Global Sustainability Summer School
Santa Fe Institute
21 Jul 2010

State of Climate Economics & Policy

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PIK

Outline

Part A: Economic and Technical Instruments

1. Energy System Transformation
2. Economic Instruments & Incentives
3. Seven Cardinal Innovations
4. Transition Management

Part B: International Climate Policy

1. The „Post-Copenhagen Syndrome“
2. The Budget Approach
3. More Pragmatic Approaches
4. Beyond CO_2

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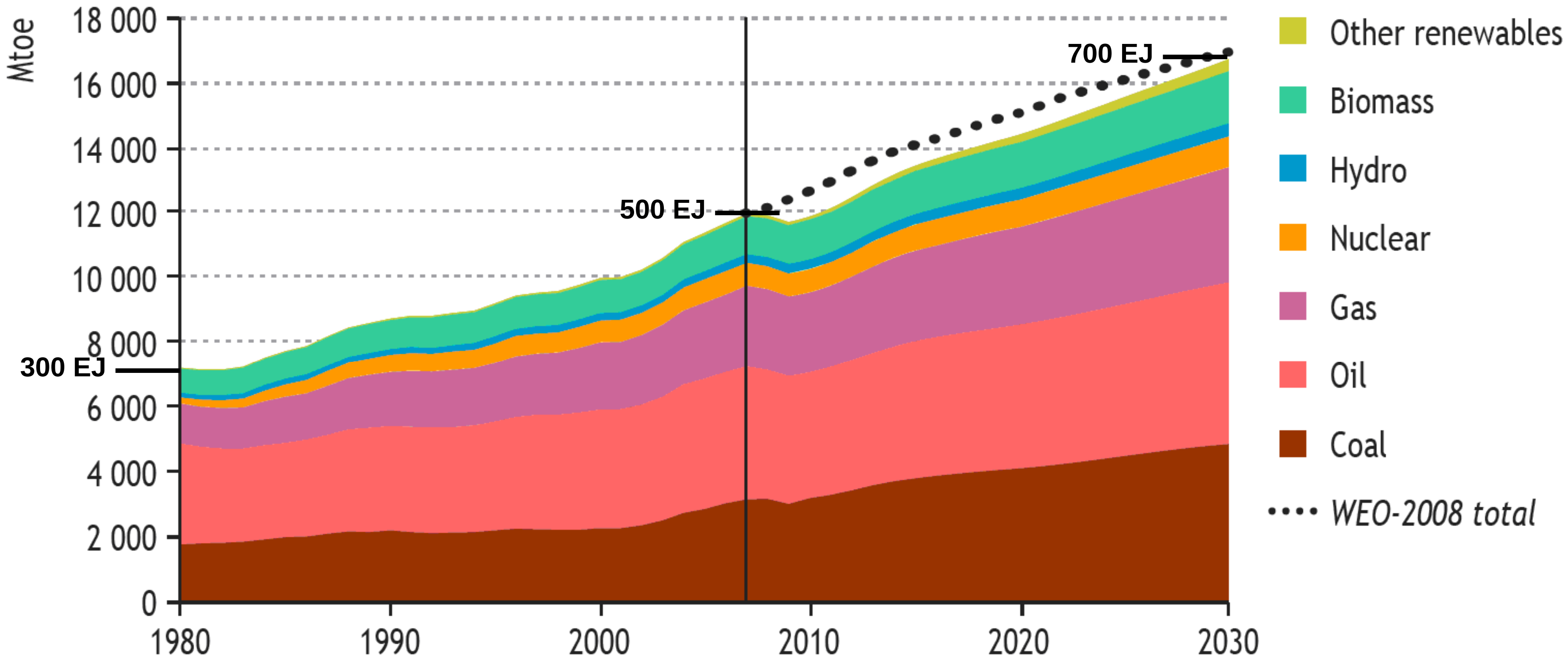
World Primary Energy Demand by Fuel in the Reference Scenario



Source: World Energy Outlook 2009

Feasibility of Low Stabilization Pathways

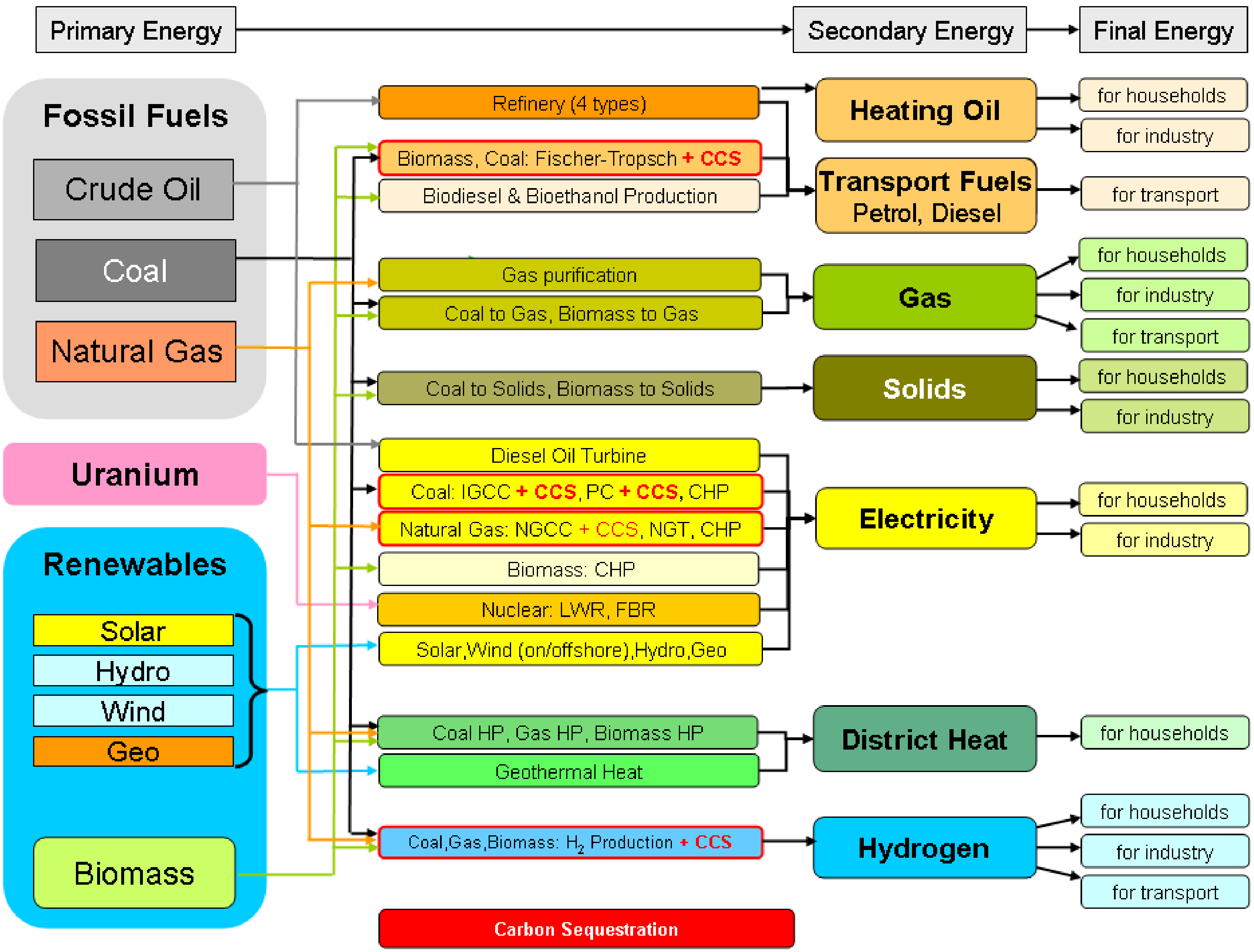
ADAM Model Comparison

Members:

PIK (REMIND model):	O. Edenhofer, M. Leimbach. L. Baumstark, B. Knopf
PSI (MERGE model):	T. Hal, S. Kypreos, B. Magné
U Cambridge (E3MG model):	T. Barker, S. Scrieciu
ENERDATA (POLES model):	A. Kitous, E. Bellevrat, B. Chateau, P. Criqui
PBL (TIMER):	D. van Vuuren, M. Isaac
Compilation of comparison:	B. Knopf

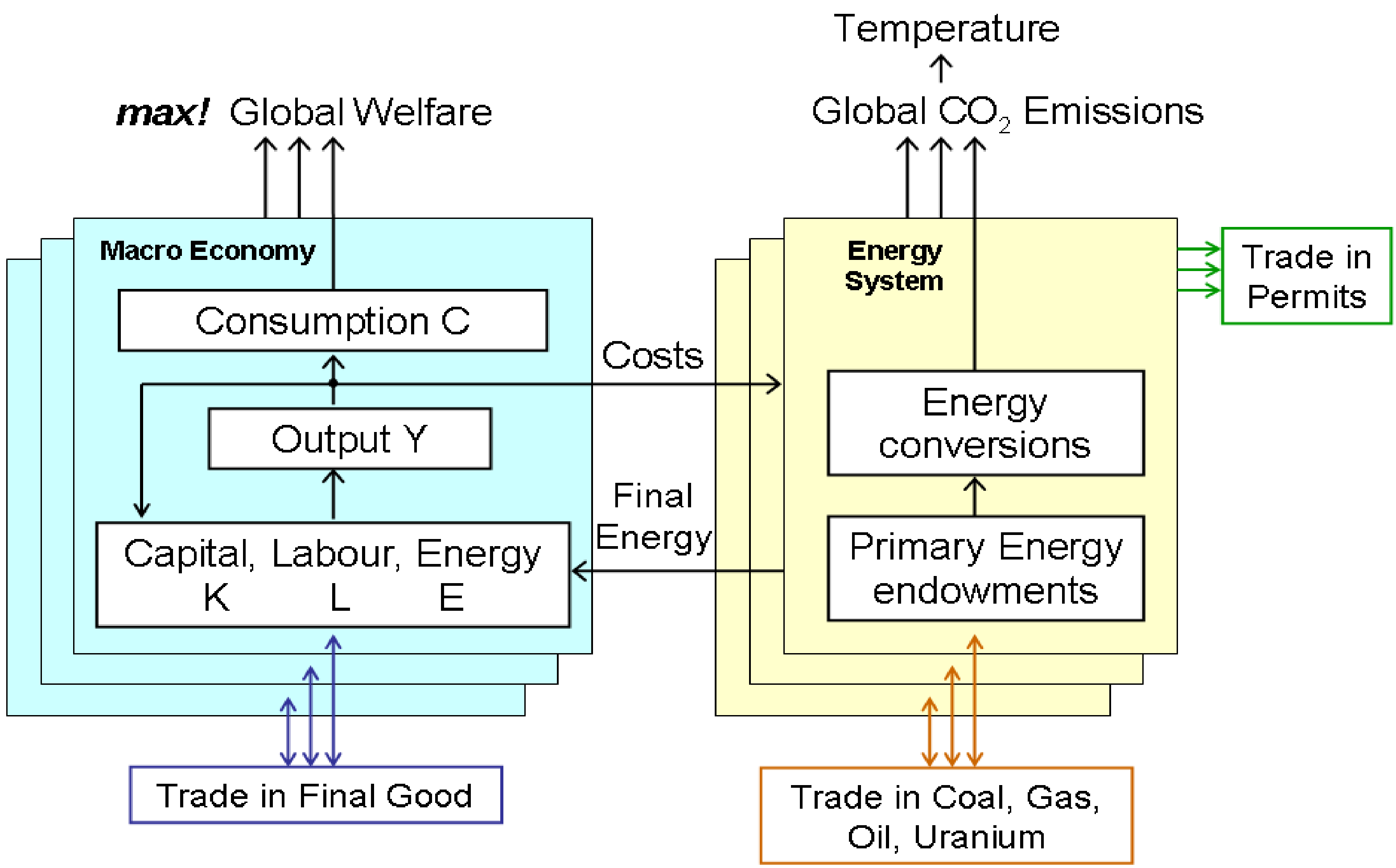
Sixth Framework Programme

The Energy System in REMIND



(Edenhofer et al. 2010)

