POTSDAM INSTITUTE FOR CLIMATE IMPACT RESEARCH

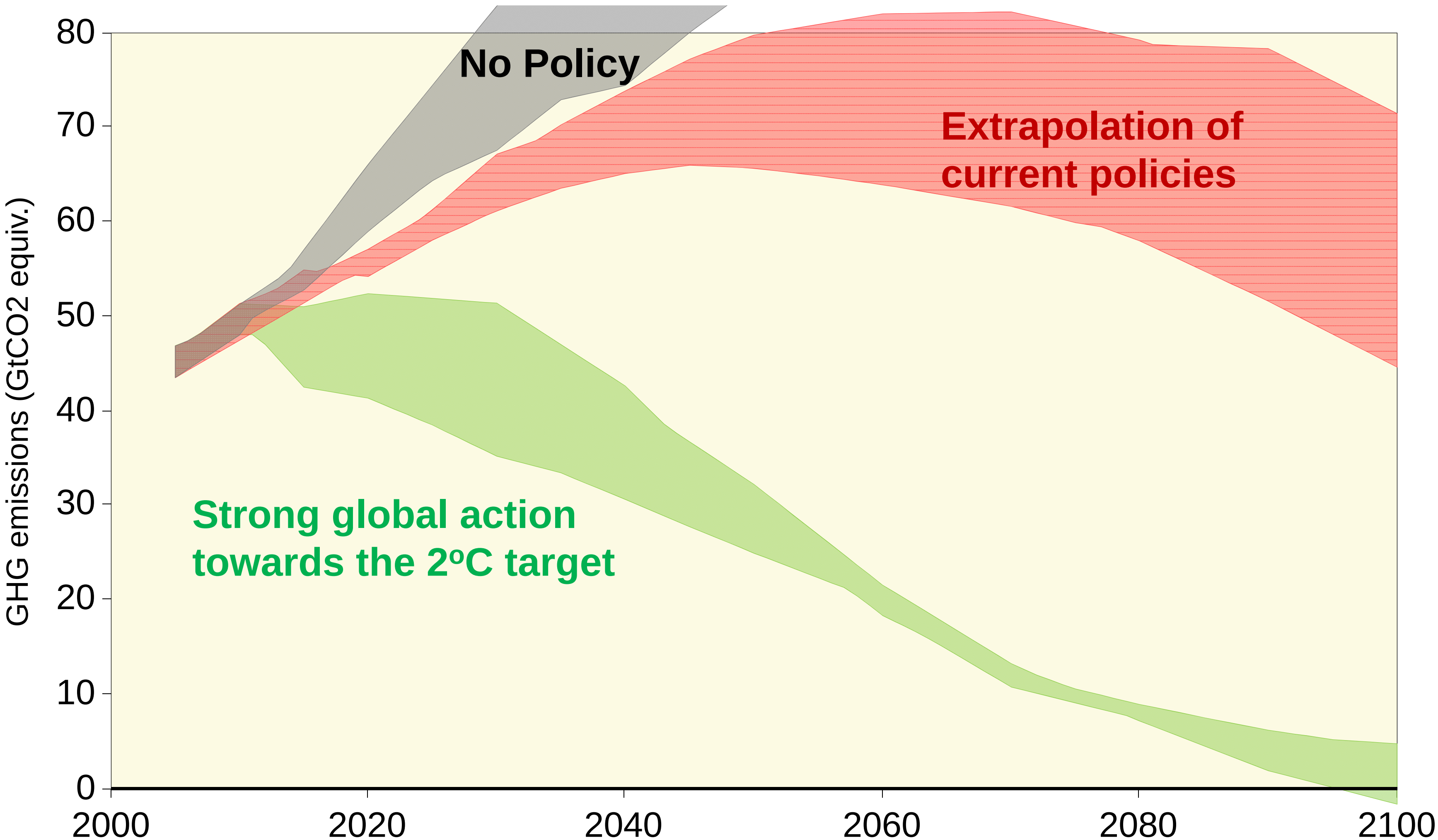
Requirements and challenges of limiting global warming to 2°C: Insights from recent integrated assessment model comparison studies and the IPCC AR5

Elmar Kriegler, Potsdam Institute for Climate Impact Research

Berlin Seminar on Energy and Climate Policy, October 14, 2014

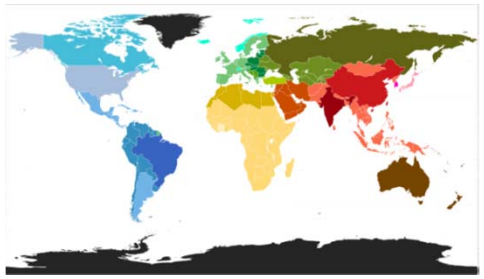
Leibniz Gemeinschaft

The scope of the mitigation challenge



New studies of the energy-land transformation

Agreement in 2015 and 2°C (LIMITS)



Global policy landscape & timing (AMPERE)

Role of Technology Availability (EMF27)

Tar Sand, Suncor upgrader March 2010

Role of emissions drivers (RoSE)

Numerous new insights on the implications of, inter alia,

- short term climate policies (until 2030),
- availability of low carbon technologies and
- different assumptions about future emissions drivers

on the costs and achievability of long term climate targets

How can global models inform the negotiation process?

Mitigation scenarios for the 21st century are of value to draw the link between short term action and long term goals

Models can provide maps of the „solution space".

Policy makers can use them to navigate through this space.

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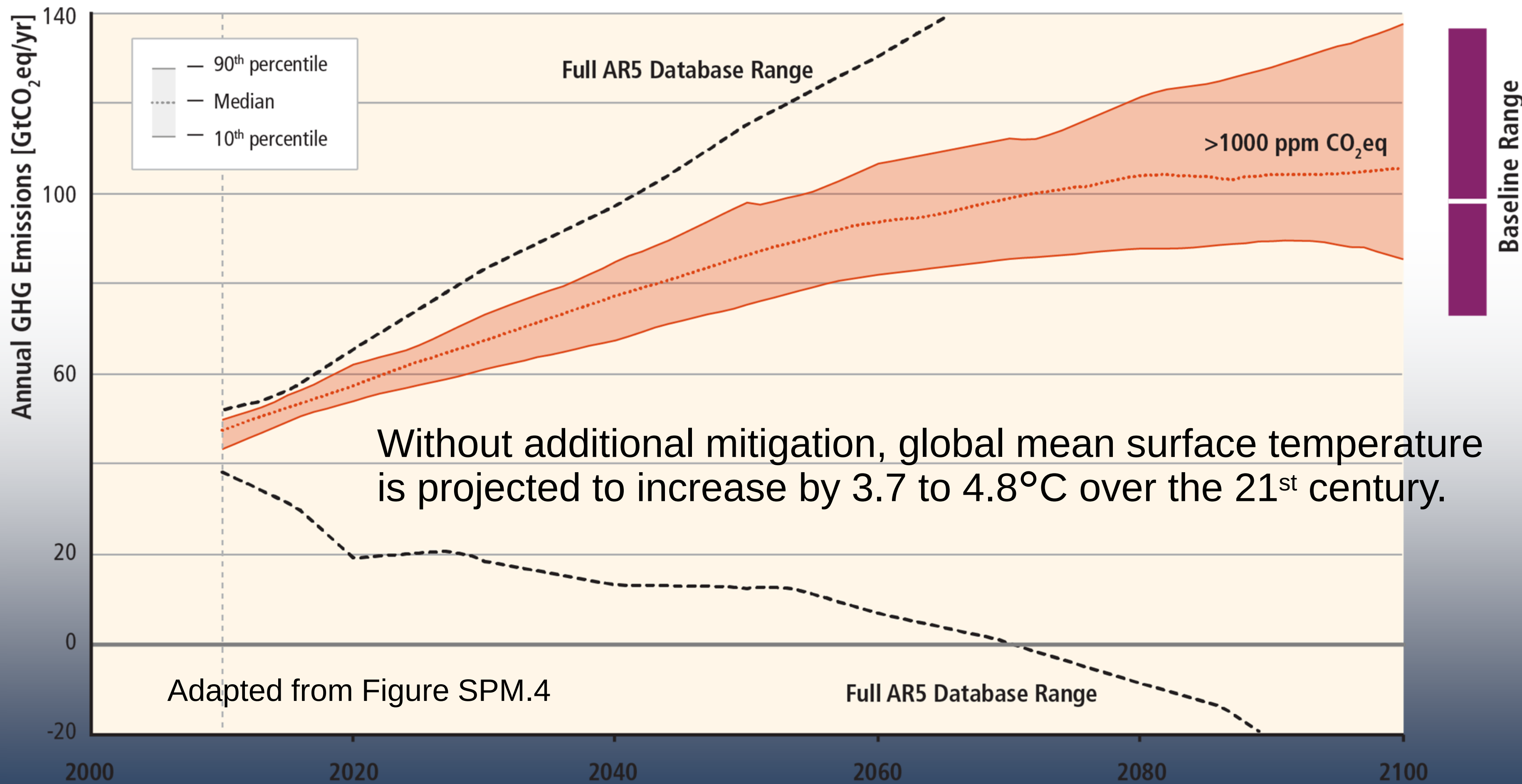
WGIII IPCC AR5:

Limiting warming to 2°C involves substantial technological, economic and institutional challenges.

