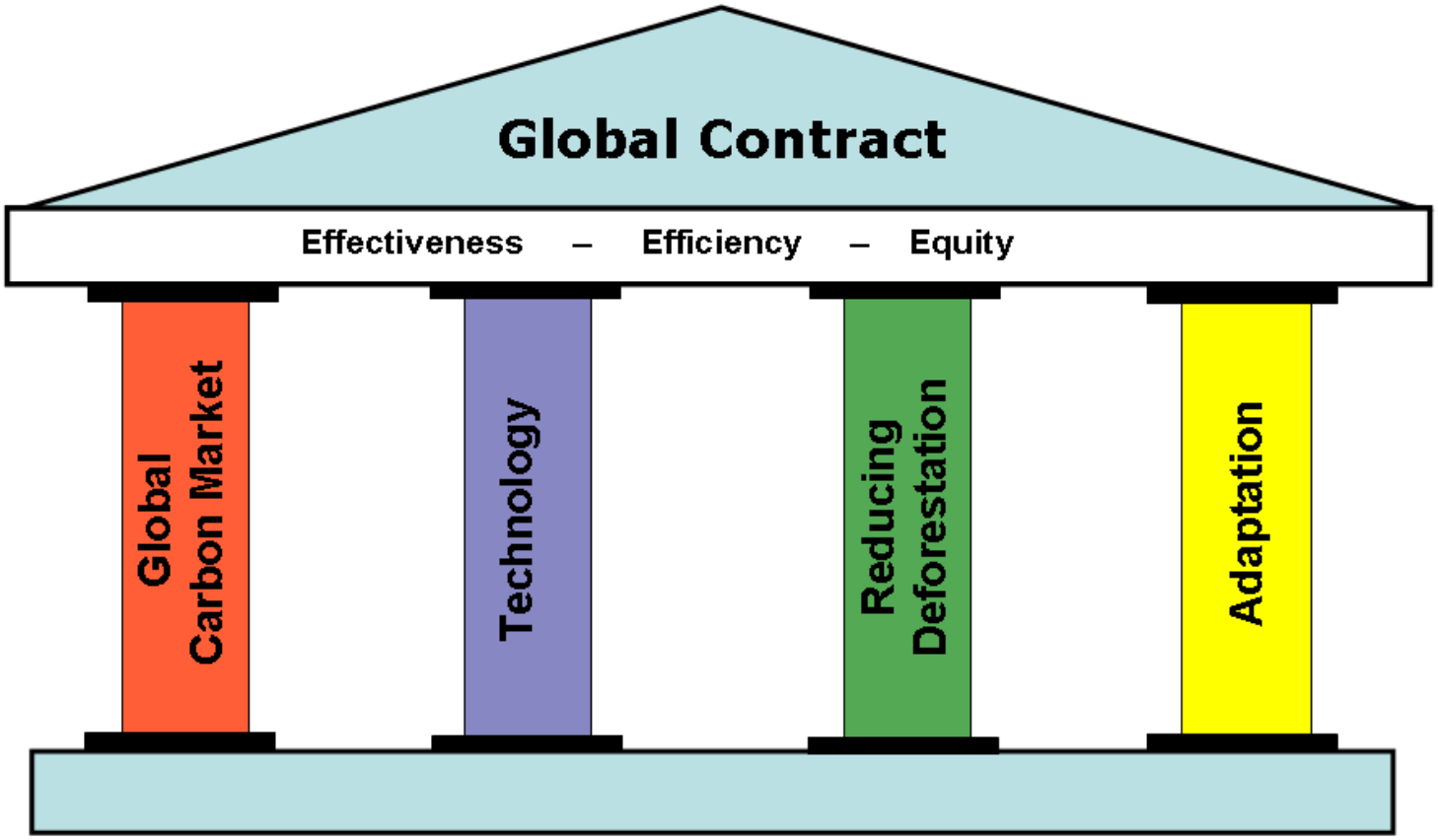
# The Supply-side of Global Warming




Cumulative historic carbon consumption (1750-2004), estimated carbon stocks in the ground, and estimated future consumption (2005-2100) for business-as-usual (BAU) and ambitious 400-ppm-CO2-eq. scenario.

*Source: Kalkuhl, Edenhofer and Lessmann 2009*

# Architecture of a Global Contract



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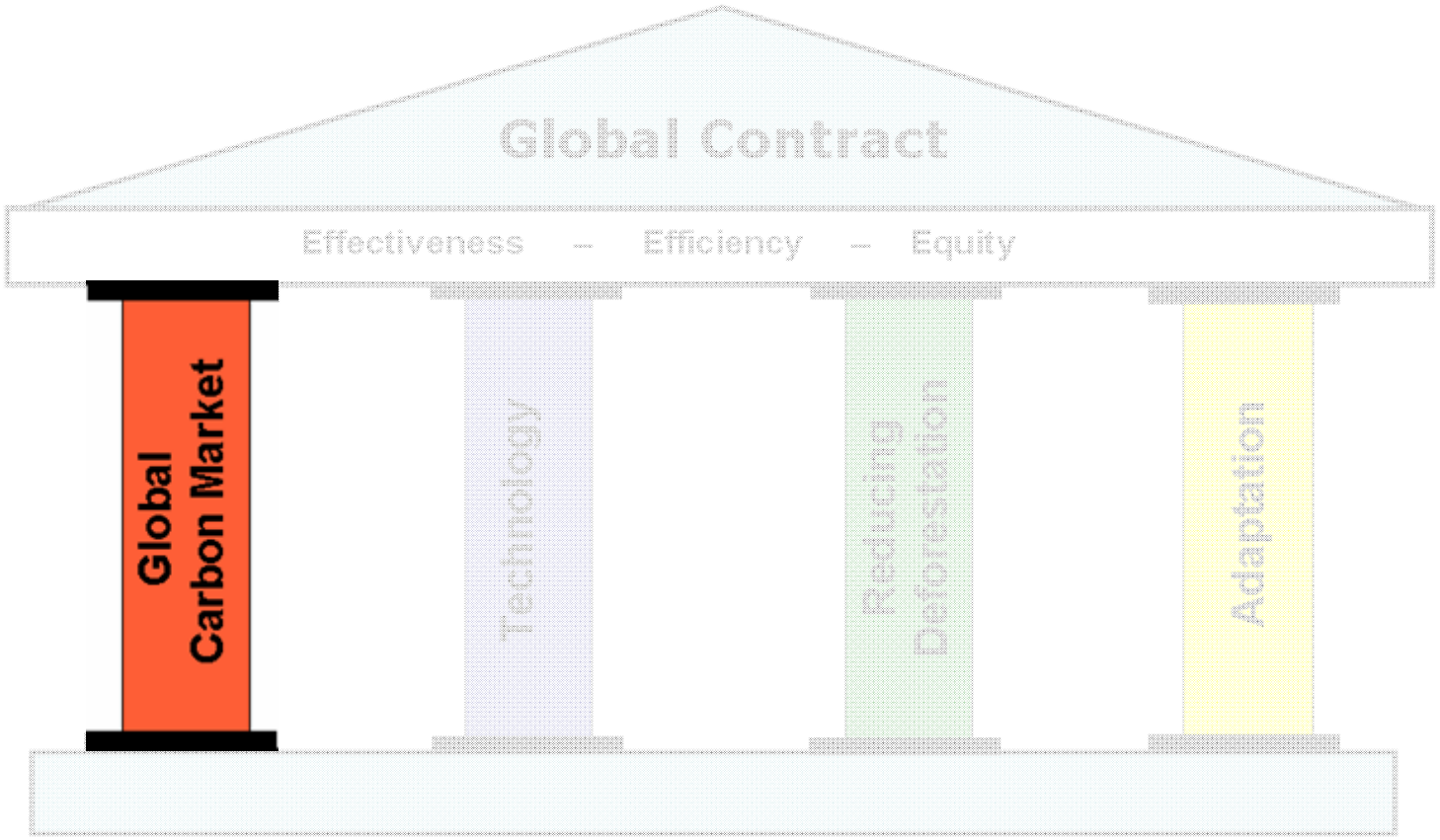
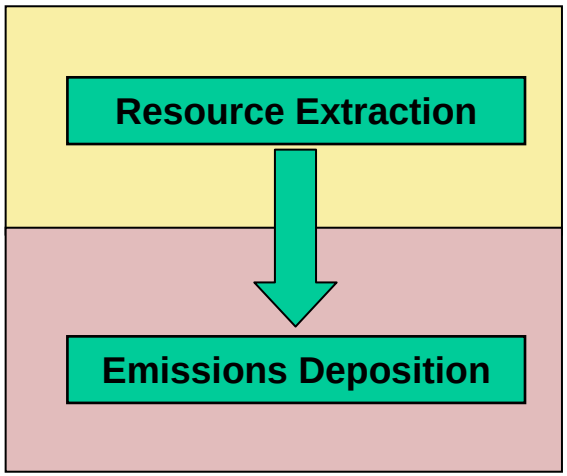