Economic feasibility
Structure of REMIND

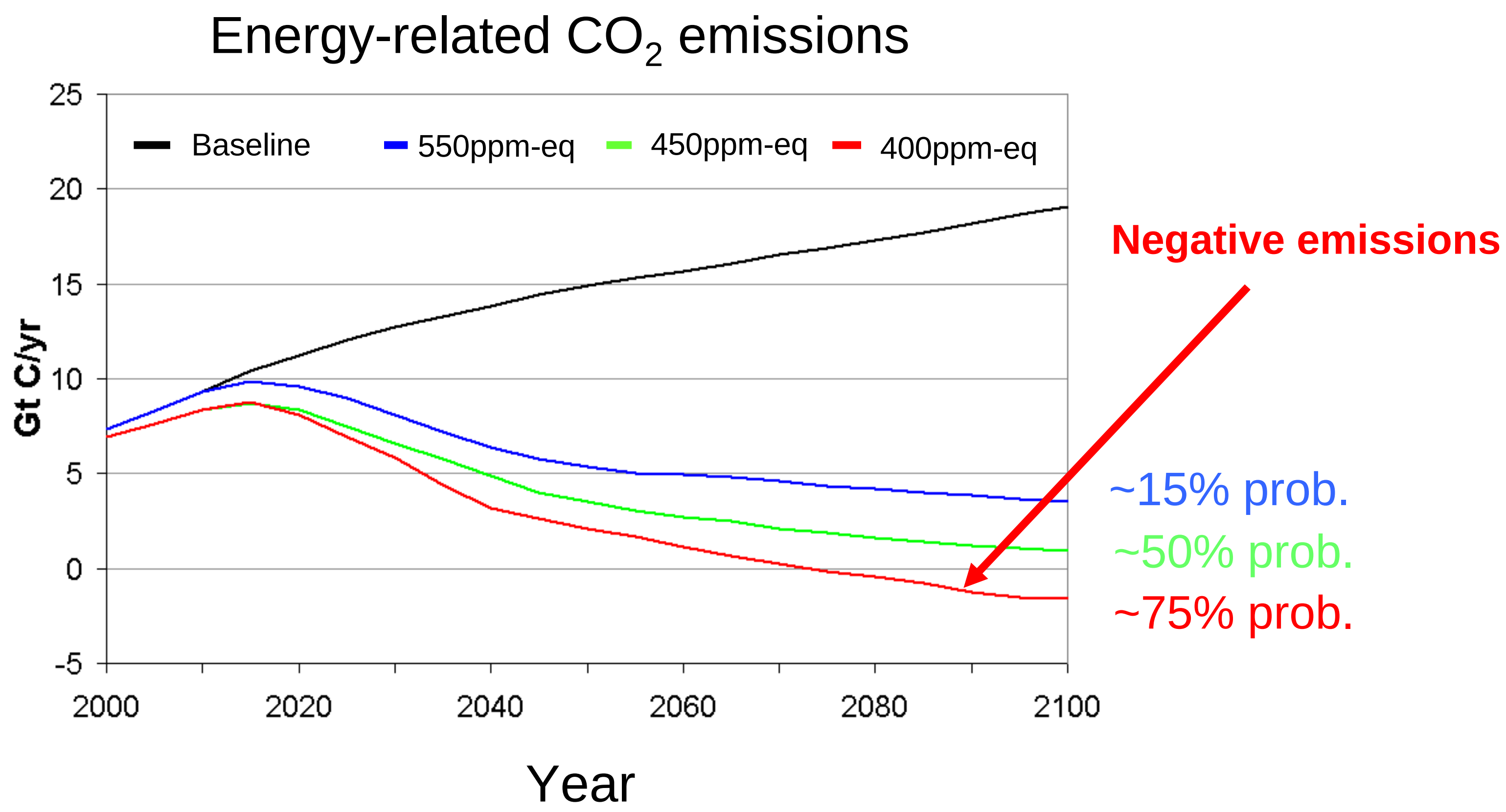


(Edenhofer et al. 2010)

Exemplary Stabilization Pathways

ADAM model comparison:

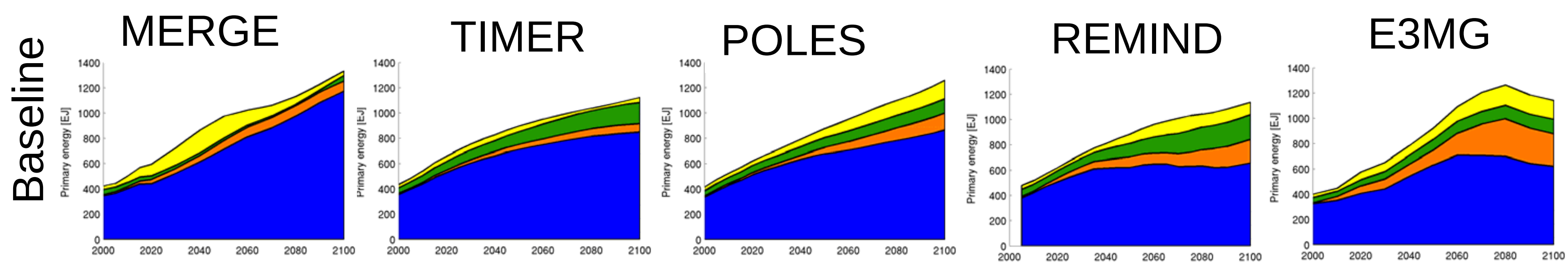
Analysis of 3 stabilisation targets with different probabilities to reach the 2° target: 550ppm-eq, 450ppm-eq, 400ppm-eq



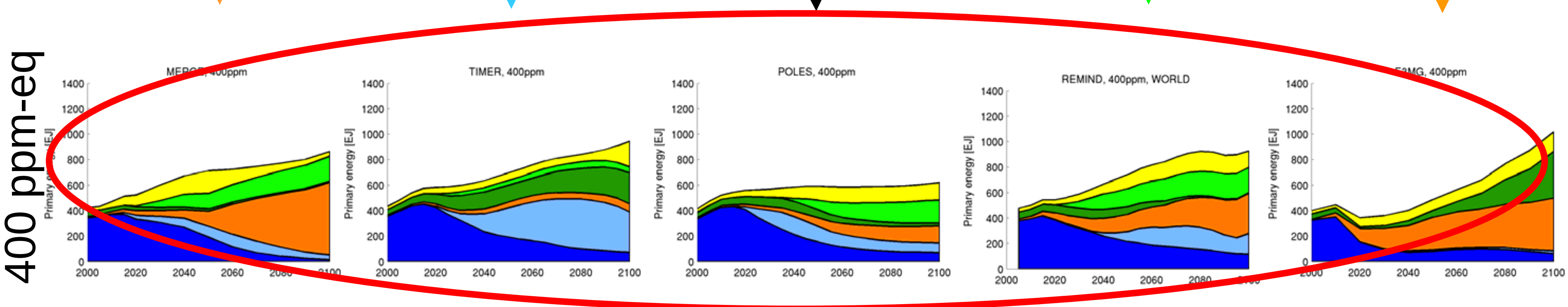
(Knopf, Edenhofer et al. 2009)

Transformation of the Energy System

models →



Many different pathways to transform the energy system



➔ Different possibilities to reach low stabilisation

➔ 400ppm can be achieved by all models

(Knopf, Edenhofer et al. 2009)

Investment Strategies – Insights From RECIPE

REPORT ON ENERGY AND CLIMATE POLICY IN EUROPE

RECIPE

THE ECONOMICS OF DECARBONIZATION

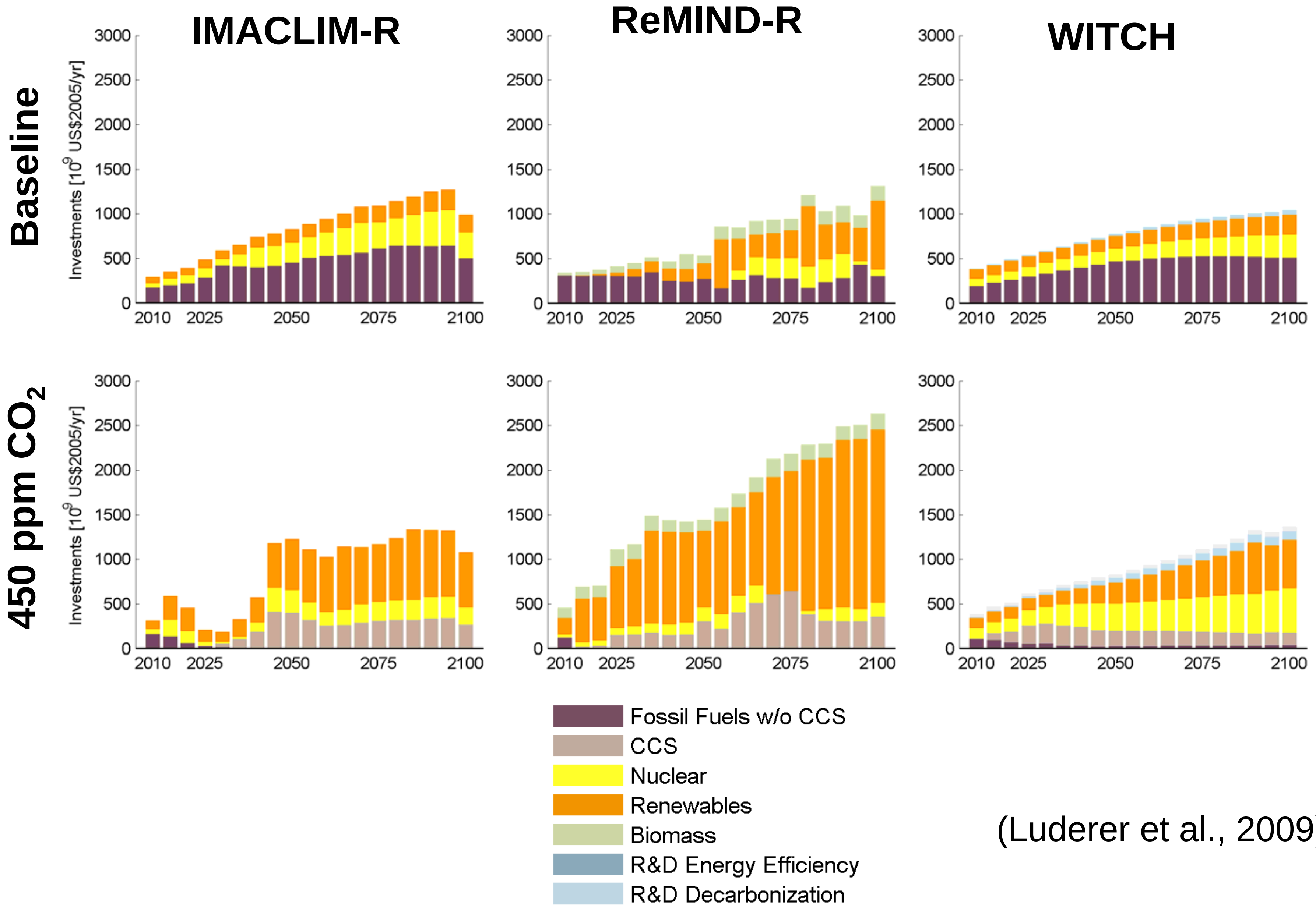
PIK

CMCC
Centro Euro-Mediterraneo per i Cambiamenti Climatici

CIRED

UNIVERSITY OF CAMBRIDGE | Electricity Policy Research Group

Energy System Investments



(Luderer et al., 2009)

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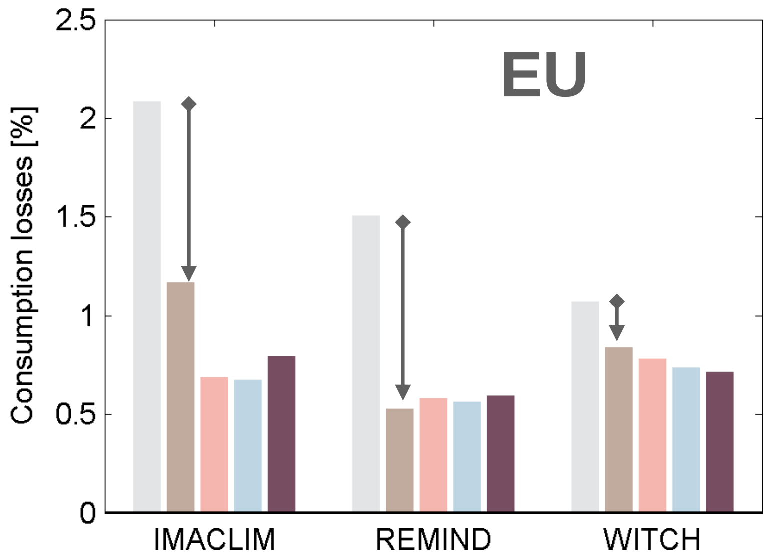
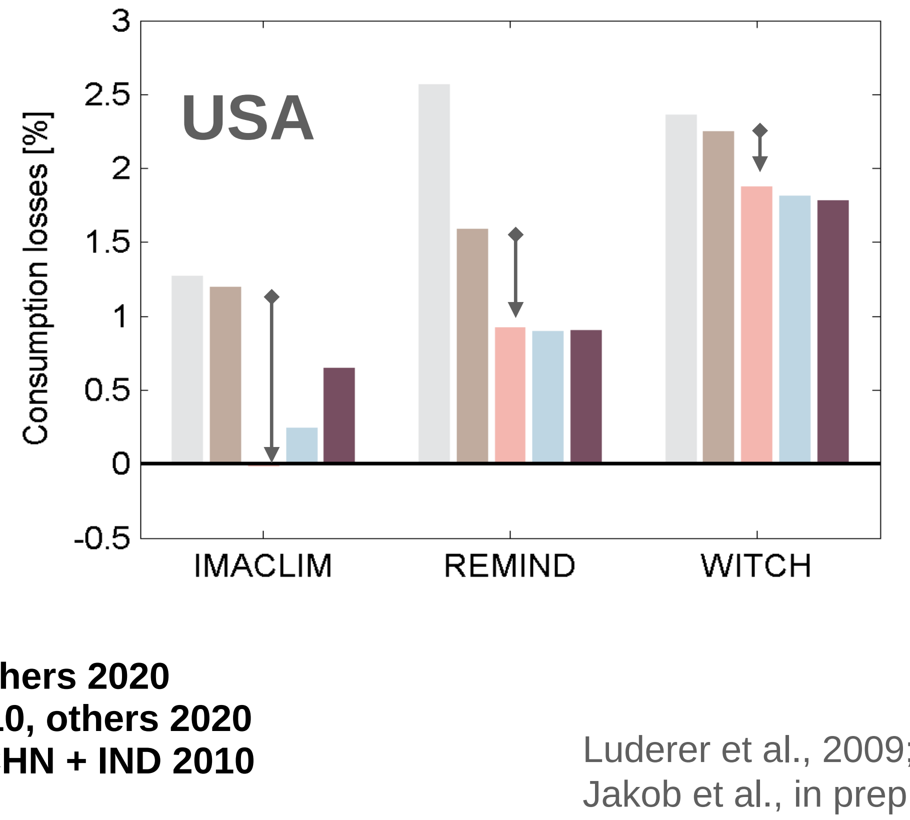
The Case for Early Action