Stabilization of atmospheric concentrations requires moving away from the baseline – regardless of the mitigation goal.



Without additional mitigation, global mean surface temperature is projected to increase by 3.7 to 4.8°C over the 21st century.

Adapted from Figure SPM.4

AR5 scenario database holds about 900 mitigation and 300 baseline emissions scenarios from the recent literature (https://secure.iiasa.ac.at/web-apps/ene/AR5DB)

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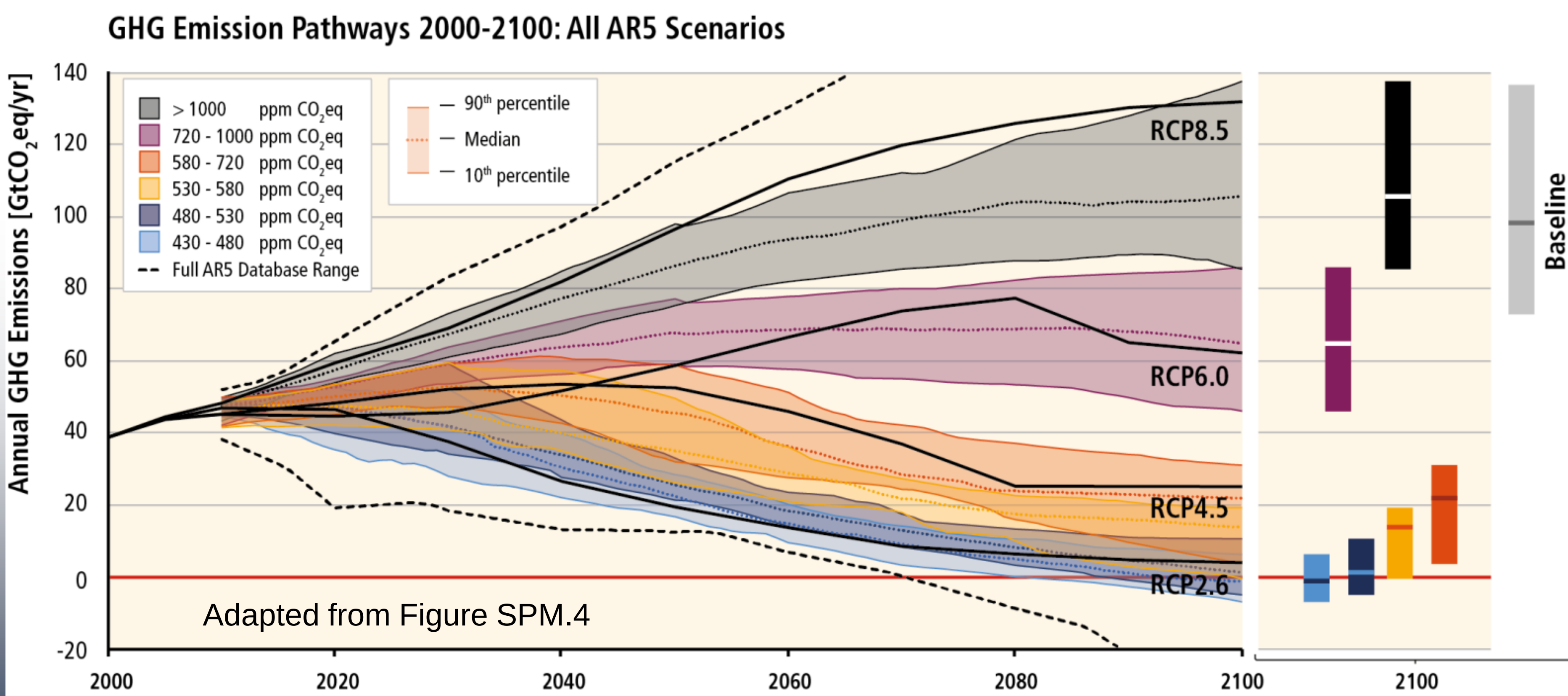


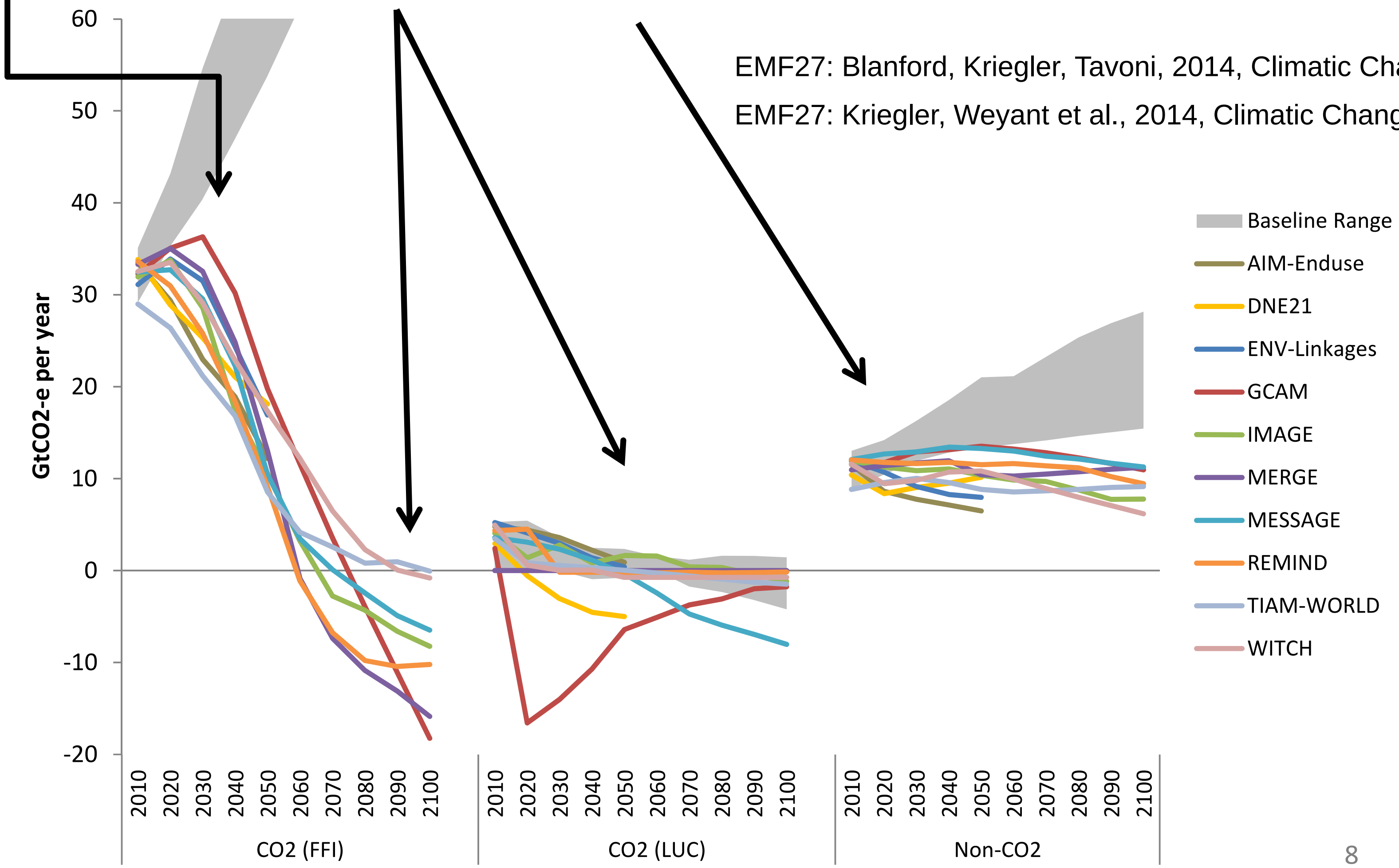
AR5 scenario database holds about 900 mitigation and 300 baseline emissions scenarios from the recent literature (https://secure.iiasa.ac.at/web-apps/ene/AR5DB)

Where are emissions reductions coming from?