# Lessons from the “Green Paradox“




**Conventional Pigouvian tax**

**Central control of extraction**

**Dynamic (non-linear) Pigouvian tax**

**Decreasing cash flow tax or subsidies on non-extraction**

**Capital income tax**

**Emissions trading scheme**

**Conventional Pigouvian tax** cannot solve the incentive problem for stock-pollutant ➔ inefficient

**Control of extraction and complete absorption of resource rent** ➔ information and implementation problems

**Dynamic (non-linear) Pigouvian tax** is optimal but difficult to implement

**Decreasing cash flow tax or subsidies on non-extraction:** Credibility, commitment and distribution problems

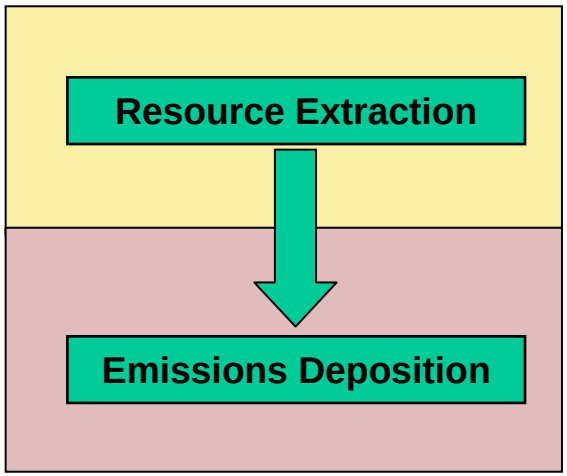
**Capital income tax:** Limited effectivity, vulnerable to other distortions on capital markets

➔ Internalizing damages might not be feasible

➔ “Decentralized“ extraction-deposition problem of carbon stocks might not exist

➔ Emissions trading scheme – an alternative?

# Lessons from the “Green Paradox“




Conventional Pigouvian tax

Central control of extraction

Dynamic (non-linear) Pigouvian tax

Decreasing cash flow tax or subsidies on non-extraction

Capital income tax

**Emissions trading scheme**

**Emissions trading scheme (ETS):**

- Determines aggregated extraction path
- But leaves flexibility to resource owners:
  - What-flexibility: coal, oil, gas, conventional/unconventional
  - When-flexibility: if intertemporal flexibilty is implemented

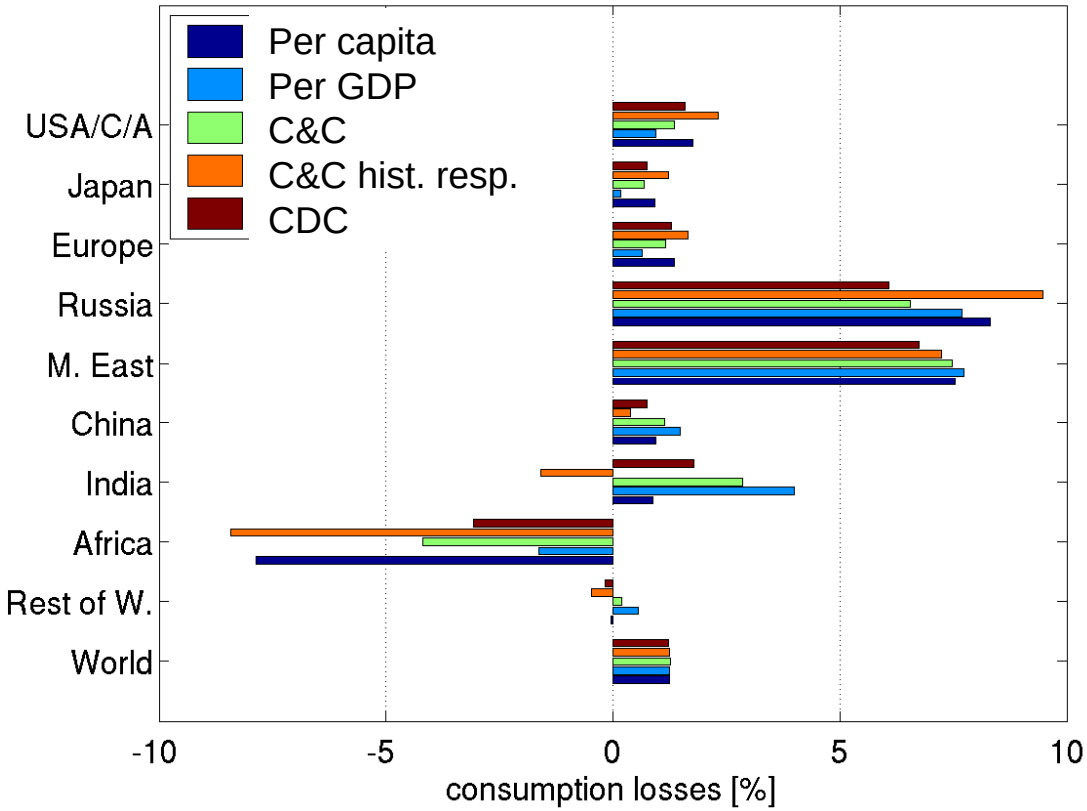
➔ How to determine caps?

➔ How to organize intertemporal permit trade?

➔ What happens to the resource rents?