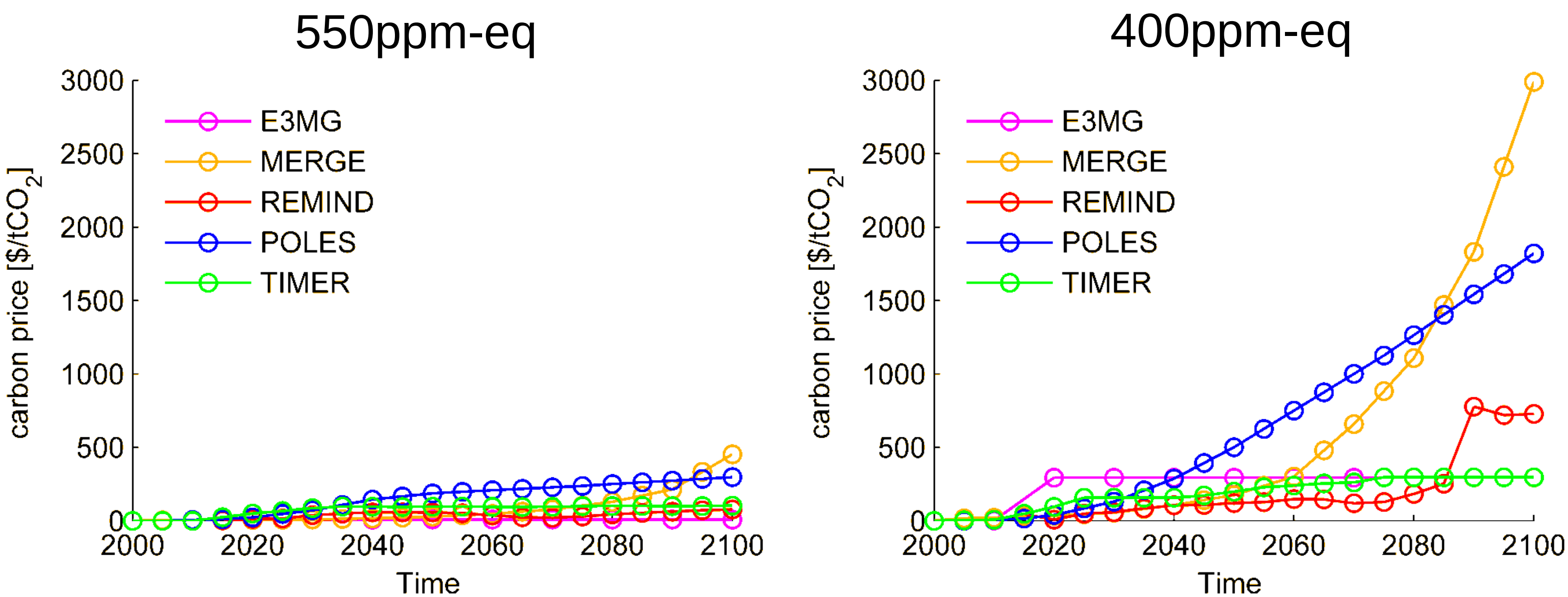
Luderer et al., 2009;
Jakob et al., in prep.

➔ If a global climate agreement is delayed until 2030, stabilization at 450ppm CO_2 or below will become infeasible

➔ The EU and USA enjoy a ‘first mover advantage’, i. e. lower mitigation costs even if other countries start later → benefit of anticipation

Instruments of Change

Carbon Price Development



Neo-classical approach (e.g., in REMIND, MERGE): perfect market, perfect foresight

→ equivalence of emission trading and tax system

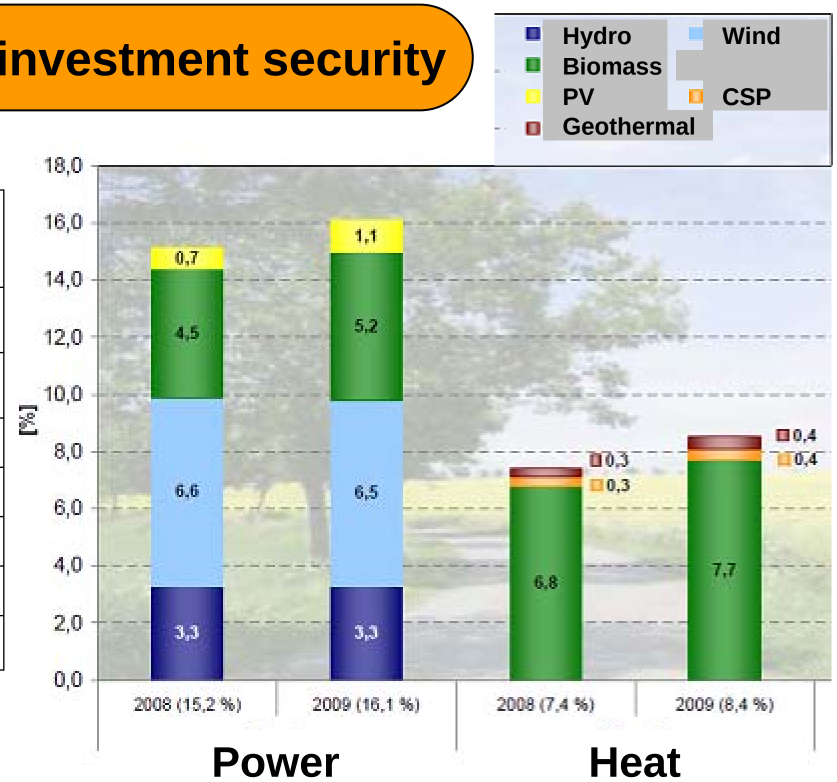
(Edenhofer et al. 2010)

Feed-in Tariffs in Germany

- **Guaranteed grid access for renewable energy projects: priority connection**
- **Feed-in priority for renewable power into the grid**
- **Fixed feed-in tariffs guaranteed by law: investment security**

Technology	Payment time [years]	Feed-in tariff [€cent/kWh]	Annual degression
Wind power (onshore)	20	9.70 (…5.02)**	1,0%
Wind power (offshore)	20	15.0 (…3.5)**	5% as of 2015
Photovoltaics	20	31.94 –43.01	8% -10%
Hydro power < 5 MW	20	7.65 -12.67	-
Large hydro > 5 MW	15	3.50 -7.29	-
Biomass	20	7.79 -11.67	1%
Geothermal energy	20	10.5 –16.0	1%

* Additional bonus up to 13 €ct/kWh if renewable raw material is used
** The tariff is paid in the beginning and is reduced during the payment time to the lower level
Sources: Renewables Academy (RENAC); RESA; Ministry for the Environment (BMU)



Global System of Feed-in Tariffs

"Delivering a low carbon energy infrastructure

Actions in the following areas are needed:

- […]

- Technology sharing and financial support, through mechanisms such as globally supported feed-in tariffs for renewable energy, to help developing countries leapfrog to a low carbon economy."

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The Seven Cardinal Innovations

1. Integration of Renewable Energy Sources ("Supersmart Grids")

2. Plus-Energy Houses („Power Houses")

3. Modular E-Mobility („Beyond Storage")

4. Systems-optimized Industrial Production („Cradle to Cradle")

5. Holistic Urban and Regional Planning („Reinvention of Urbanity & Rurality")

6. Sustainable Biomass Management („De- & Anti-Carbonisation")

7. Regenerative Water Supply („Solar Desalination")

The Seven Cardinal Innovations

1. Integration of Renewable Energy Sources ("Supersmart Grids")

DESERTEC Consortium

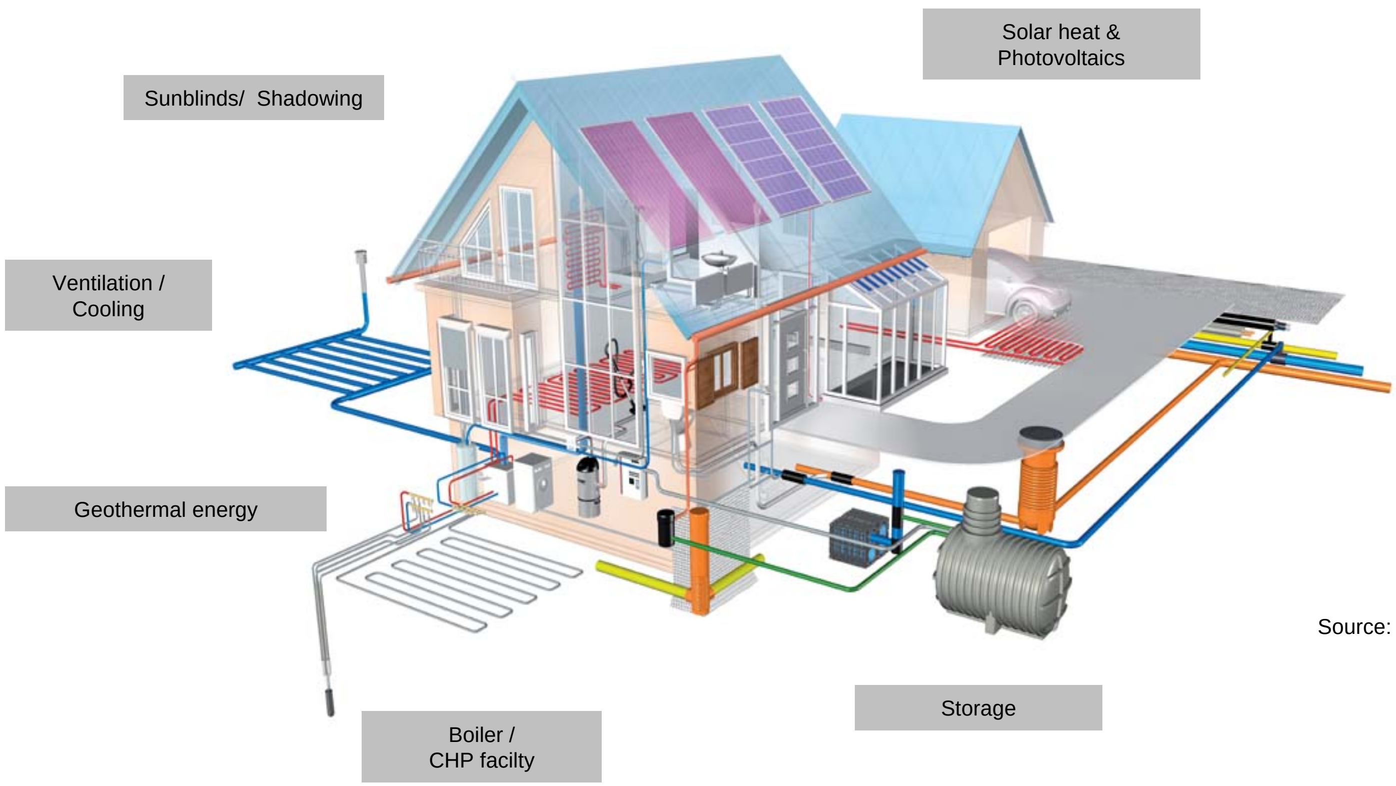
Objectives: solar thermal power plants in deserts of North Africa largely fulfill the electricity demand of producer countries and supply 15% of European electrical power

Estimated costs: EUR 400 billion

RWE
HSH NORDBANK
ABB
SCHOTT solar
ABENGOA SOLAR
SIEMENS
cevital
m+w zander
Deutsche Bank
MAN Solar Millennium
e.on
Münchener Rück Munich Re Group

The Seven Cardinal Innovations

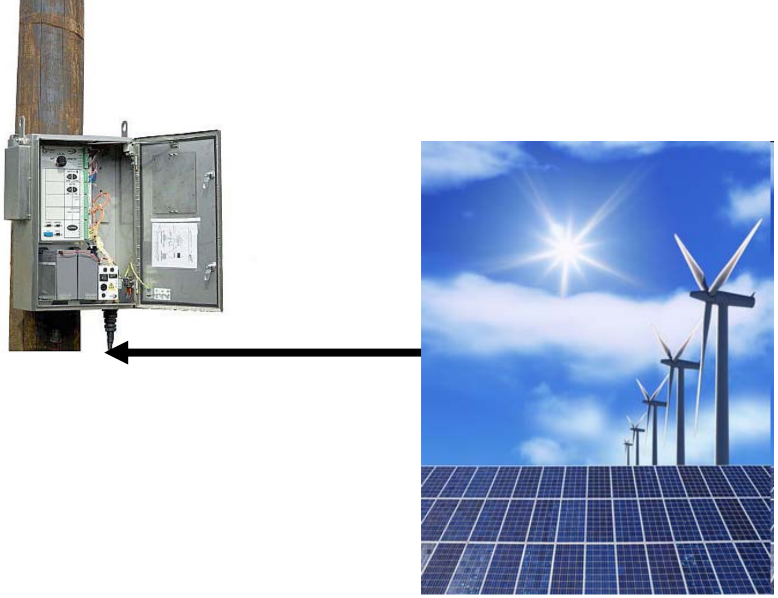
2. Plus-Energy House („Power Houses“)



Source: REHAU AG + Co.