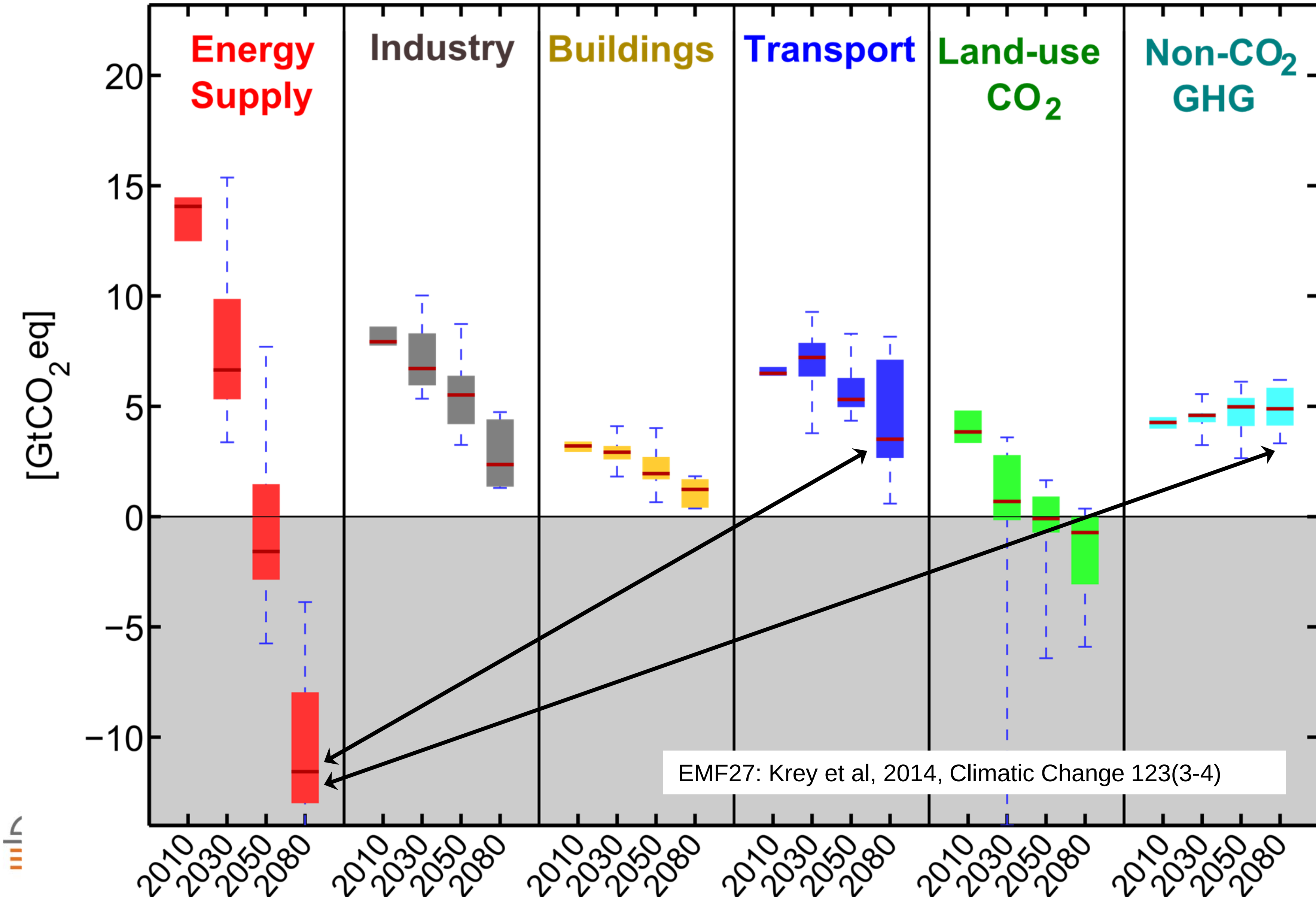
- **Energy sector main venue for mitigation**
- **Land use sector can play key role, but large uncertainty**
  (negative emissions, ag emissions that are hard to eliminate)

EMF27: Blanford, Kriegler, Tavoni, 2014, Climatic Change 123(3-4)

EMF27: Kriegler, Weyant et al., 2014, Climatic Change 123(3-4)