... to be explored

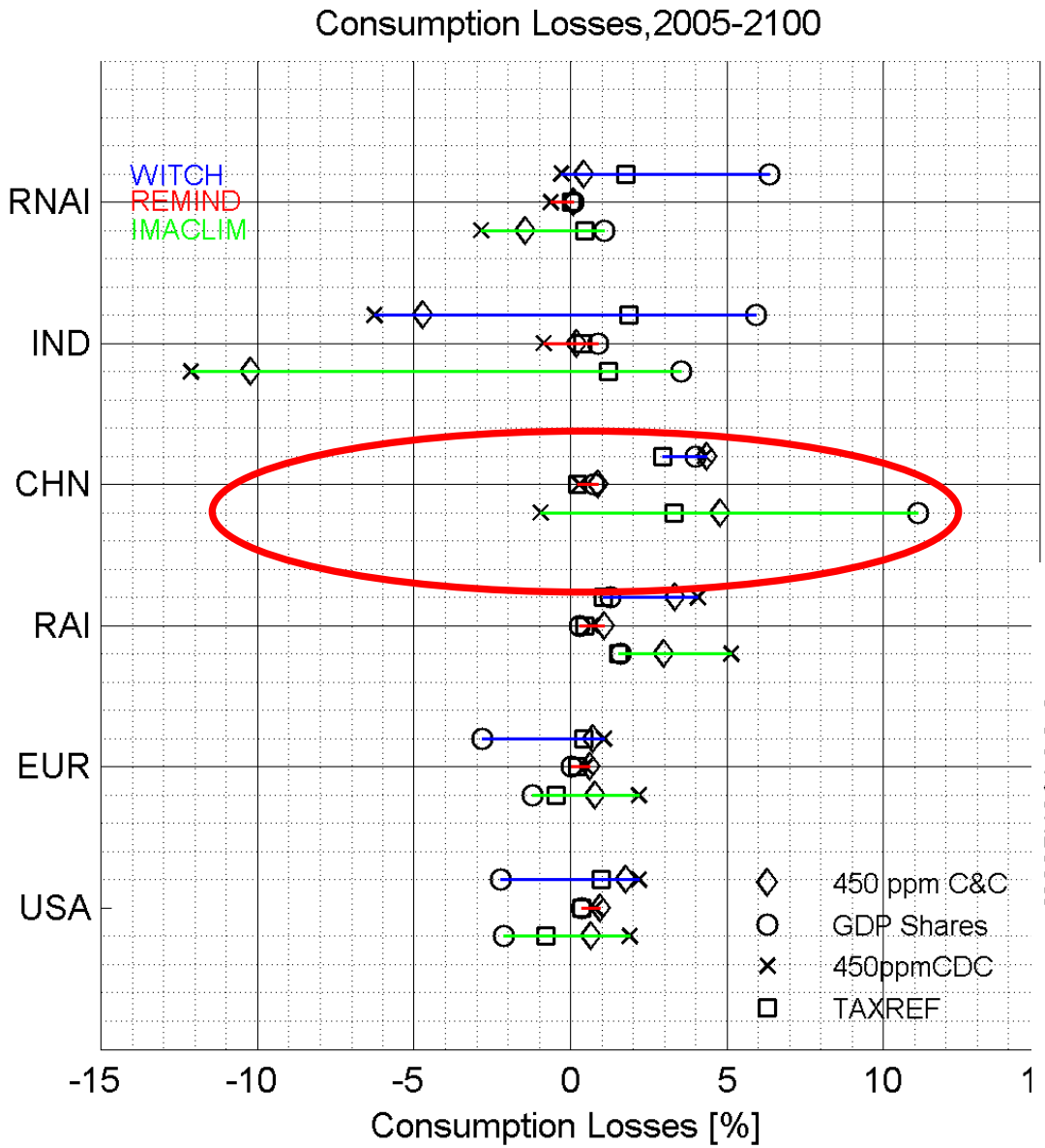
# Regional Mitigation Costs

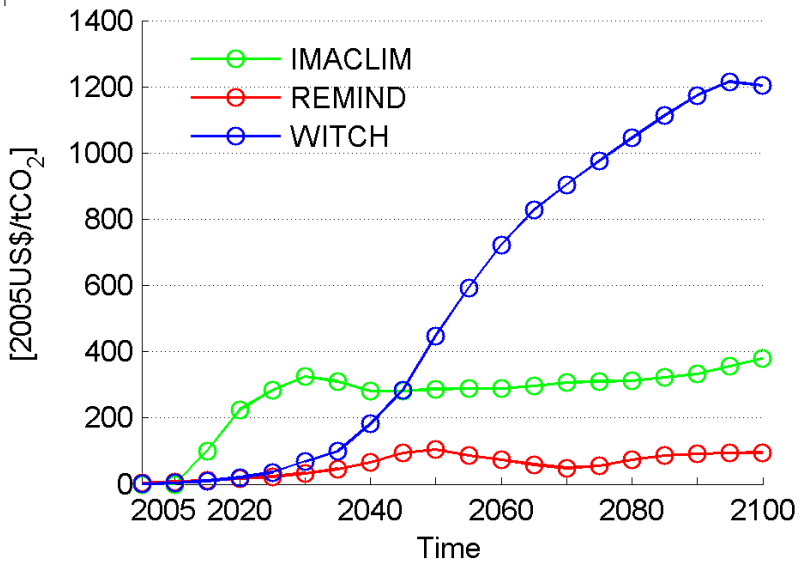



*Knopf, 2009*

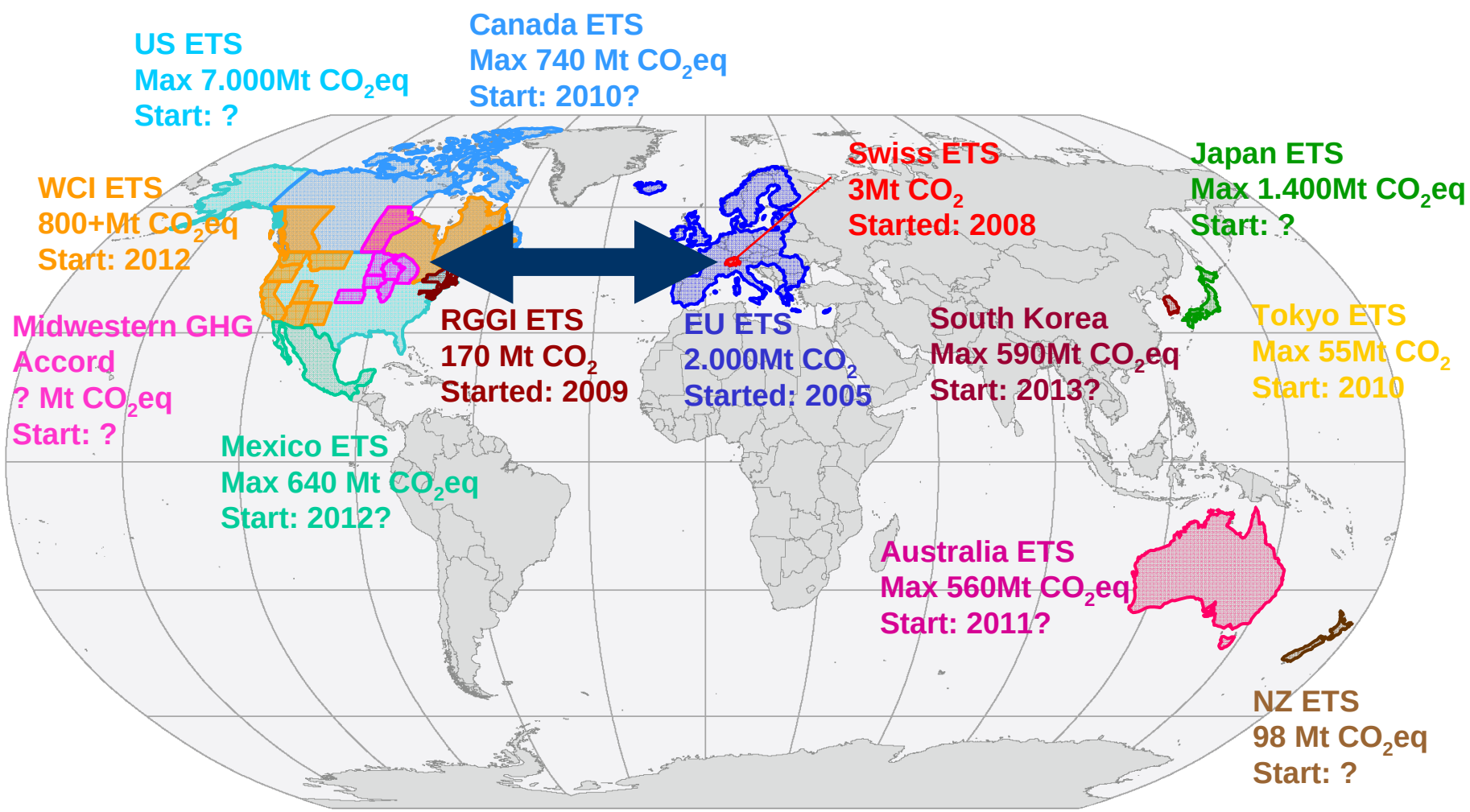
Will permit trade create new rent-seeking economies?