The Seven Cardinal Innovations

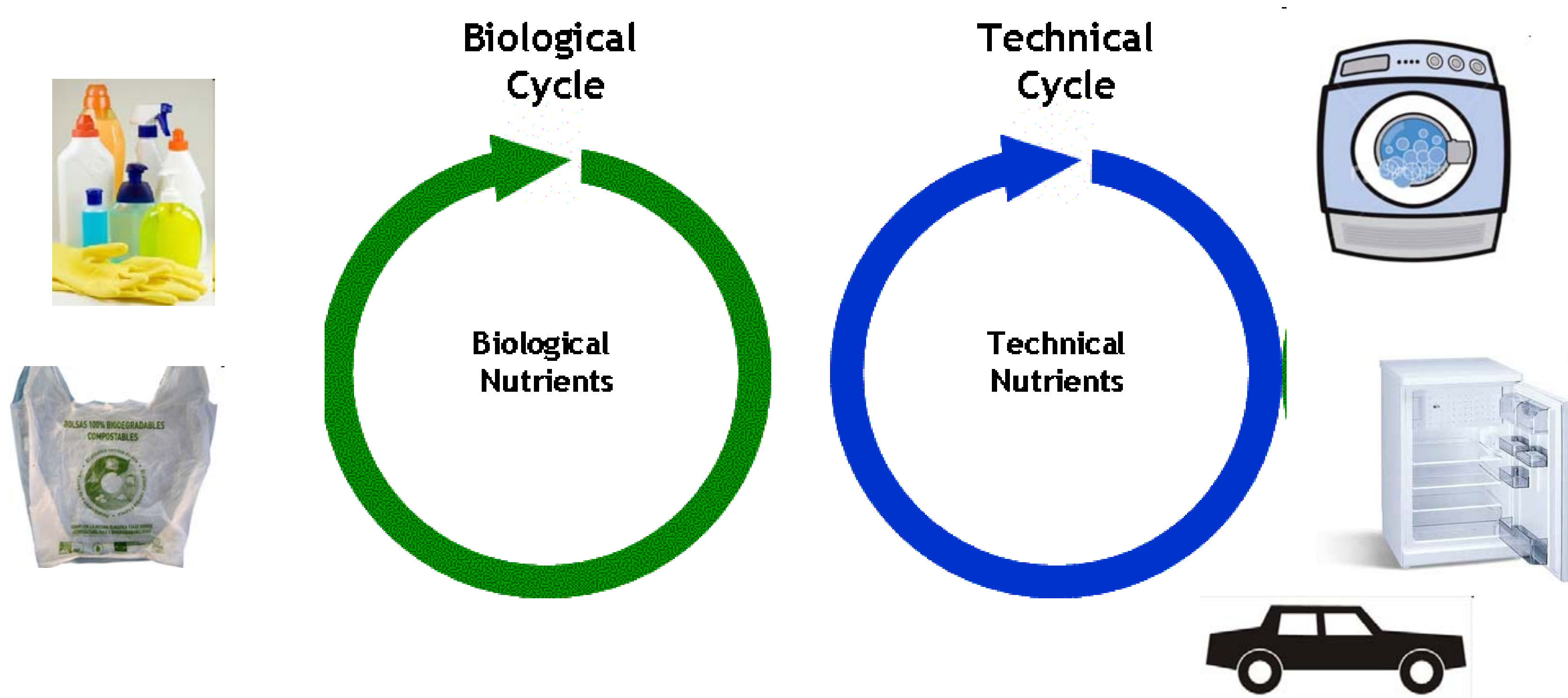
3. Modular E-Mobility („Beyond Storage“)



Bordeaux-Tram

The Seven Cardinal Innovations

4. Systems-optimized Industrial Production („Cradle to Cradle“)



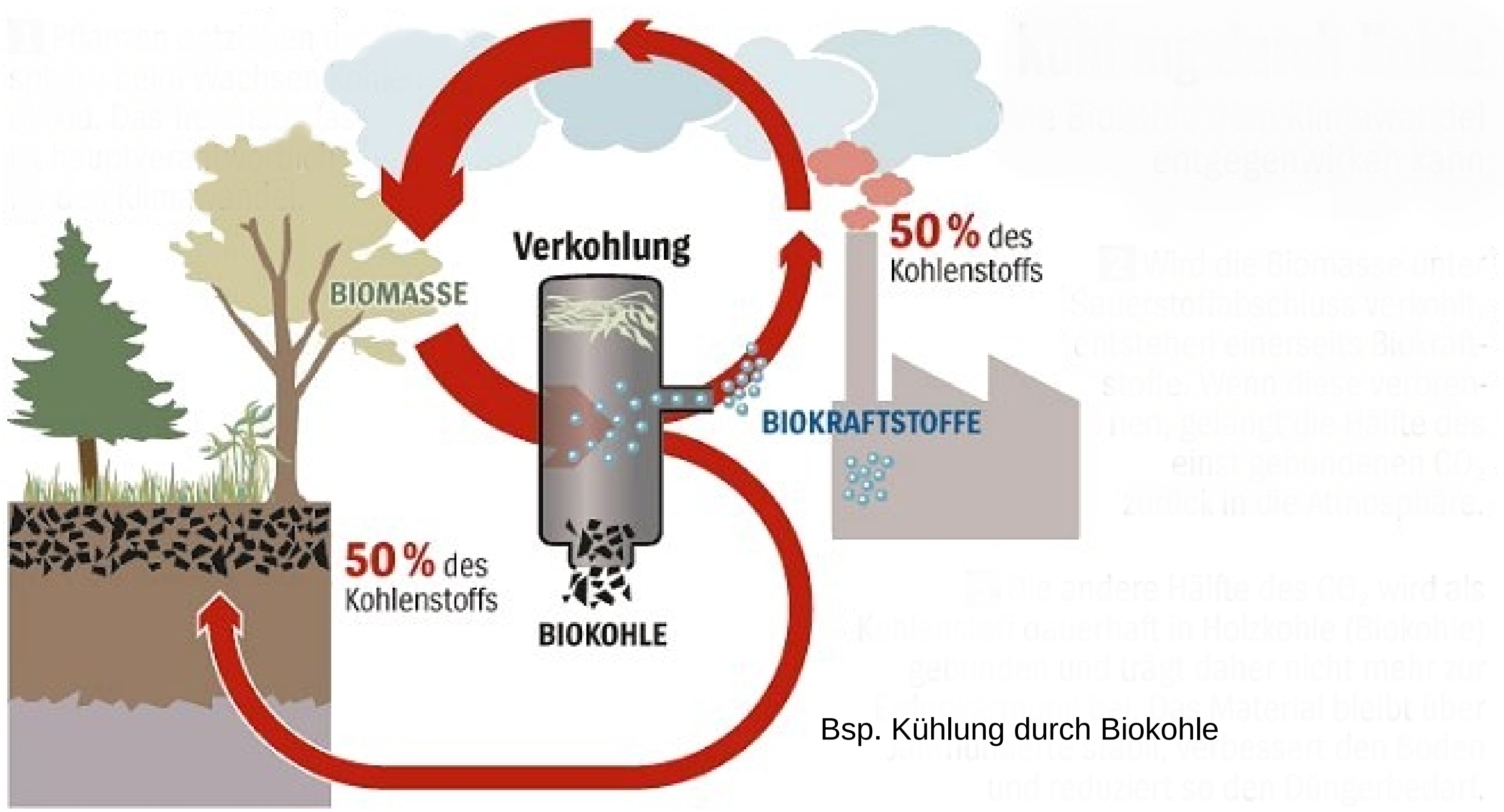
The Seven Cardinal Innovations

5. Holistic Urban and Regional Planning („Reinvention of Urbanity & Rurality“)

Vision for Masdar City

The Seven Cardinal Innovations

6. Sustainable Biomass Management („De- & Anti-Carbonisation“)



Bsp. Kühlung durch Biokohle

The Seven Cardinal Innovations

7. Regenerative Water Supply („Solar Desalination“)

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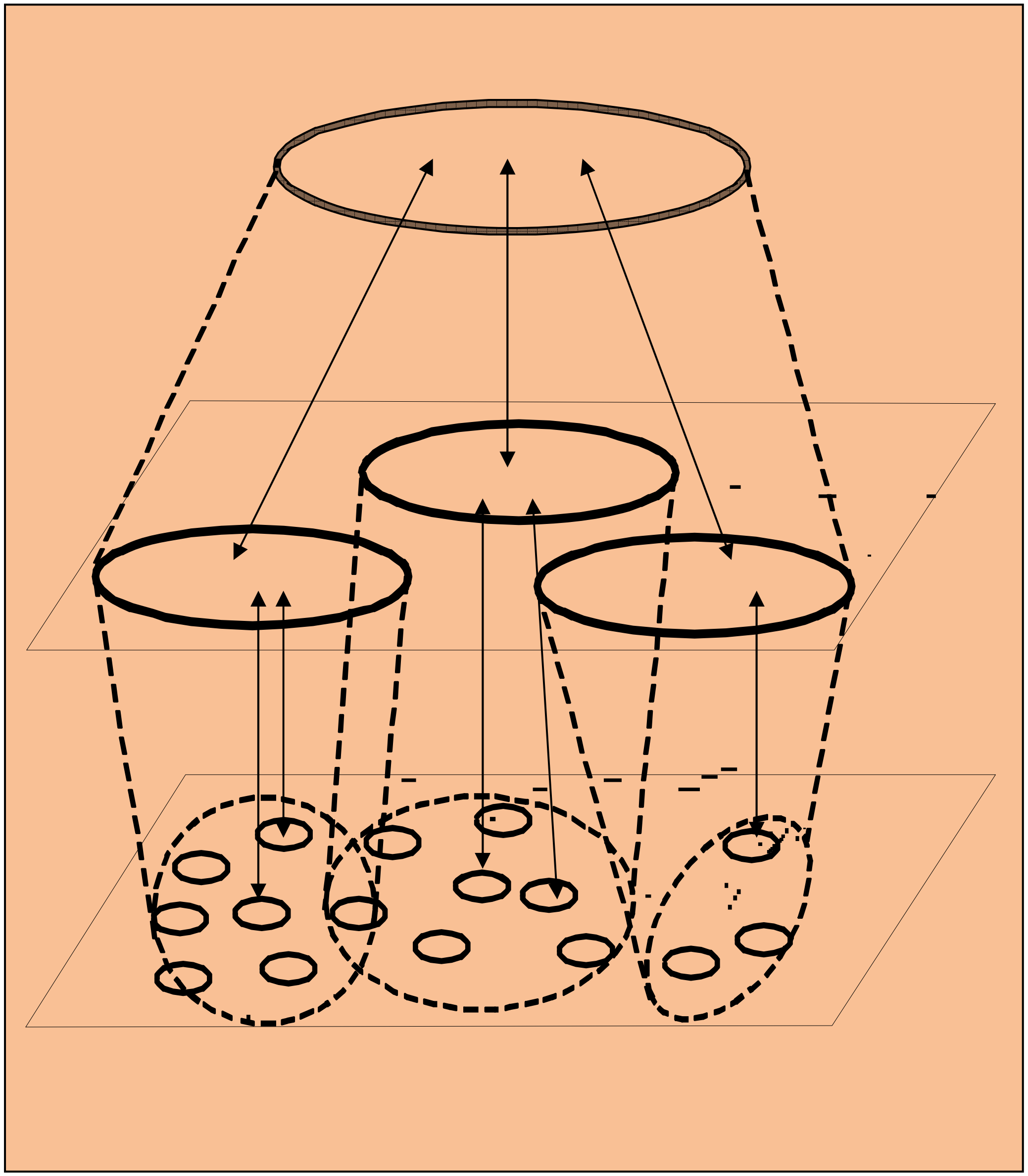
Multiple Levels



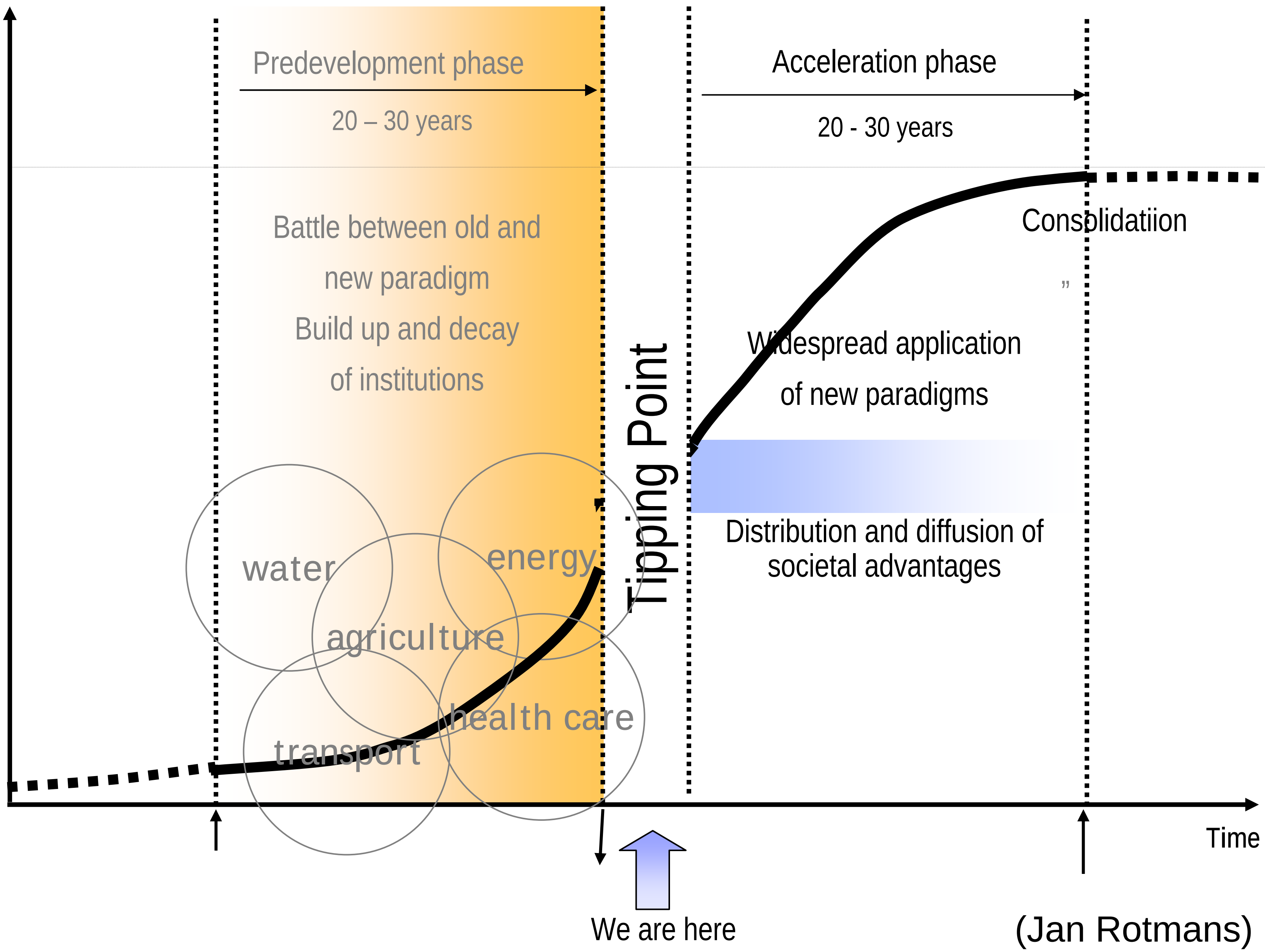
Macro-level
autonomous trends, paradigms, slow developments

Meso-level
regime: dominant structures, cultures and practices (but also niche regimes)

Micro-level
fast developments: innovative ideas, projects, techniques, niche actors

(Jan Rotmans)

Breakthrough to Sustainable Societies



(Jan Rotmans)

Micro-Stimulation of Sustainability Transition

Illustration:

Cloud Seeding

Part B: International Climate Policy

1. The „Post-Copenhagen Syndrome“

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The Remains of COP 15

COP15 COPENHAGEN
UN CLIMATE CHANGE CONFERENCE 2009

'Copenhagen Accord'

- 2°C-guardrail
- Pledge and review; submissions by 31 Jan 2010
- Financial commitments: "new and additional funding"; short-term (2010-12): USD 30 billion; long-term (by 2010): USD 100 billion per year
- Copenhagen Green Climate Fund
- Technology Mechanism

Formal Decision

Decision -/CP.15

The Conference of the Parties,

Takes note of the Copenhagen Accord of 18 December 2009.