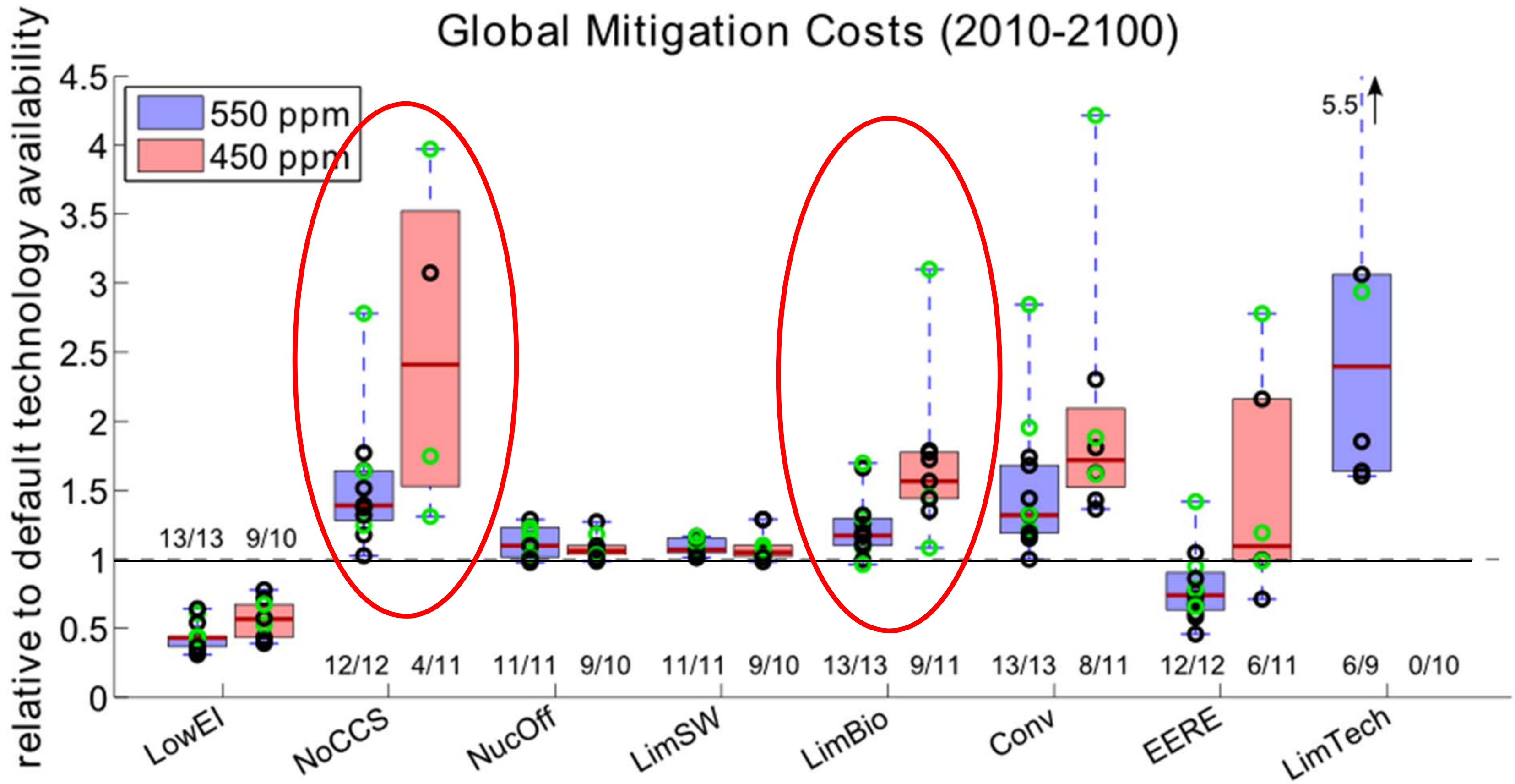


Emissions reductions by sectors



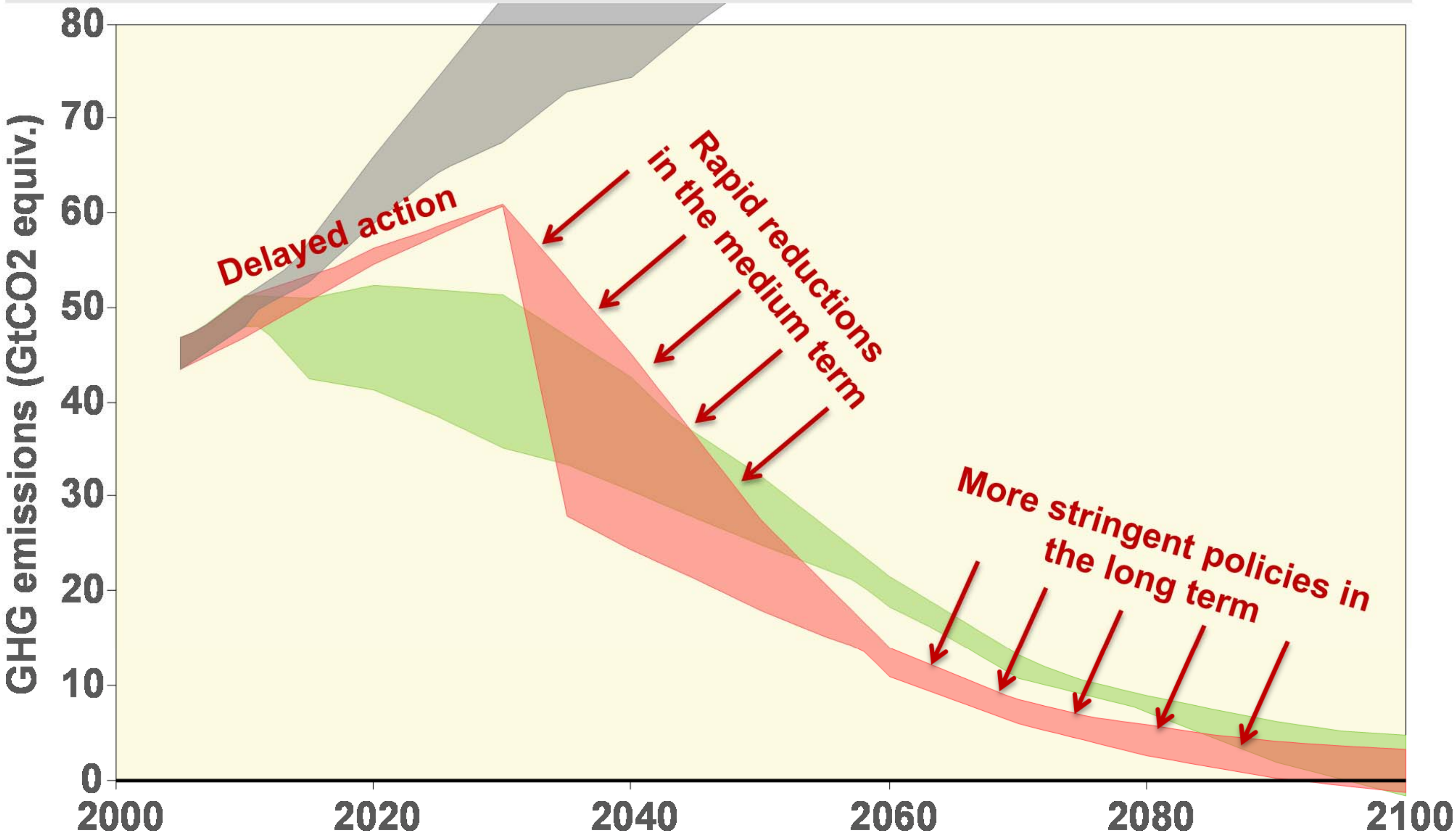
The role of technology for mitigation

BECCS is very valuable mitigation strategy, particular for 450 ppm



Krey, Luderer et al., 2014, Climatic Change 123(3-4)
Kriegler, Weyant et al., 2014, Climatic Change 123(3-4)

What if climate policy fails to bring down global emissions before 2030?



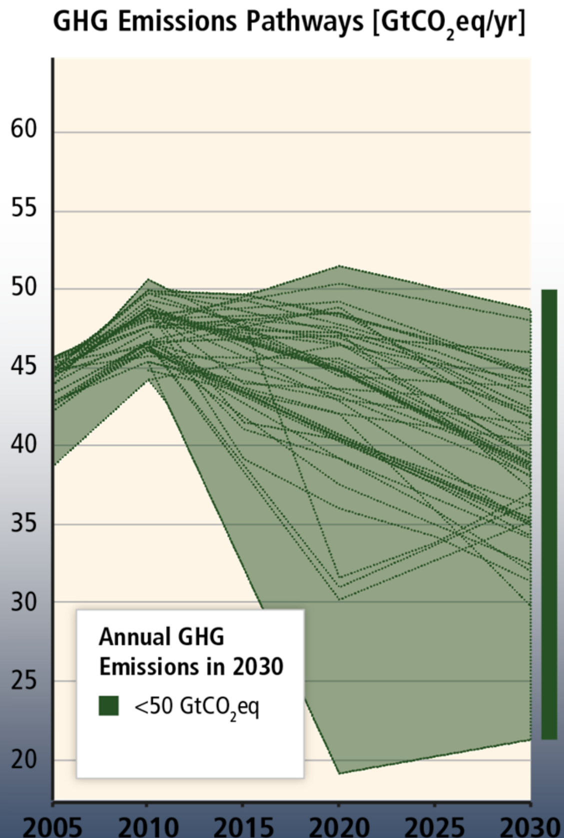
Riahi, Kriegler et al. (2014) Tech. For. & Soc. Change, forthcoming; AMPERE study

PIK

AMPERE

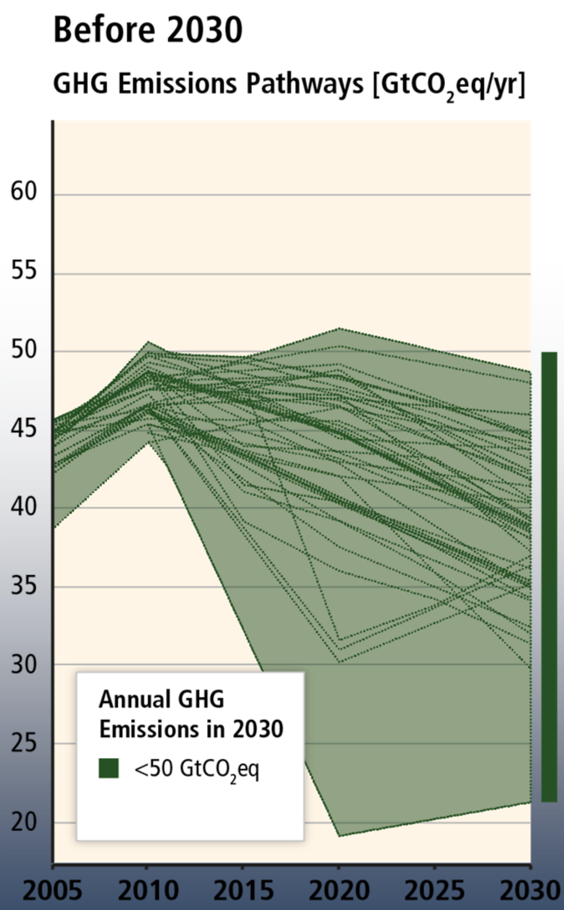
Delaying mitigation increases the difficulty and narrows the options for limiting warming to 2°C.