# Allocation rules and regional distribution of mitigation costs



# Domestic Cap and Trade: Linking Emerging $CO_2$-Markets



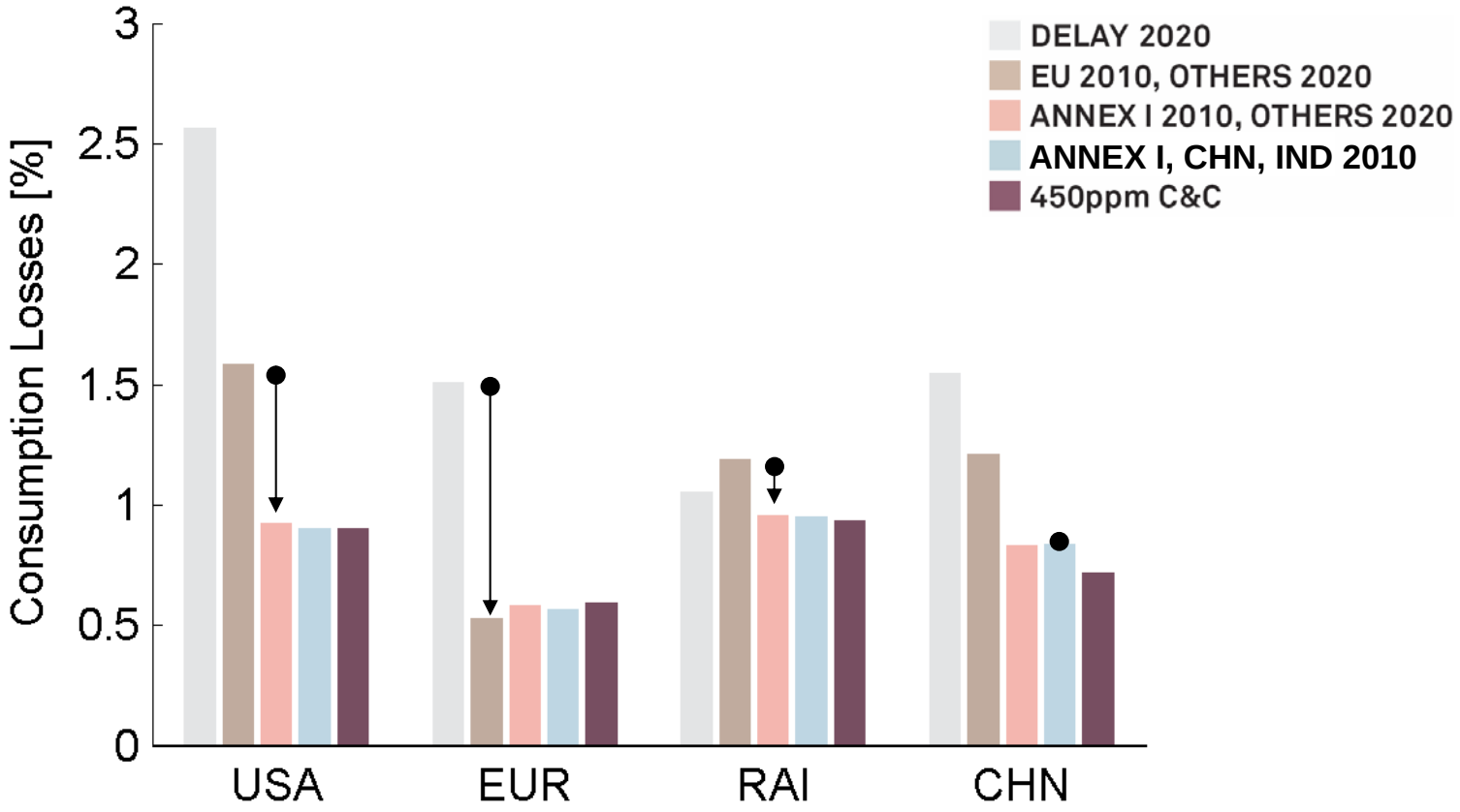

***"The European Commission is preparing to call on the United States to create a trans-Atlantic system of carbon trading"***