Subscription Sheet

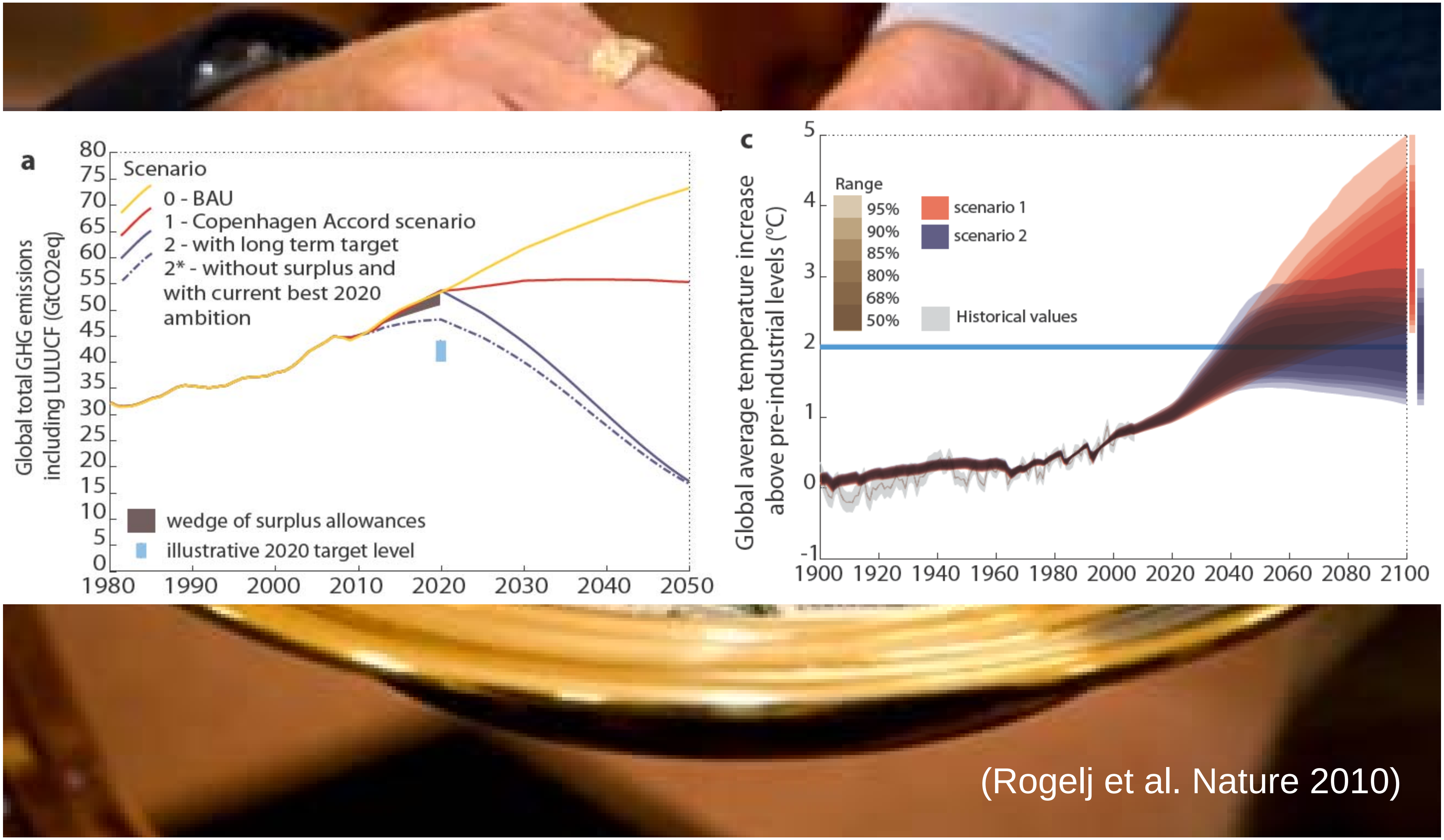
76 submitted their pledges

e.g., US submission; emissions reduction in 2020 (base year 2005):

„In the range of 17%, in conformity with anticipated U.S. energy and climate legislation, recognizing that the final target will be reported to the Secretariat in light of enacted legislation." (Source: www.unfccc.org)

Copenhagen – What Ended Up on the Collection Plate?

Agreeing on 2°C, but heading for > 3°C



(Rogelj et al. Nature 2010)

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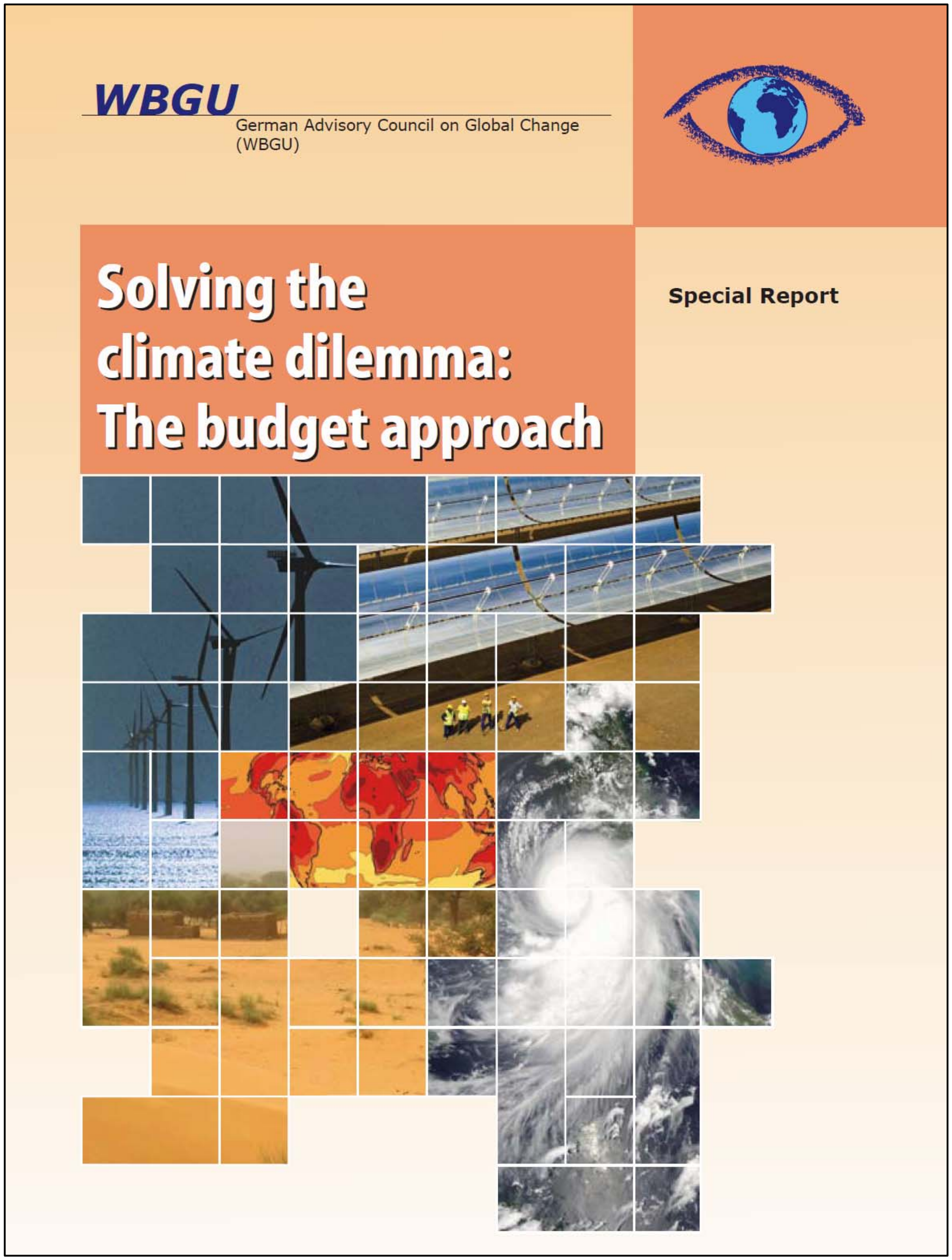

Keeping the Carbon Dose Sub- lethal

"World Formula" for Climate Policy

$$C_{glob}(p) = \int_{T_1}^{T_2} E_{glob}(t)dt$$

Total global CO_2 budget in period $[T_1,T_2]$ that keeps global warming below 2°C with probability p

Integral over global profile of CO_2 emissions

$$C_{nat} = \int_{T_1}^{T_2} E_{nat}(t)dt = C_{glob}(p)\frac{M_{nat}(T_M)}{M_{glob}(T_M)}$$

National CO_2 budget in $[T_1,T_2]$

Integral over national emission profile

Fraction of global CO_2 budget as determined by ratio of national population M_{nat} to world population M_{glob} at time T_M

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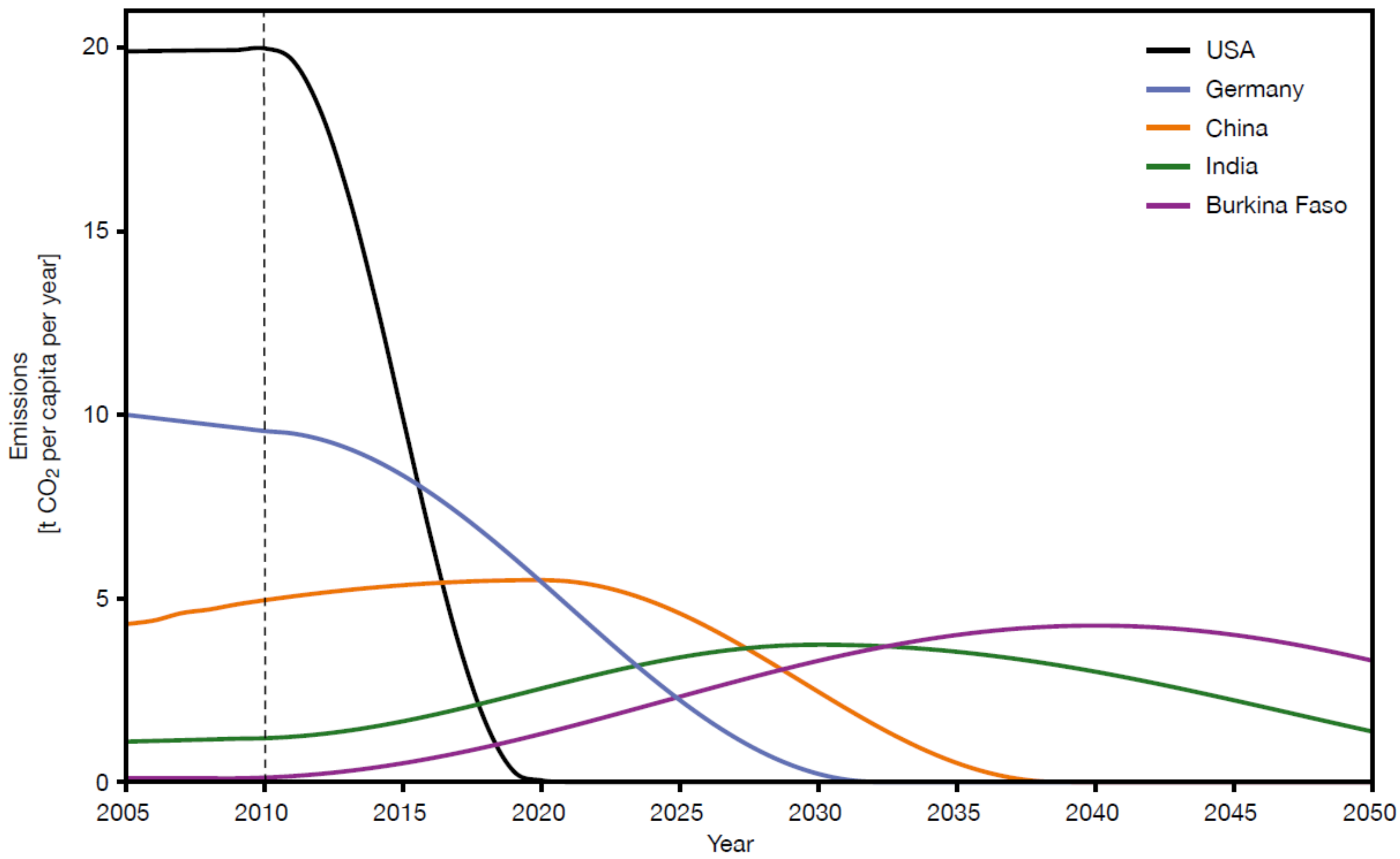
National CO_2 budget in $[T_1,T_2]$