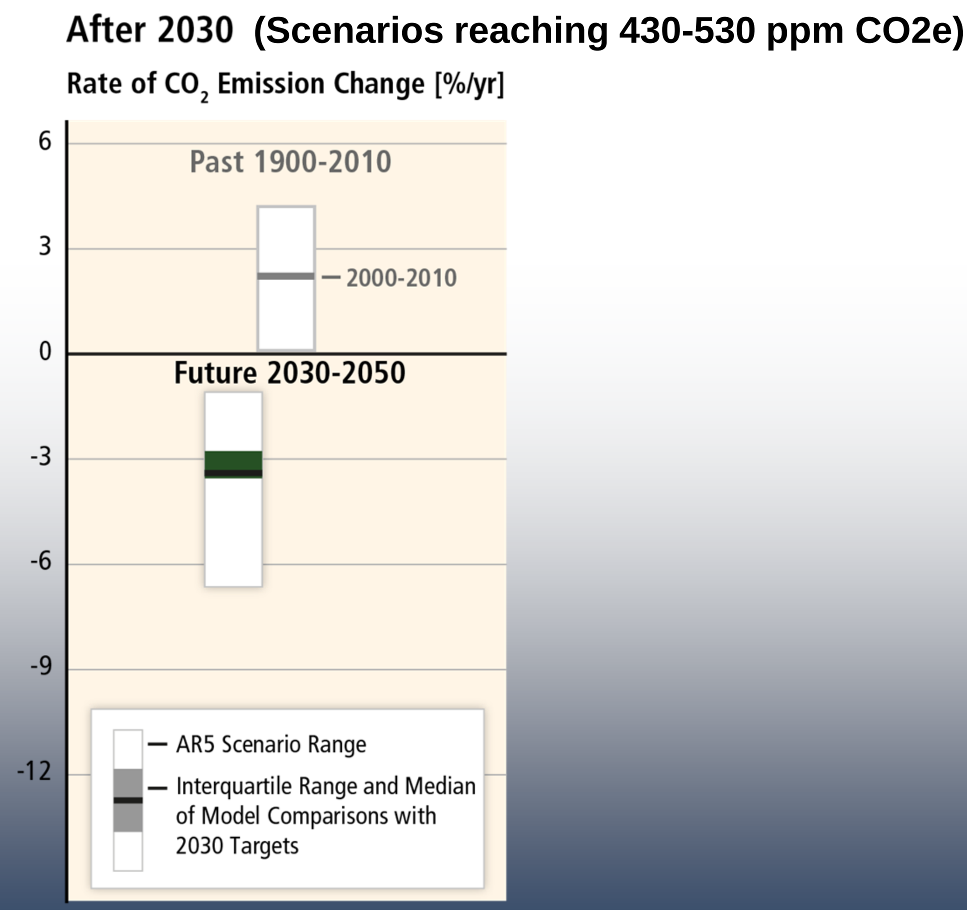
Before 2030 **(Cost effective scenarios reaching 430-530 ppm CO2e)**



Adapted from Figure SPM.5

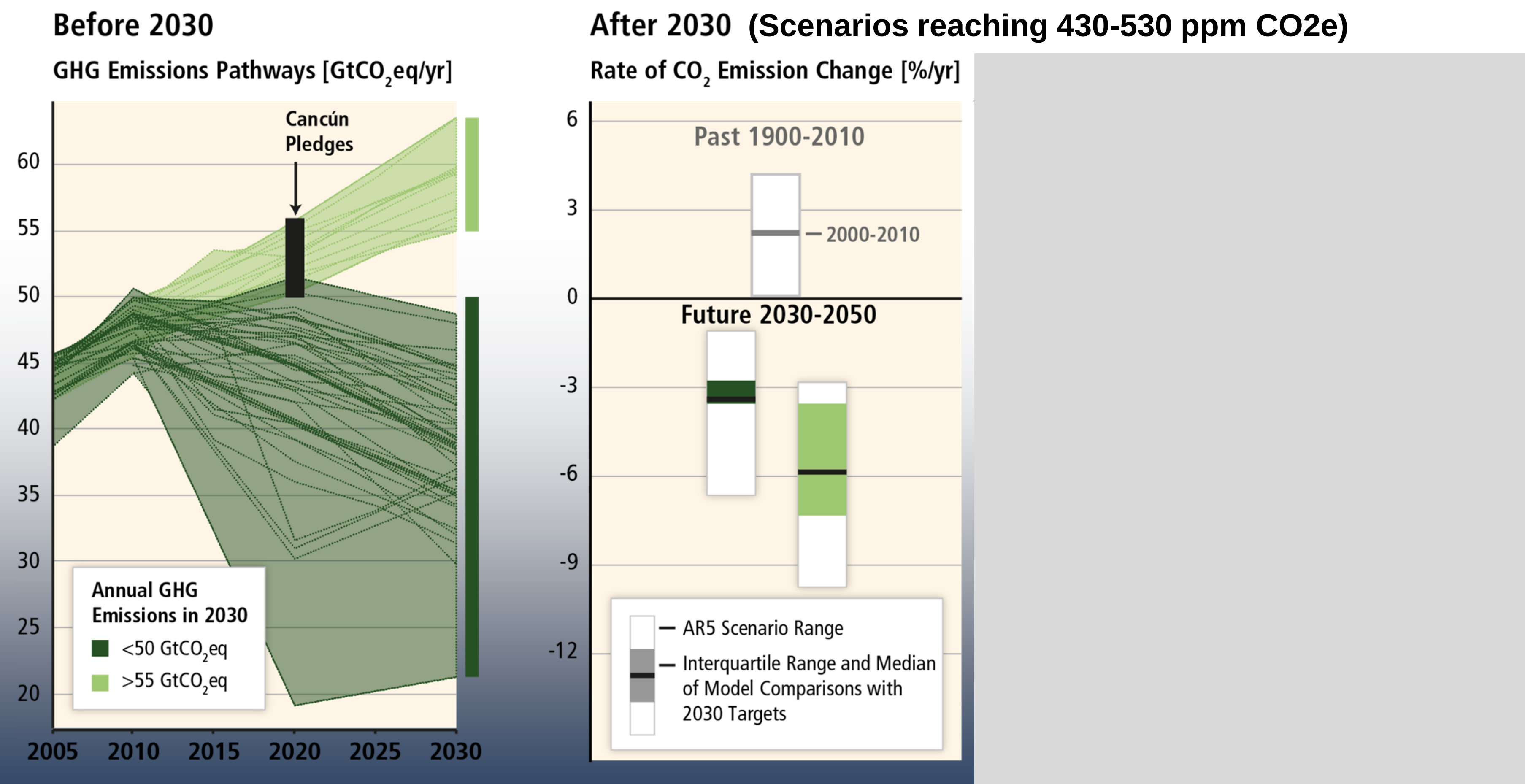
Delaying mitigation increases the difficulty and narrows the options for limiting warming to 2°C.