- Herald Tribune, Friday, January 23rd, 2009

*Source: Flachsland (2009)*

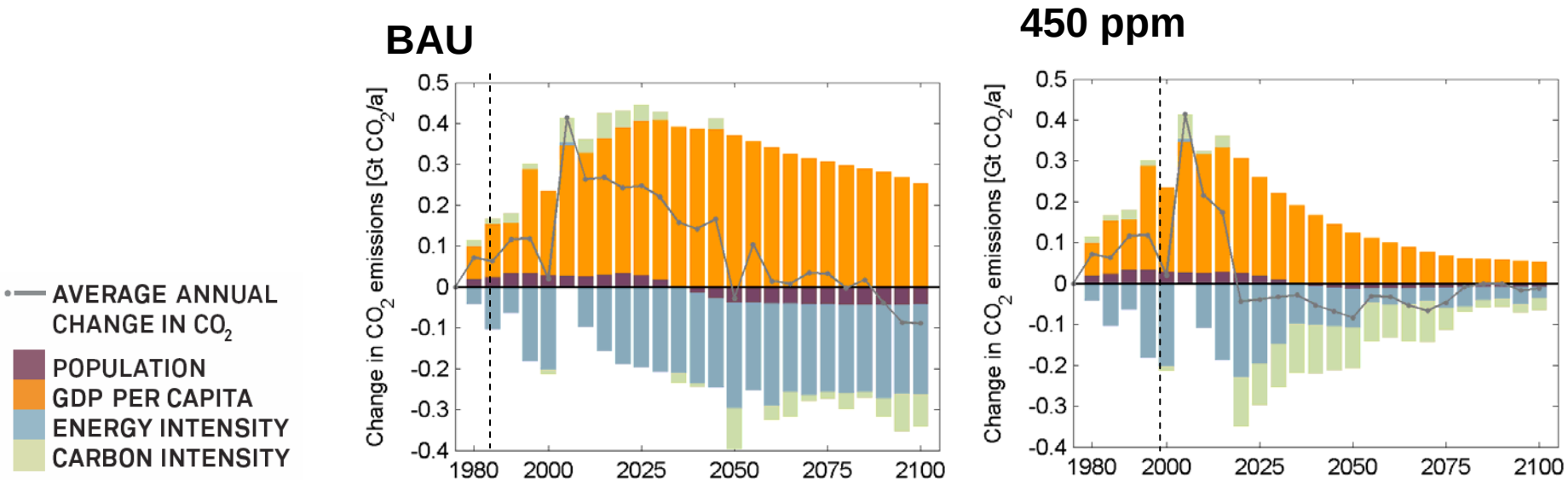
# The Value of Early Action

In a world serious about achieving 2°C, early action is beneficial to China:

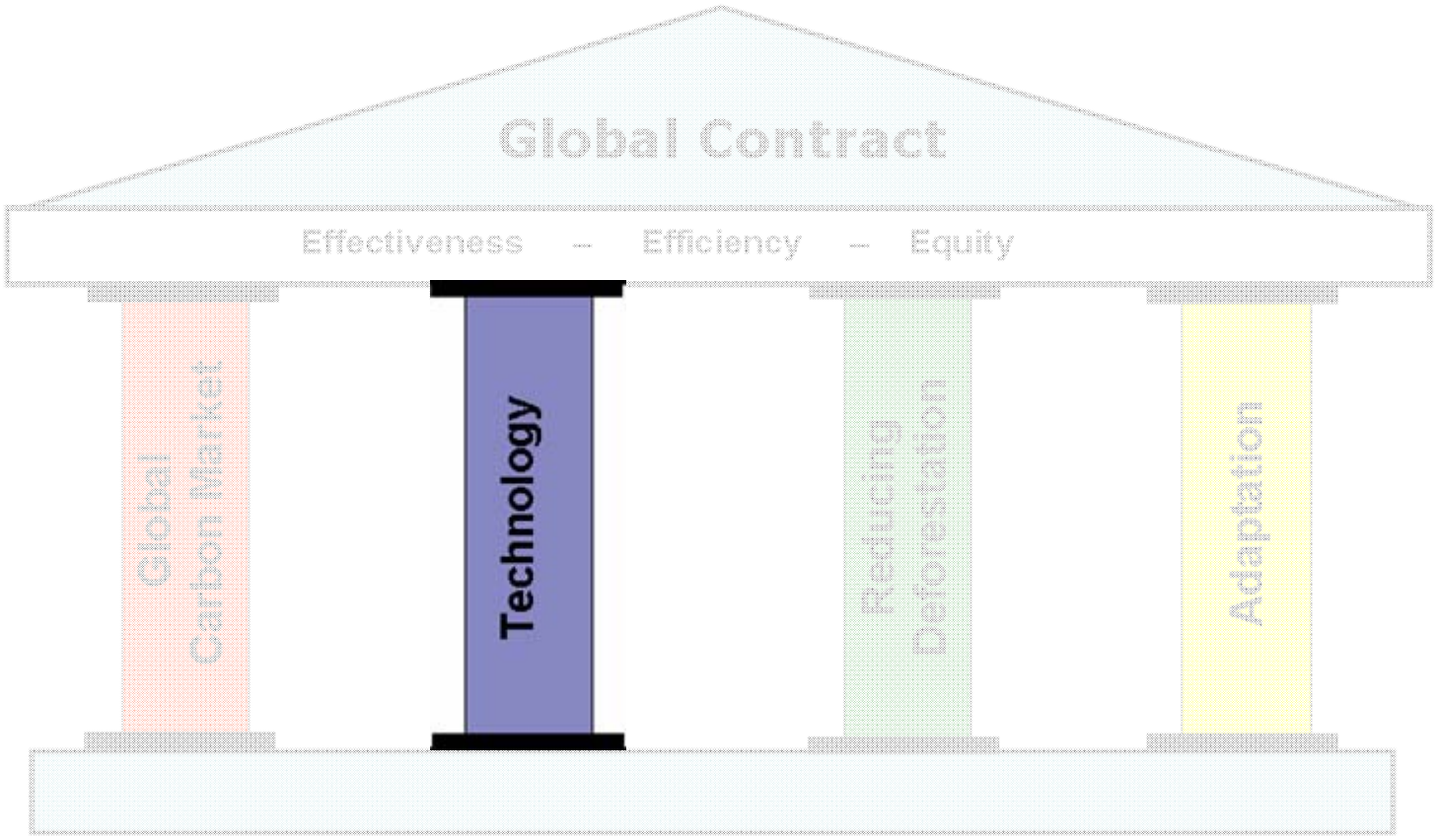


# Macro-Economic Effects of Climate Policy

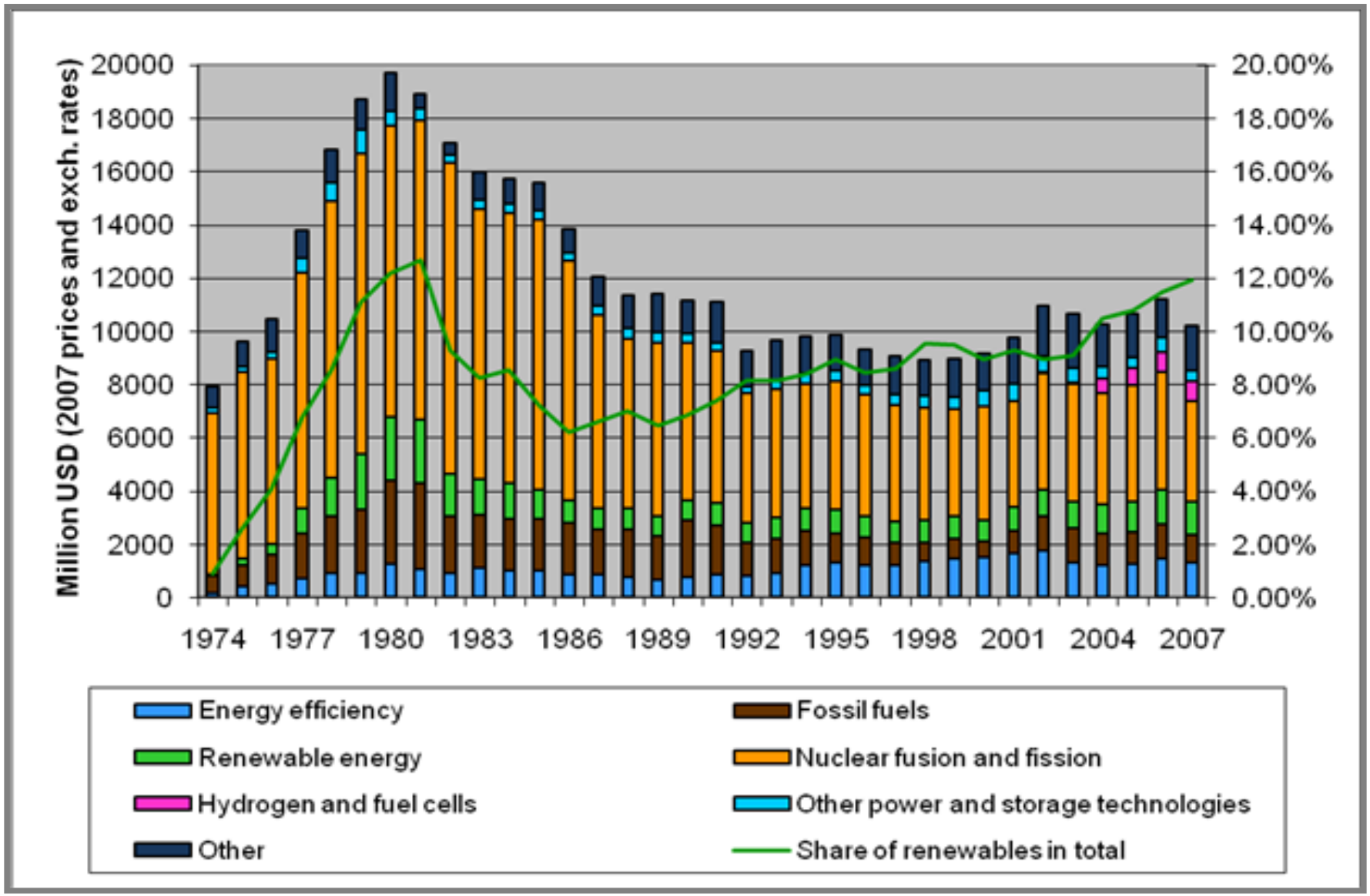
## Result for China



# Architecture of a Global Contract

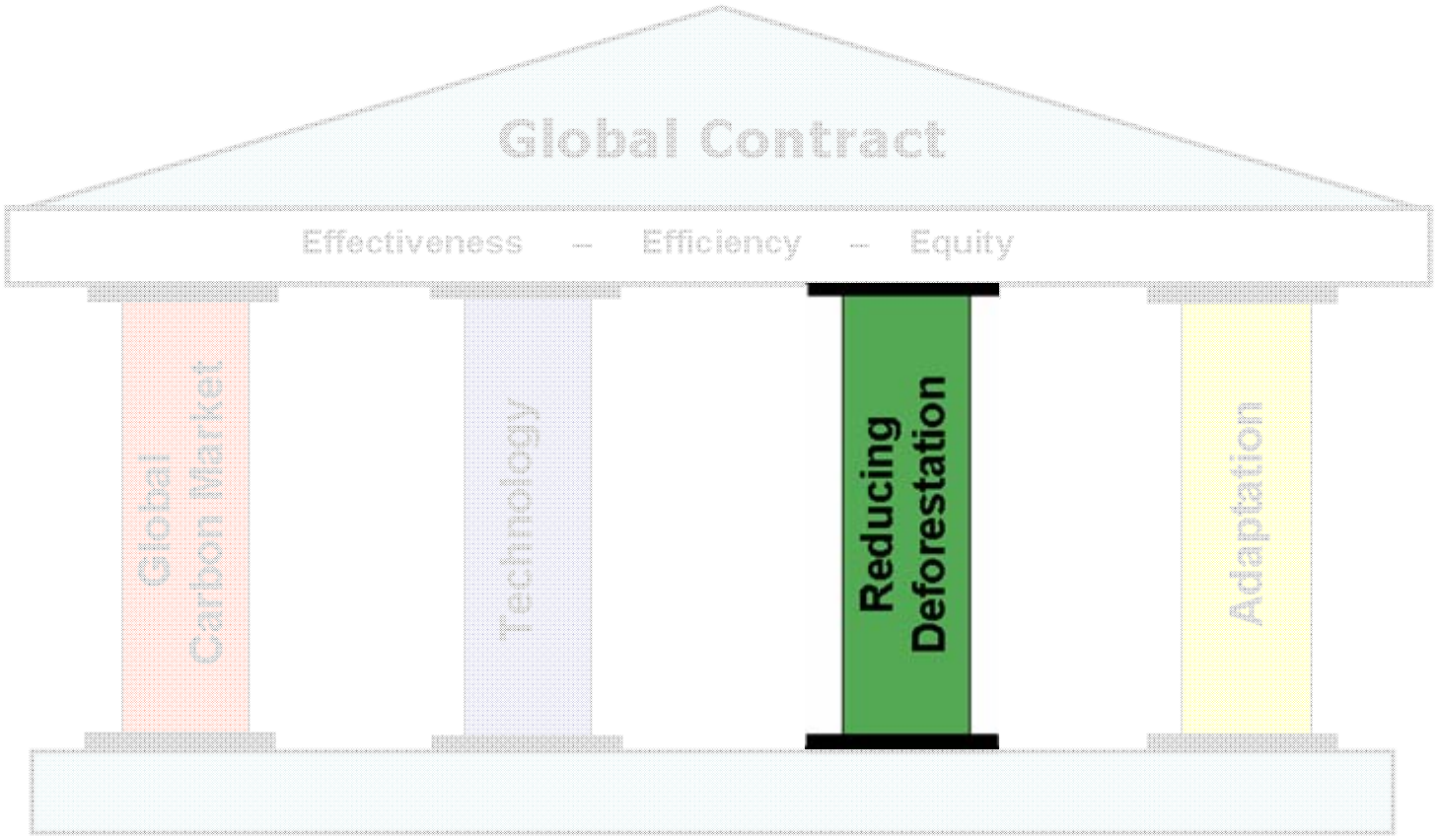


# R&D-Investment in Energy Technologies

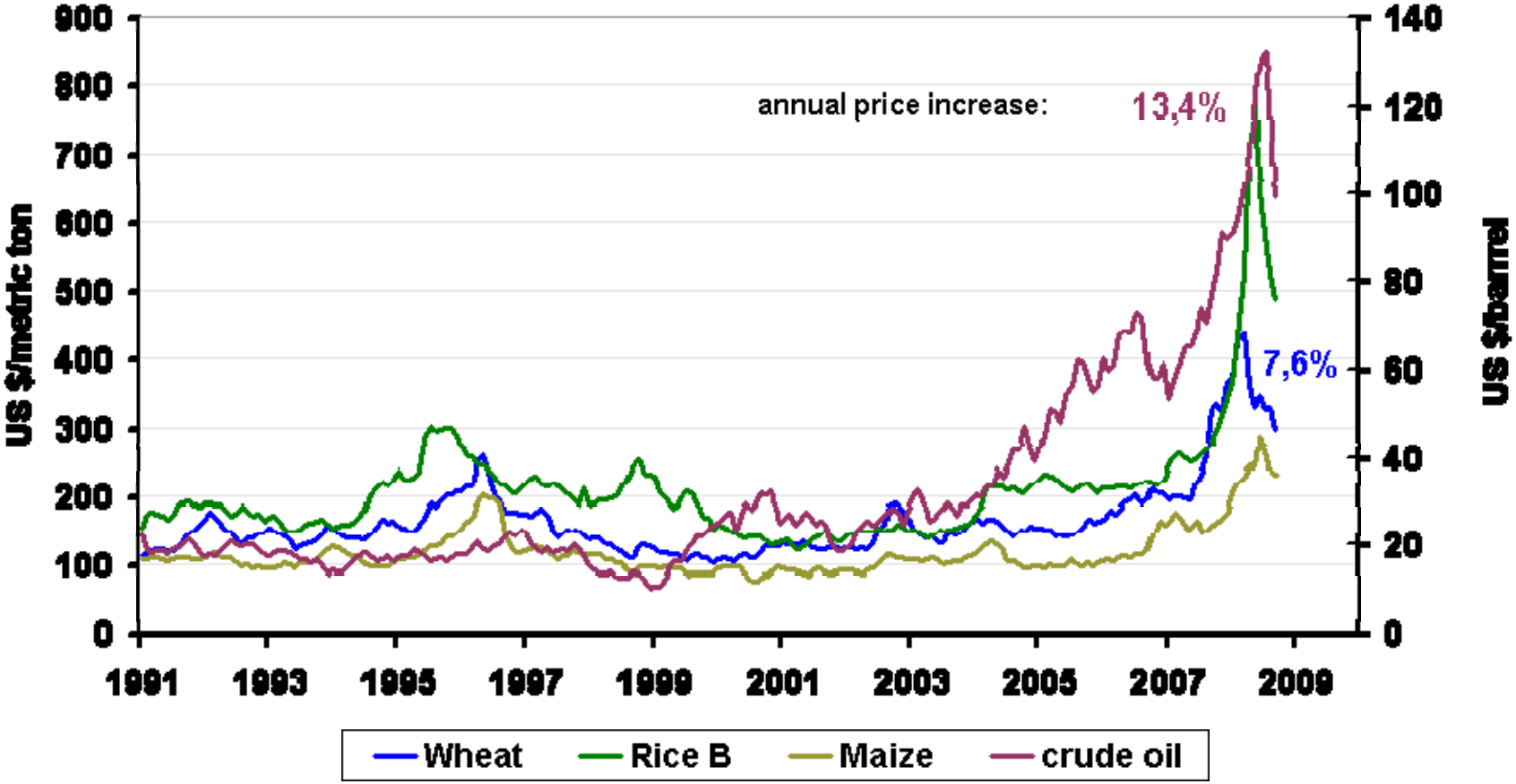



*Source: Updated version of IPCC (2007), AR4*

# Architecture of a Global Contract



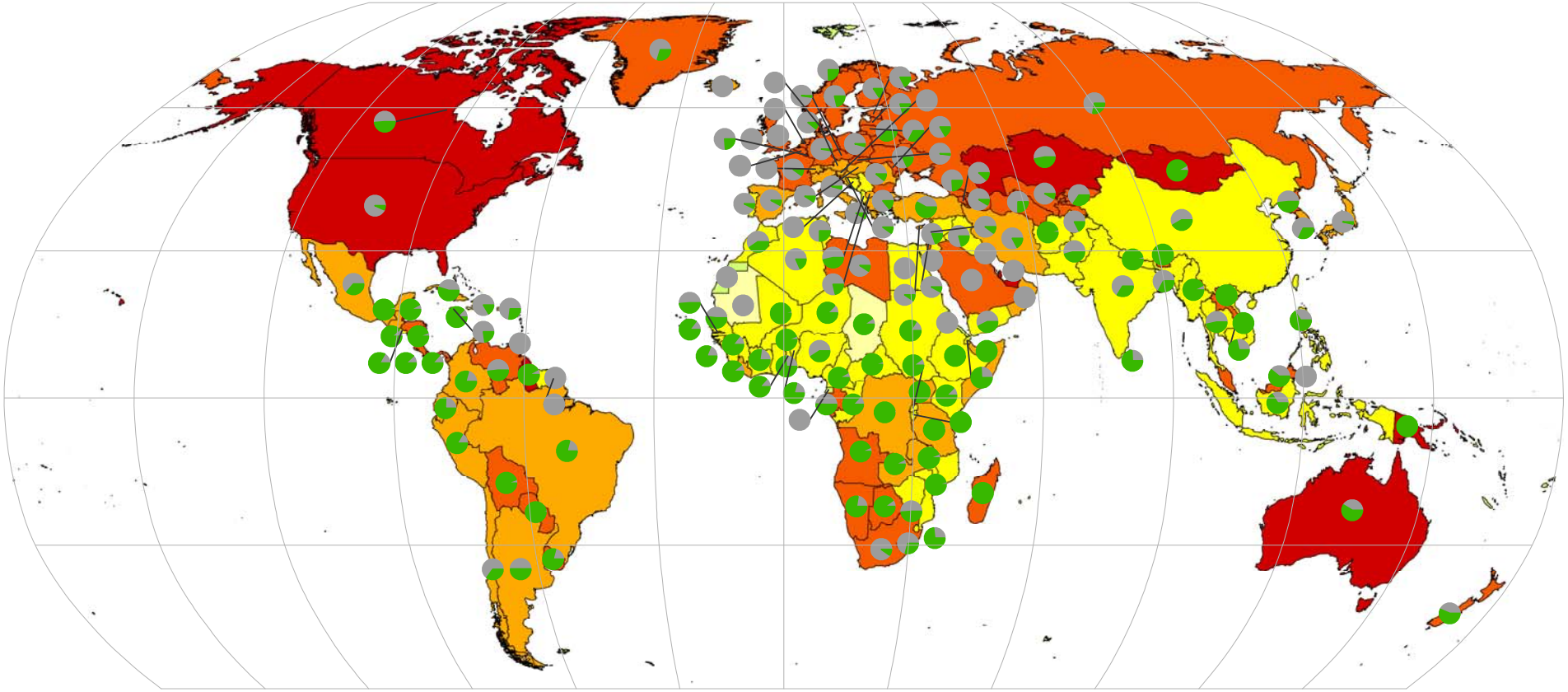
# Market Prices for staple foods and crude oil
# monthly averages 1991 - 2008




*Source: IMF; FAO International Commodity Prices*

# Reducing Deforestation: Fossil vs. LUCF $CO_2$ Emissions

## $CO_2$ emissions per person and year, 1950 - 2003



**$CO_2$ emissions from fossil fuel combustion and cement production, and including land use change (kg C per person and year from 1950 - 2003)**