Integral over national emission profile

Fraction of global CO_2 budget as determined by ratio of national population M_{nat} to world population M_{glob} at time T_M

Four political parameters

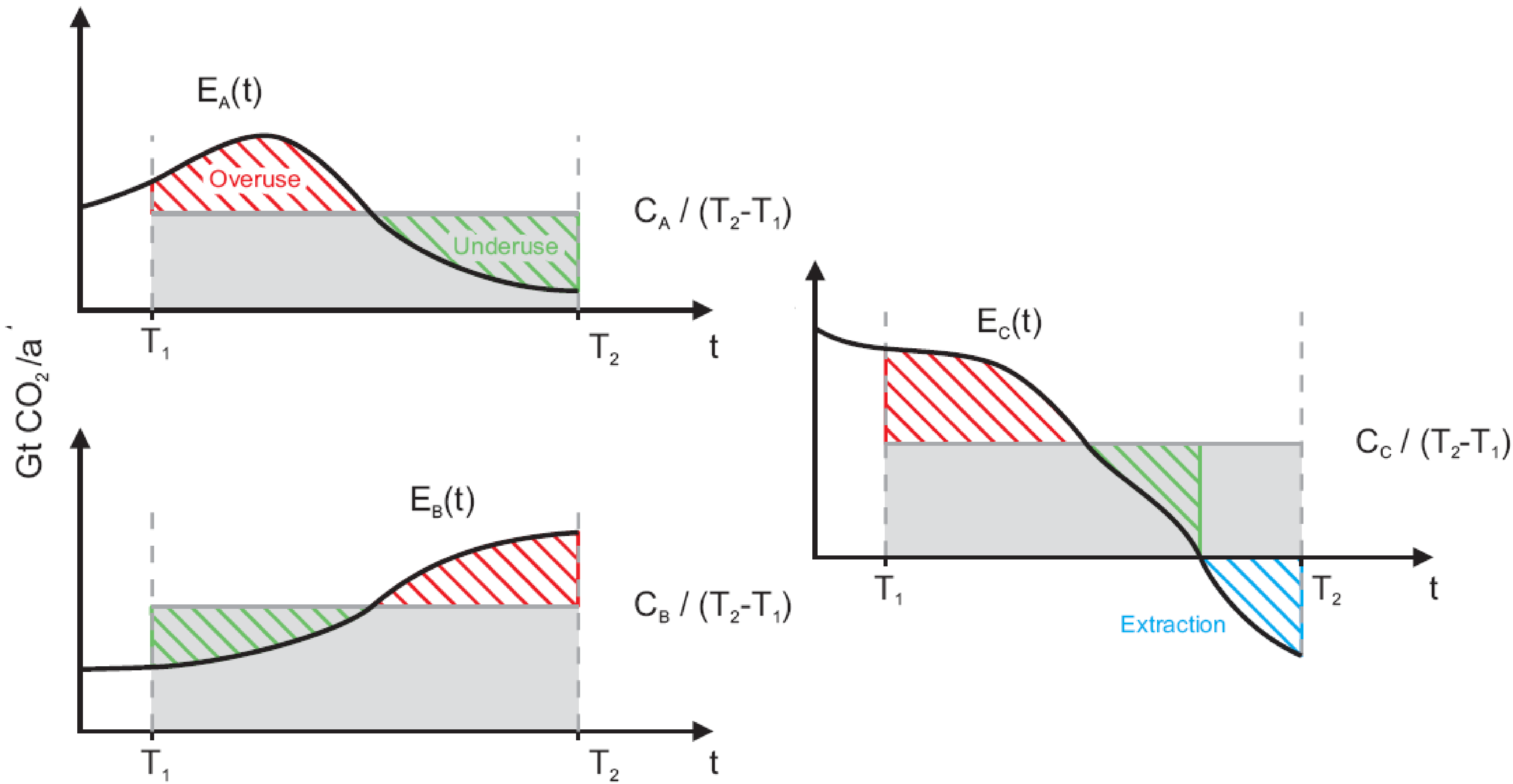
Examples of Theoretical Emissions Trajectories



Examples of equal per-capita emissions of selected countries for 2010–2050, without emissions trading. Trajectories start from current emission levels.

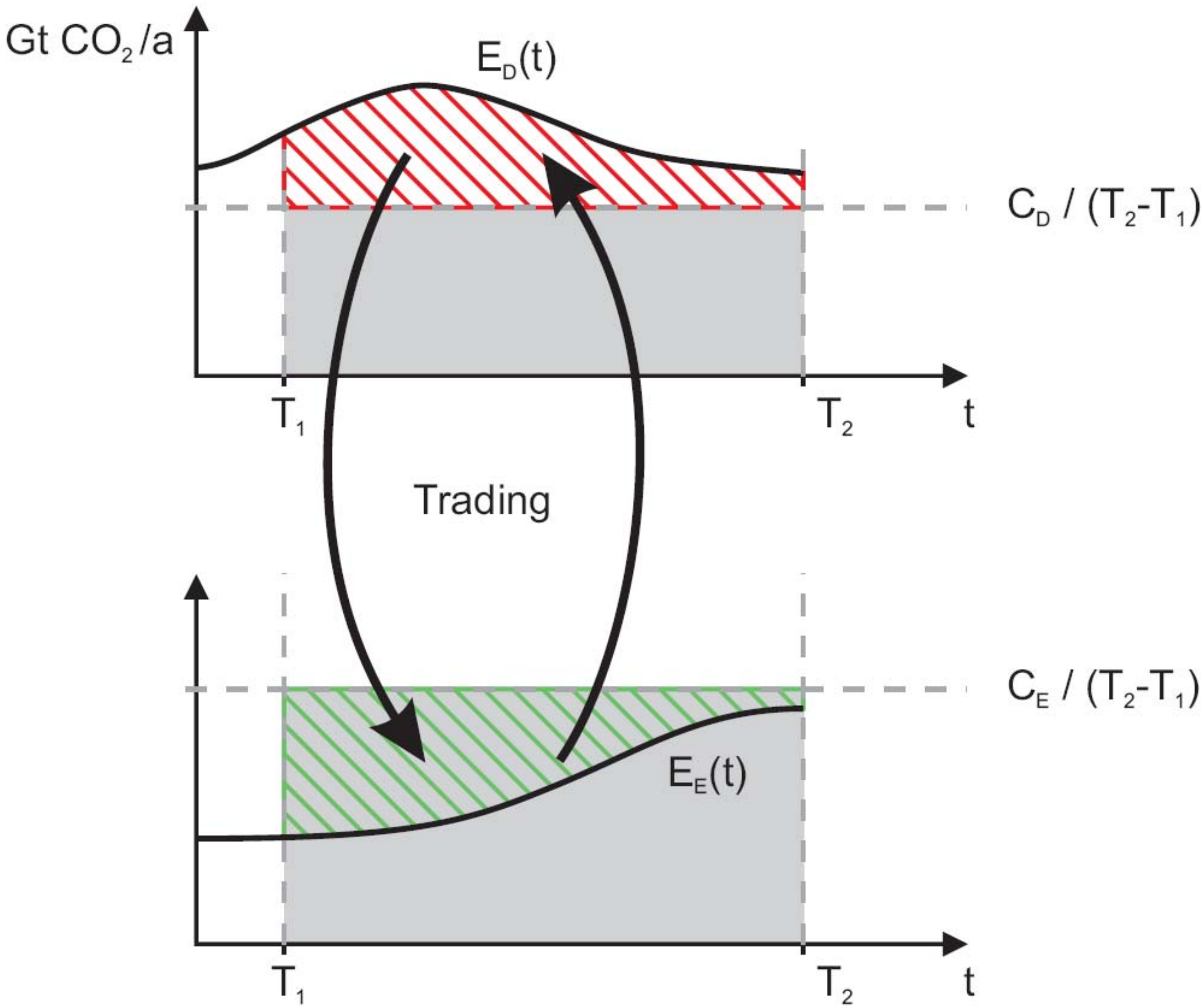
(WBGU Special Report, 2009)

Inter-Temporal Flexibility



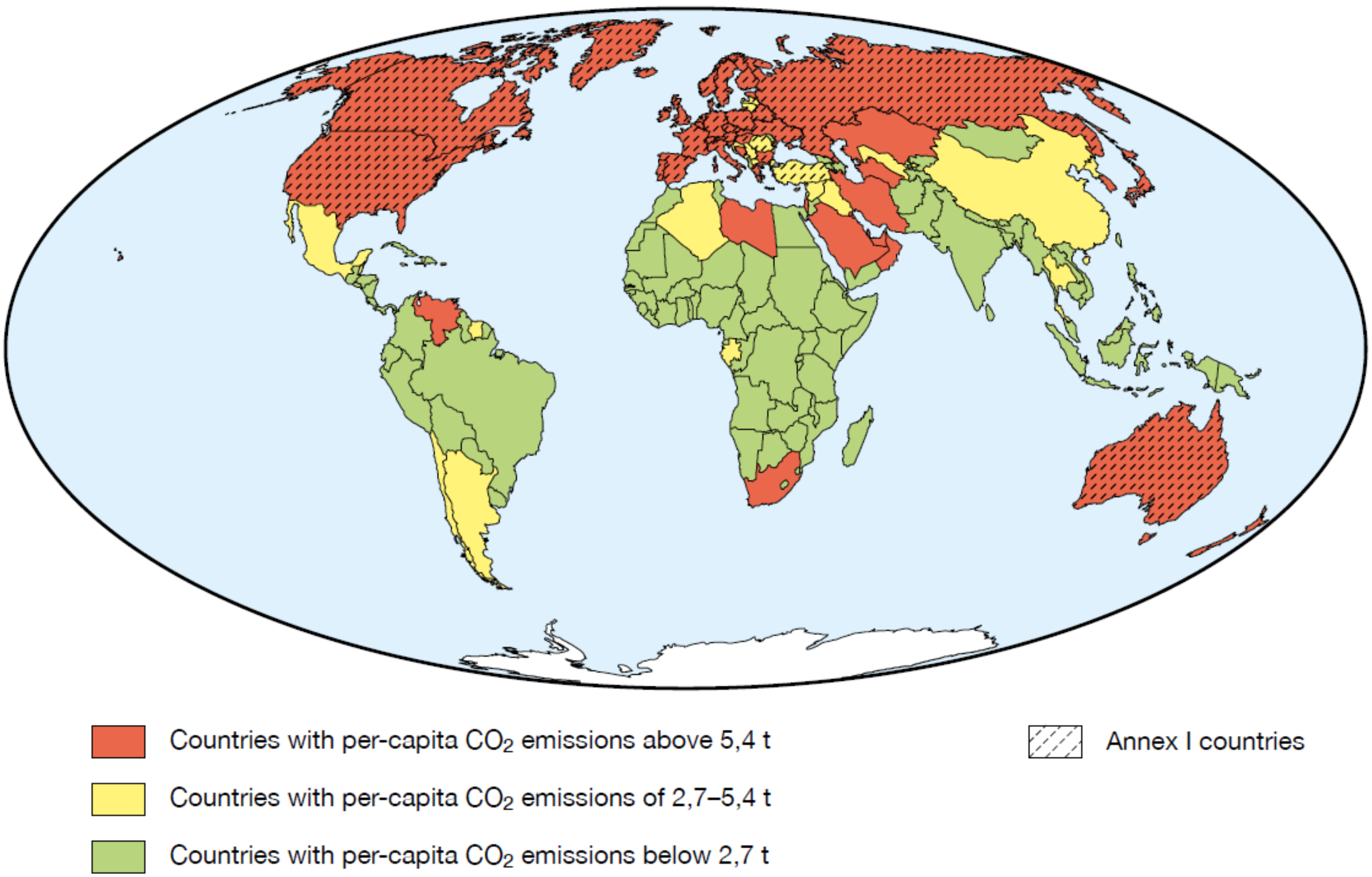
National emission profiles respecting national CO_2 budgets.

Inter-Regional Flexibility



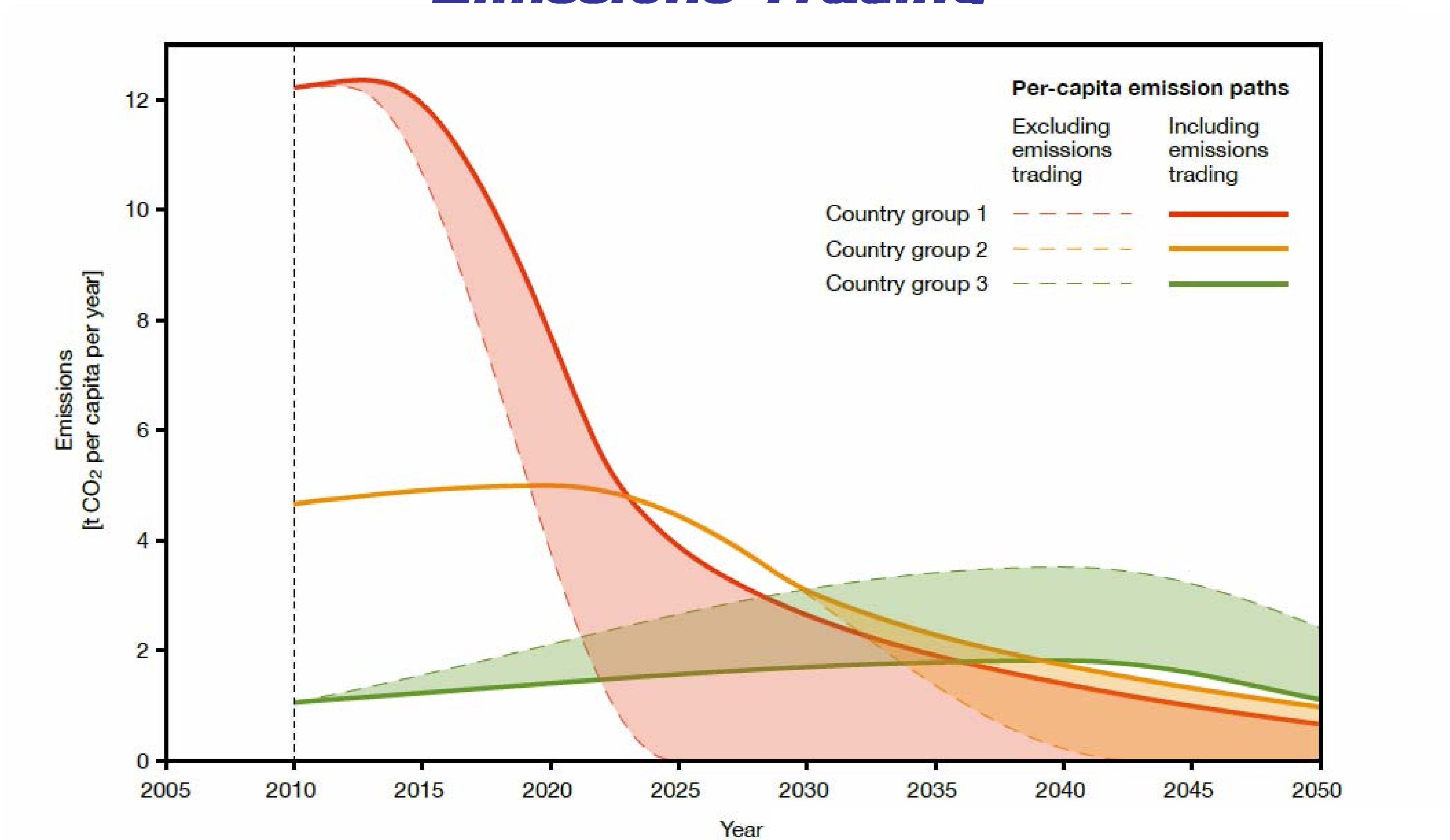
Exemplary emissions trading between two countries D and E.