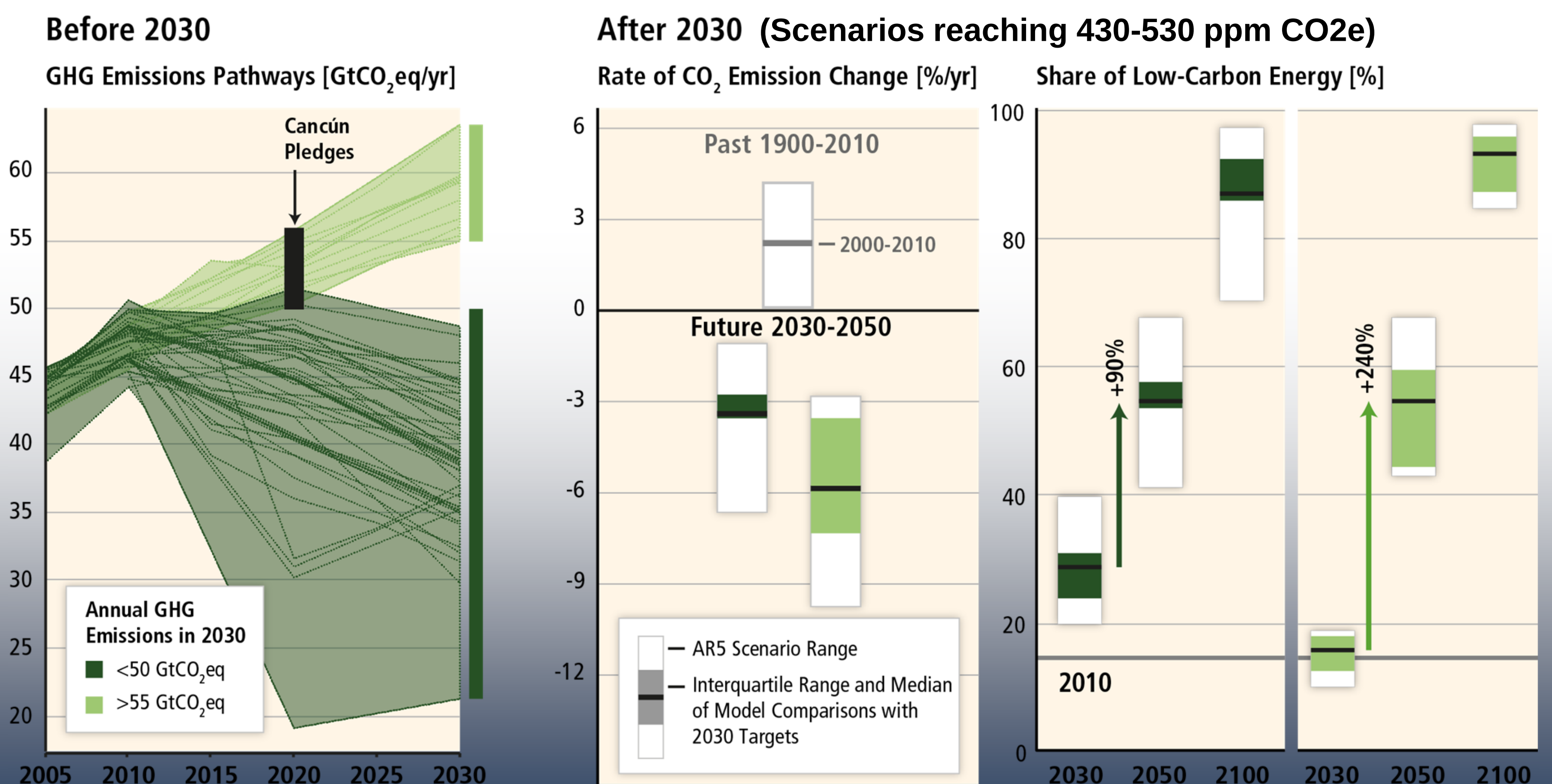
Adapted from Figure SPM.5

Delaying mitigation is estimated to increase the difficulty and narrow the options for limiting warming to 2°C.



Adapted from Figure SPM.5

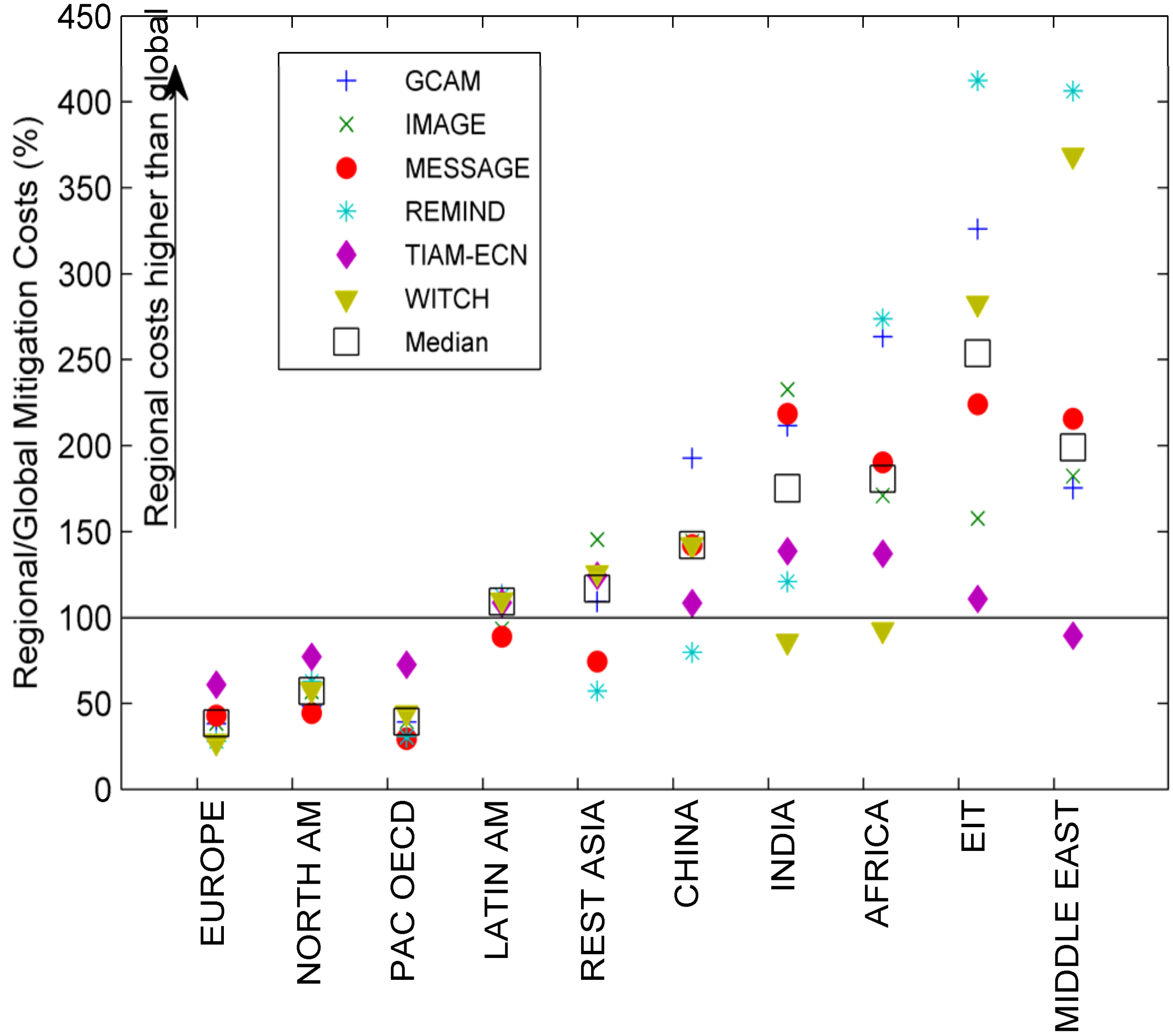
Delaying mitigation increases the difficulty and narrows the options for limiting warming to 2°C.



Adapted from Figure SPM.5

How mitigation costs will be distributed regionally, in the absence of transfers (2°C case)?

LIMITS: Tavoni et al, 2013, Climate Change Economics 4(4)



LIMITS

Burden sharing schemes

IAMs maximize policy efficiency (equal marginal abatement costs) -> determine actual emissions levels

Mitigation doesn't need to be paid domestically -> carbon markets and permit allocation trading

Resource sharing:

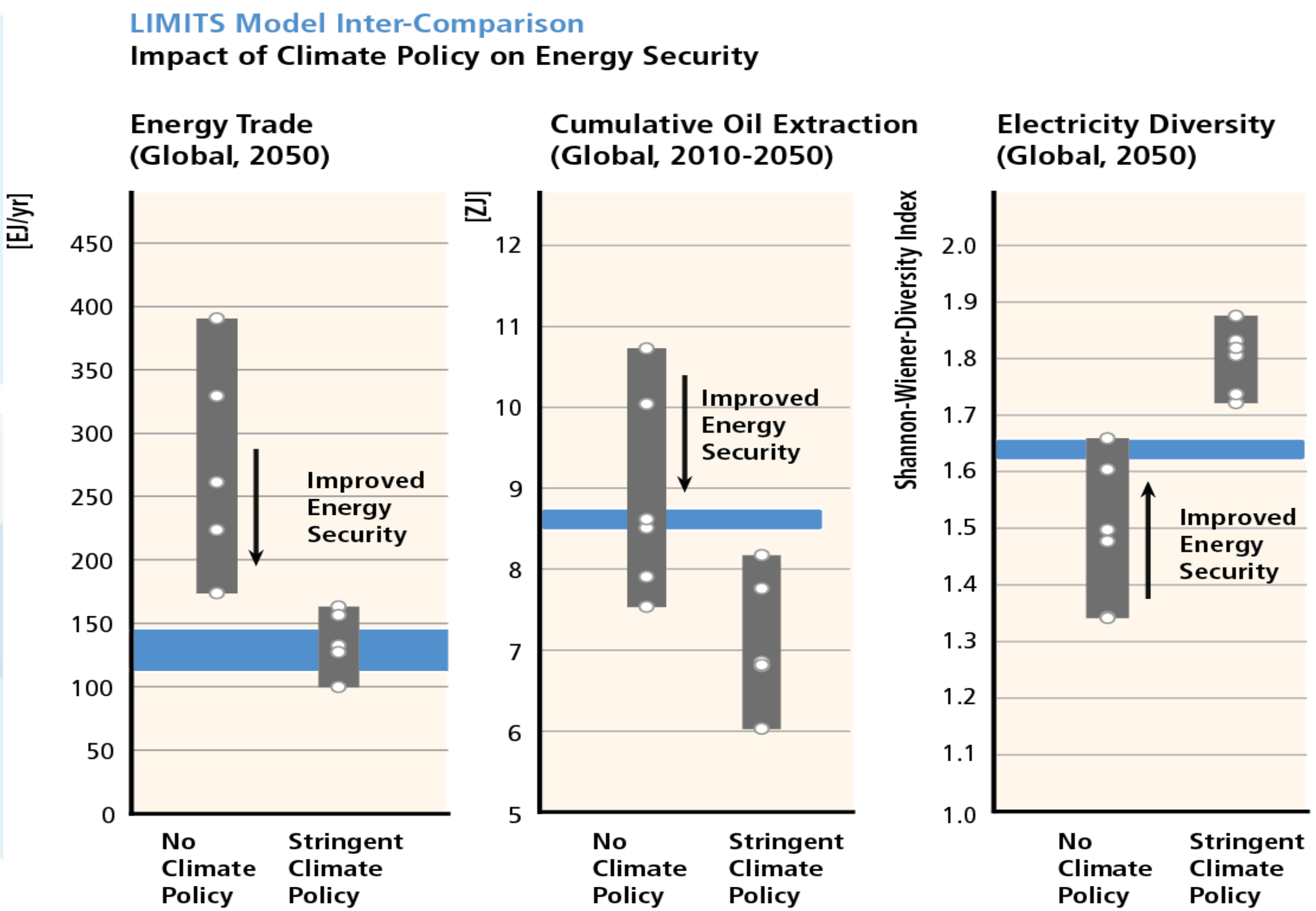
Allocation based on the equalization of regional per capita emissions by 2050

Effort sharing:

Allocation based on equalization of regional mitigation costs (2025 onwards)

LIMITS

Multiple Benefits of GHG Mitigation for Energy Security



IPCC AR5, WGIII – Technical Summary based on LIMITS

Discussion

EMF27 Study on Global Technology and Climate Policy Strategies

Special issue in Climatic Change

- Synthesis (Kriegler, Weyant et al.), Policy Overview (Blanford et al.), Technology Overview (Krey et al.)
- X-cuts on Energy Efficiency (Sugiyama et al.), CCS (Koelbl et al.), Nuclear (Kim et al.), Non-Bio Renewables (Luderer et al.), Bioenergy (Rose et al.), Land use (Popp et al.), Resources (McCollum et al.), Non-Kyoto forcing (Rose et al.)
- 17 modeling team papers

18 participating models (17 x global, 1 x India)

AIM-Enduse, BET, DNE21+, EC-IAM, ENV-Linkages, FARM, GCAM, GCAM-IIM, GRAPE, IMACLIM, IMAGE, MERGE, MESSAGE, Phoenix, POLES, REMIND-MAgPIE, TIAM-ECN, WITCH

	FullTech	LowEI	NoCCS	NucOff	LimSW	LimBio	Conv	EERE	LimTech
Baseline	13/13	13/13		11/11	11/11	13/13	13/13	13/13	11/11
550 ppm	13/13	13/13	12/12	11/11	11/11	13/13	13/13	12/12	6/9
450 ppm	10/11	9/10	4/11	9/10	9/10	9/11	8/11	6/11	0/10

Overview of AMPERE (*Assessment of Climate Change Mitigation Pathways and Evaluation of the Robustness of Mitigation Cost Estimates)*

Project duration: Feb 2011 – Jan 2014, Web: ampere-project.eu

Funding: 3.1 million EUR from the EU 7th Framework Programme

AMPERE consortium (22 partners):

Global Integrated Assessment Modelling

Fondazione Eni Enrico Mattei, Universiteit Utrecht, CIRED, CNRS, European Commission, PIK (Coordinator), Paul Scherrer Institut PSI, Enerdata

EU Energy-Econ Modelling

IIASA, E3M-lab ICCS, CPB Netherlands Bureau for Economic Policy Analysis, Université Paris 1 Panthéon-Sorbonne, Technische Universität Wien (Vienna University of Technology), University of Stuttgart Germany

Climate Science

Met Office, Climate Analytics

Policy Outreach

CEPS

International Partners

Japan: NIES, RITE (Research Institute of Innovative Technology for the Earth)

China: ERI (Energy Research Institute)

India: IIM Ahmedabad

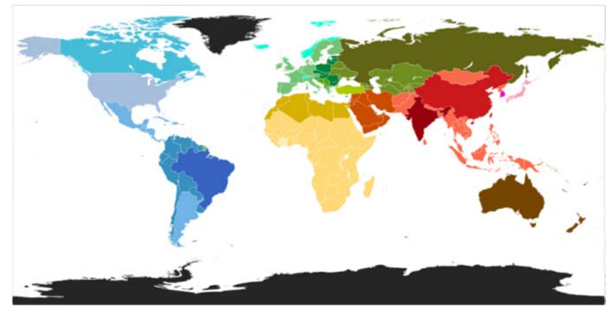
USA: Pacific Northwest National Laboratory (Proudly Operated by Battelle Since 1965)

AMPERE research areas

How are mitigation costs and outcomes affected by uncertainties and constraints in these areas?

Climate system

Technology availability and progress

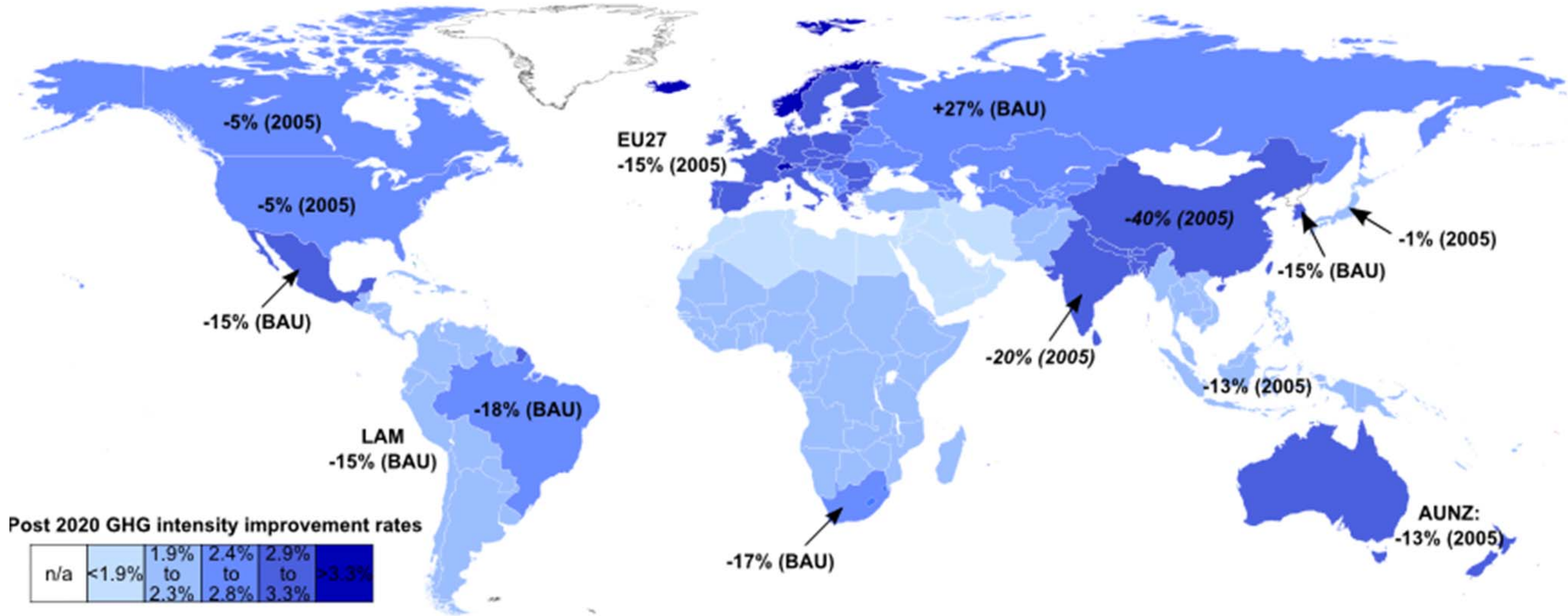


Global policy landscape & timing

What are the implications for climate policy in Europe?