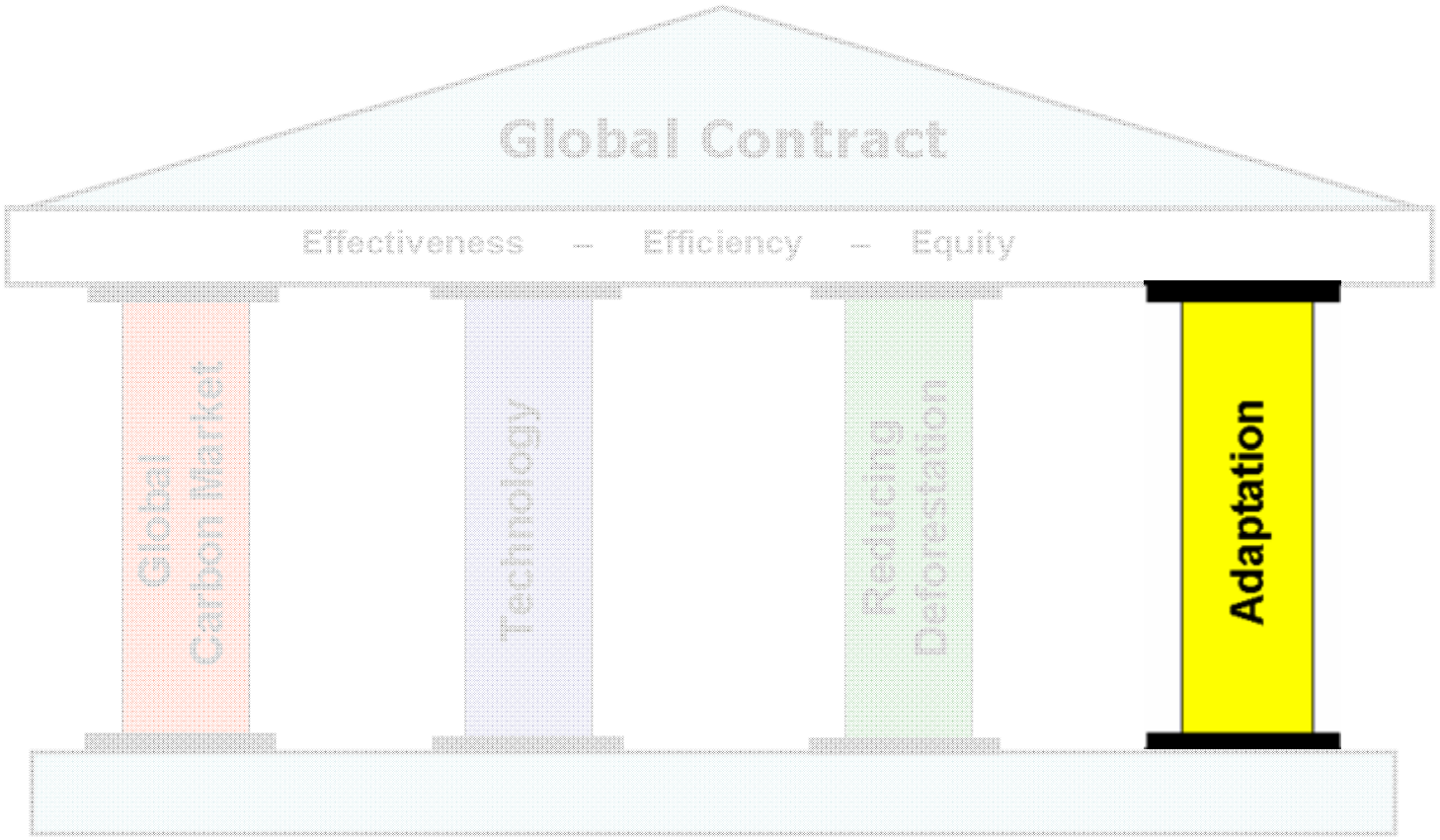
-1000 - 0
0 - 100
100 - 1000
1000 - 2000
2000 - 5000
5000 - 15000

**Ratio**

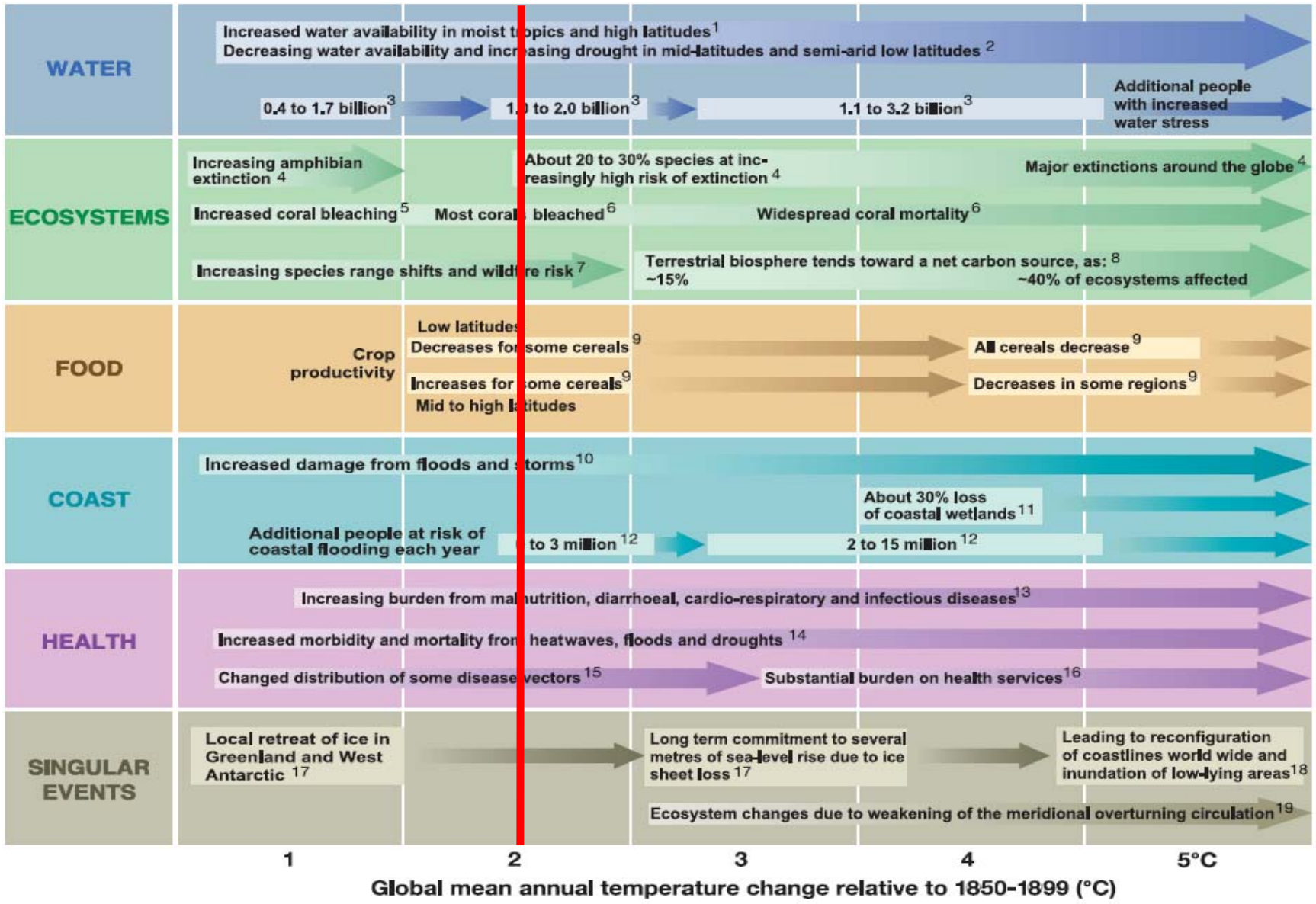
Emissions per year from fossil fuel combustion and cement production

Emissions per year from land use change

# Architecture of a Global Contract



# Mitigation and Adaptation



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