CO_2 Emissions by Country



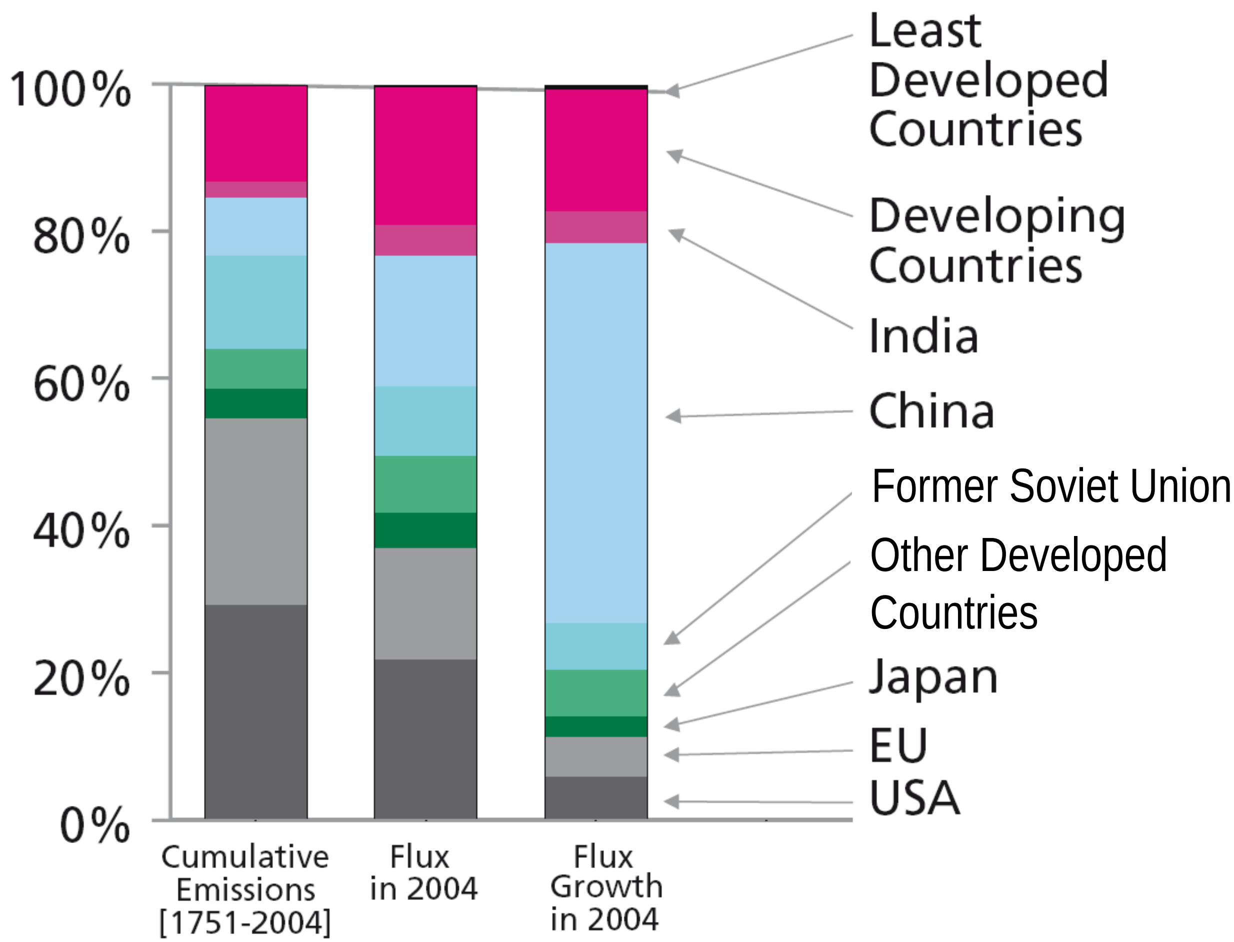
Per-capita CO_2 emissions in 2005, differentiated by emission levels and country.

Examples of Per-Capita Emissions Paths of CO_2 of Three Groups of Countries *without* *Emissions Trading*



(WBGU Special Report 2009)

Stocks and Flows Problem



Stocks are dominated by the historical emissions from developed countries.
The rate of increase in emissions (flows) is dominated by developing countries.

(Figure 11 Synthesis Report)

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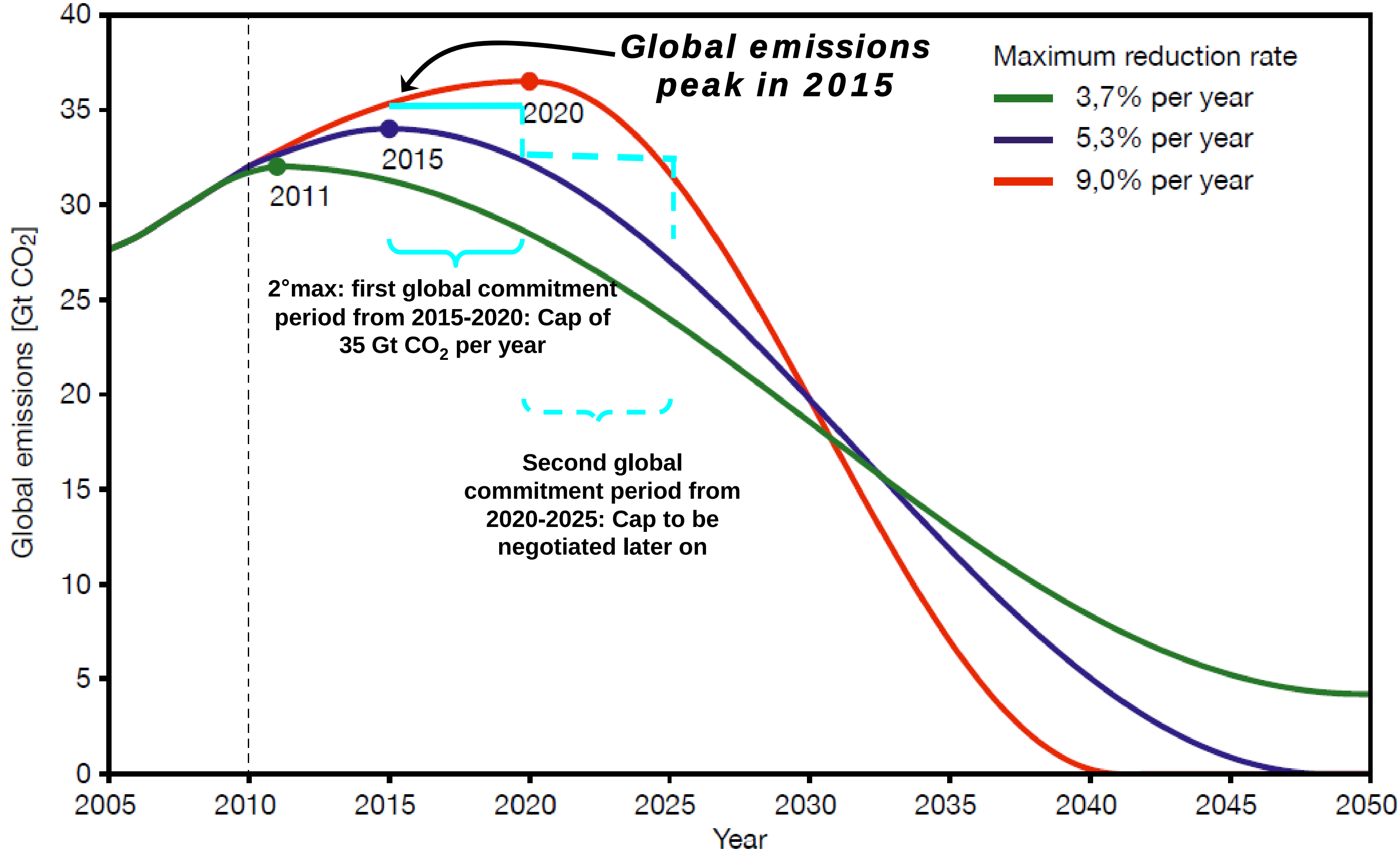
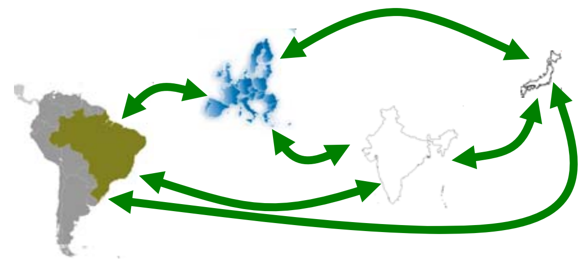
2°max – A Pragmatic Way Forward



The WBGU Policy Paper

Improving the UNFCCC process



Forming new multi-lateral climate partnerships and European leadership

Supporting „bottom-up“ climate actions in civil society

Sub-global Alliances of Climate Pioneers

WBGU
German Advisory Council on Global Change

Policy Paper

Alliances based on thematic areas, e.g.

- Forest Conservation
- Infrastructural Development
- Improving Energy Efficiency
- Expansion of Renewables

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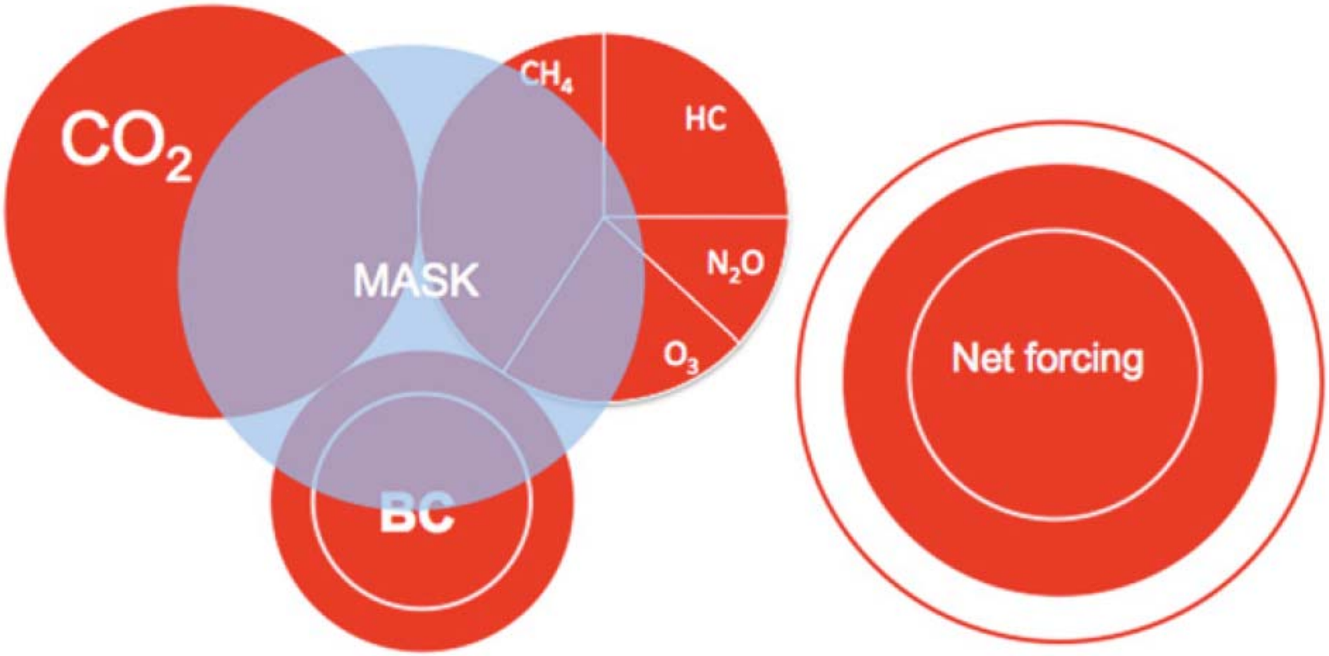
From the Carbon Budget to the Radiant Energy Budget



„Avenues for Managing the Watts“

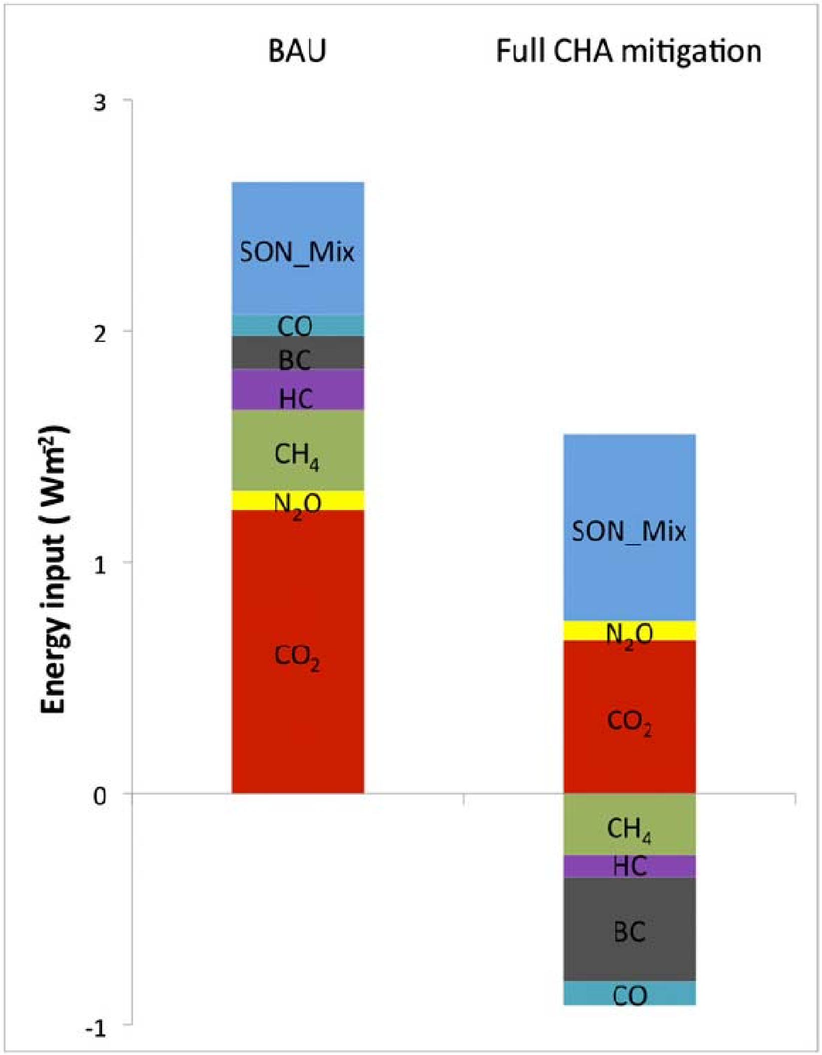
i. Reduce CO_2-emissions according to the carbon budget approach

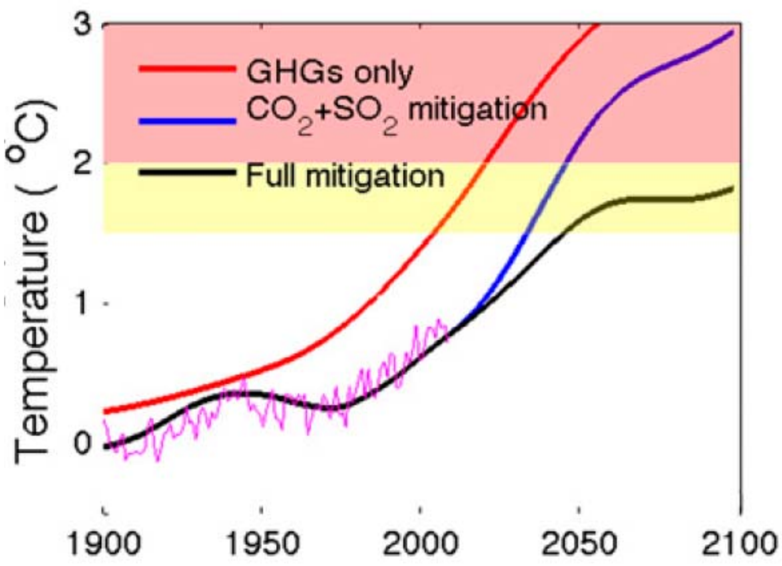
ii. Offset warming from the reduction of aerosol masking, i.e. reduce black carbon (BC), tropospheric ozone (O_3)

iii. Reduce emissions of short-lived greenhouse gases methane (CH_4) and halocarbons (HC)

(Ramanathan & Xu 2010 PNAS)

Radiant Energy Budget – Mitigation Scenarios



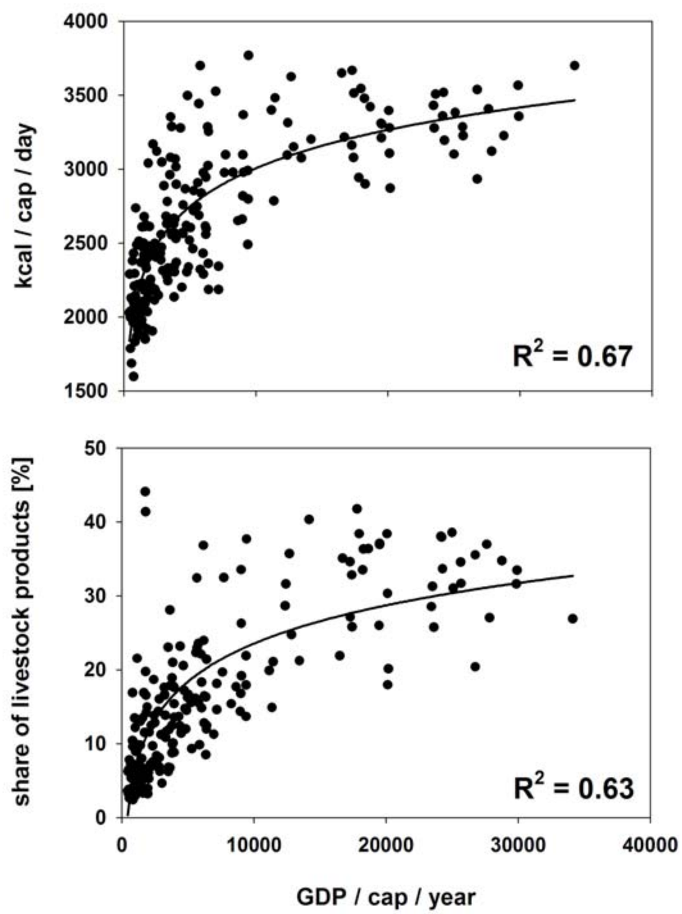


Full mitigation:

< 50% probability of exceeding 2 °C before 2100

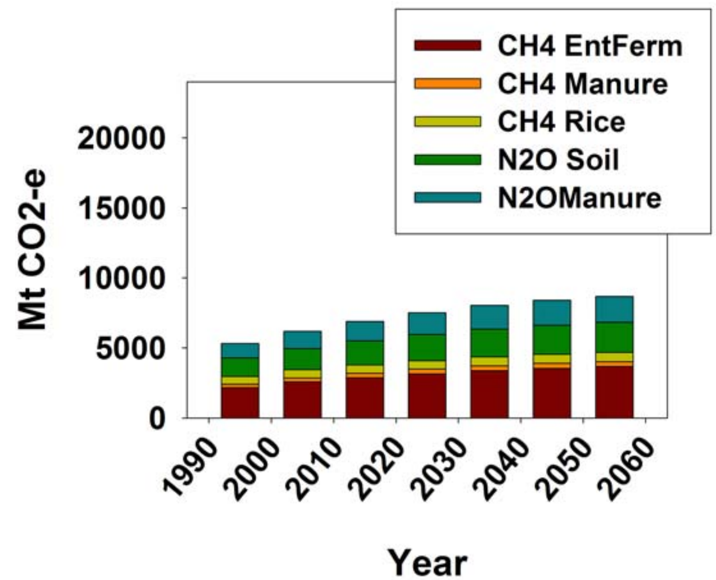
(Ramanathan & Xu 2010 PNAS)

Diet Shifts and Non-CO_2 GHGs from Agricultural Production



BAU: constant share of animal products in human diets

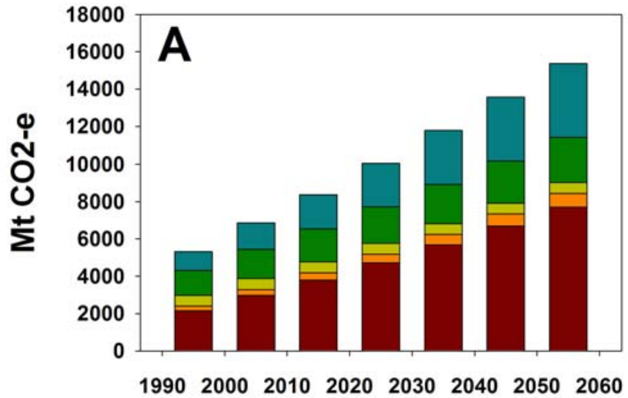
63% increase of CO2-e by 2055, compared to 1995



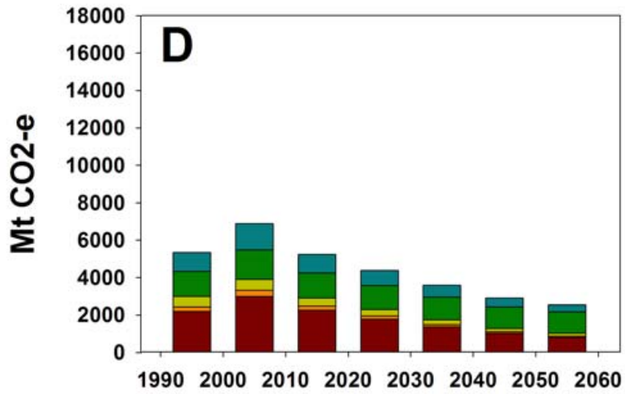
(Popp et al. 2010 Global Environmental Change)

Scope of agricultural methane and nitrous oxide emission reductions

Increased meat scenario

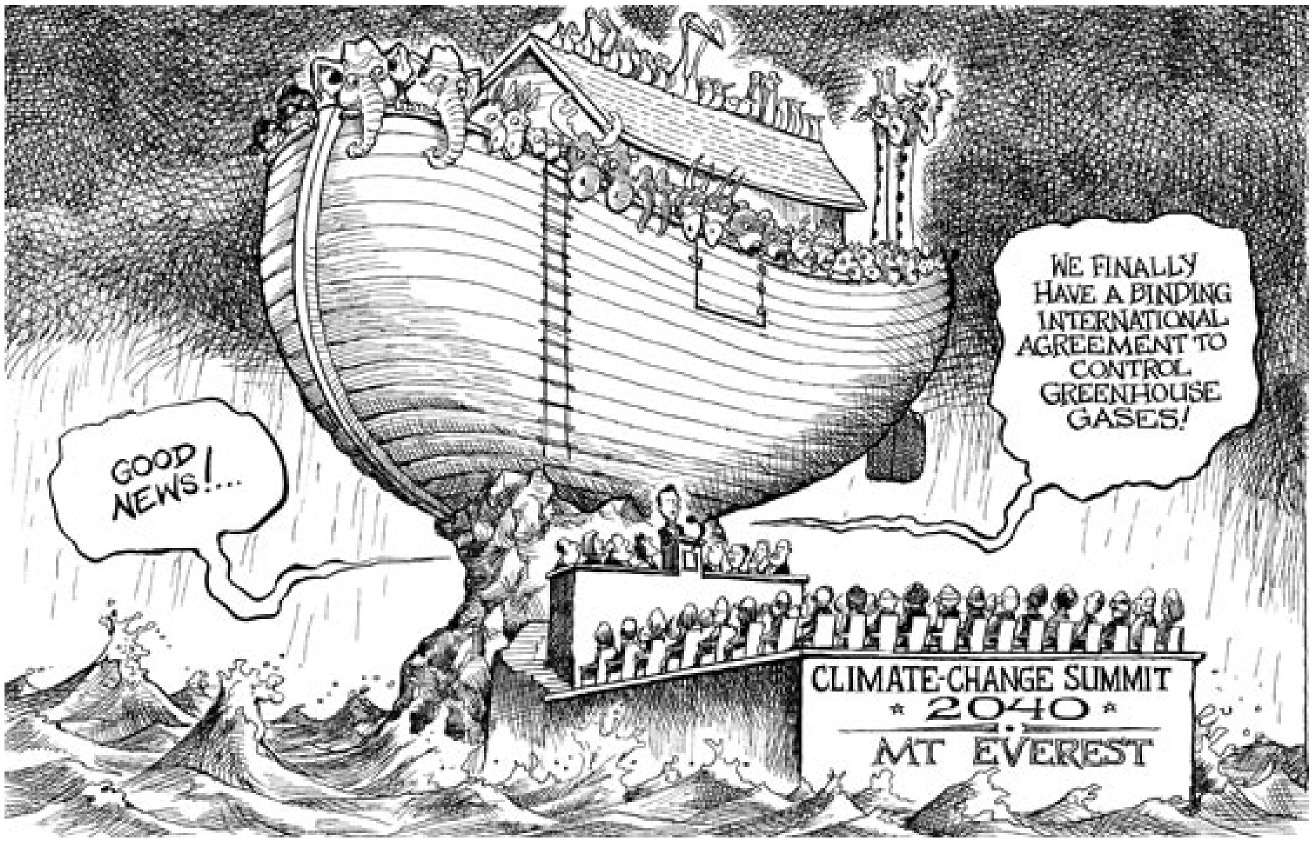


Decreased meat scenario
+ technical mitigation



When taking the link between GDP and food energy demand and the share of livestock products in total caloric intake into account projected methane and nitrous oxide emissions from agricultural production can be cut by more than 80% by 2055.

(Popp et al. 2010 Global Environmental Change)



Questions? Comments?