Image sources: www.cafleurebon.com, Protoscar, AMPERE, www.globalccsinstitute.com

How to get from here to global cooperation?



Diverse national energy/climate policies, mixed progress on 2020 pledges

AMPERE reference policy: Regional 2020 emissions targets

Regional RE quotas for electricity (2020)

Capacity targets for Wind, Solar, Nuclear (2020-30)

Extrapolation of GHG intensity improvements beyond 2020

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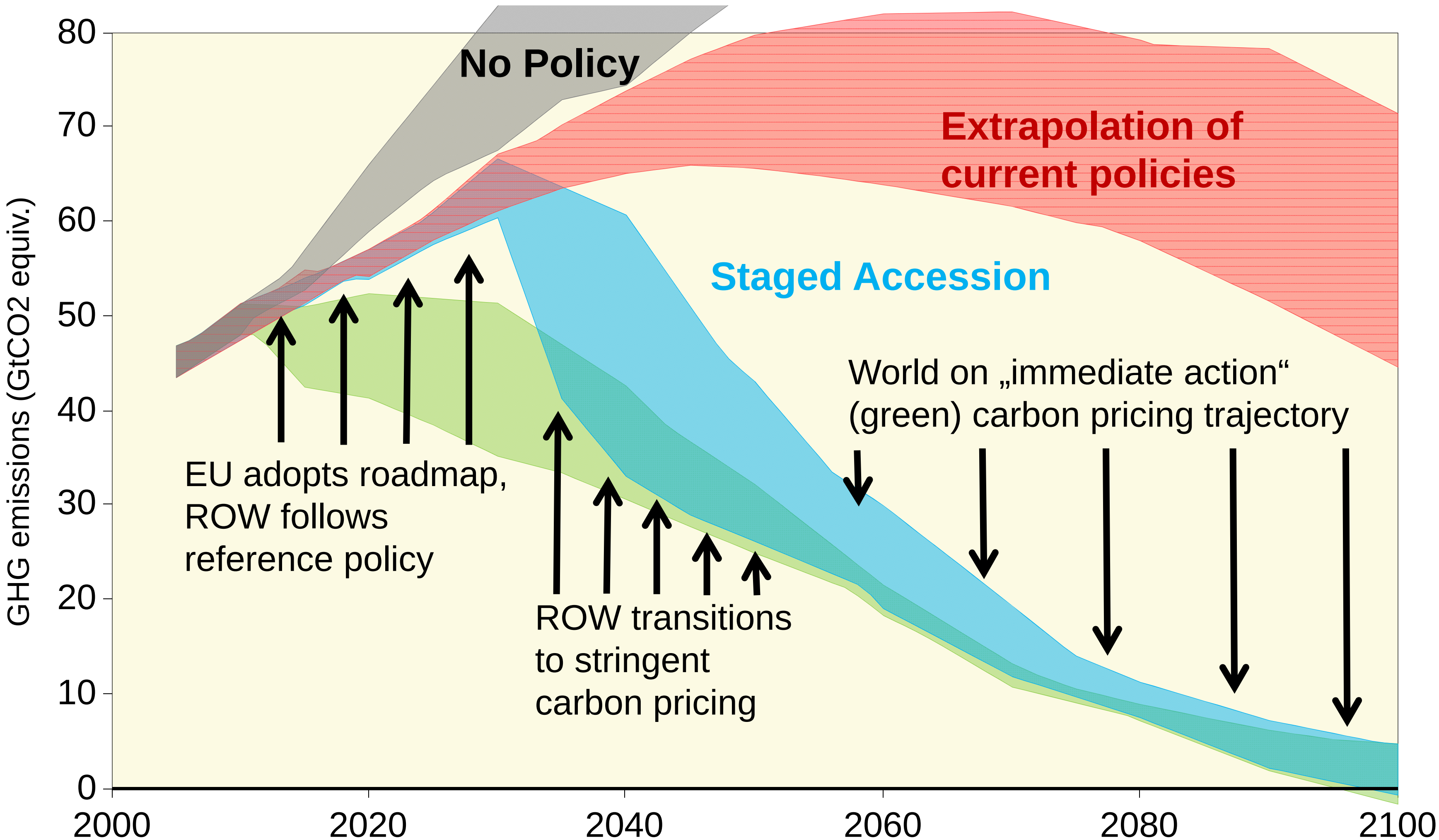
Staged accession to a global climate regime



PIK

Kriegler, Riahi et al. (2014) Tech. For. & Soc. Change, forthcoming

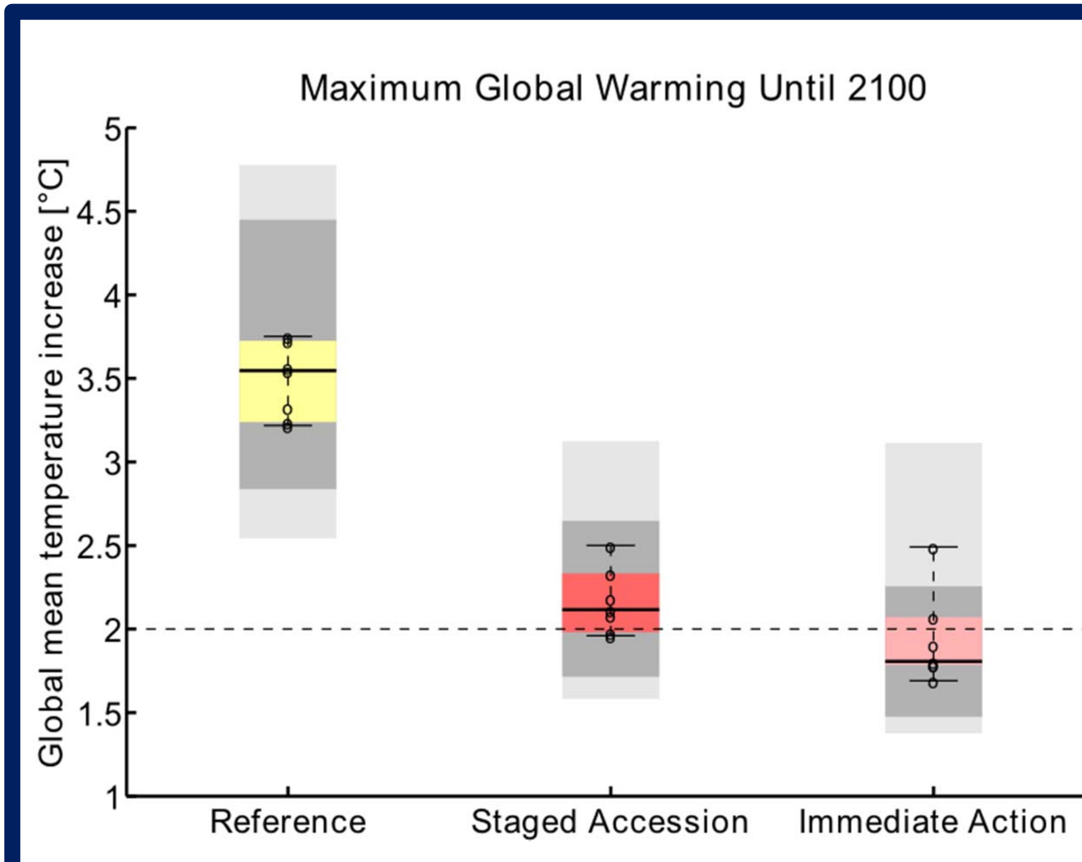
AMPERE

Signalling commitment to ambitious climate targets will bring large climate benefits if others follow

- **Signalling effect of early mover action is key.**
  Without staged accession by major emitters, no warming benefit.

- **Warming can be reduced significantly,**
  if other major emitters join stringent action by 2030 (staged accession).

- **The 2°C target is likely surpassed temporarily**
  in a staged accession setting (by 0.5°C or less)

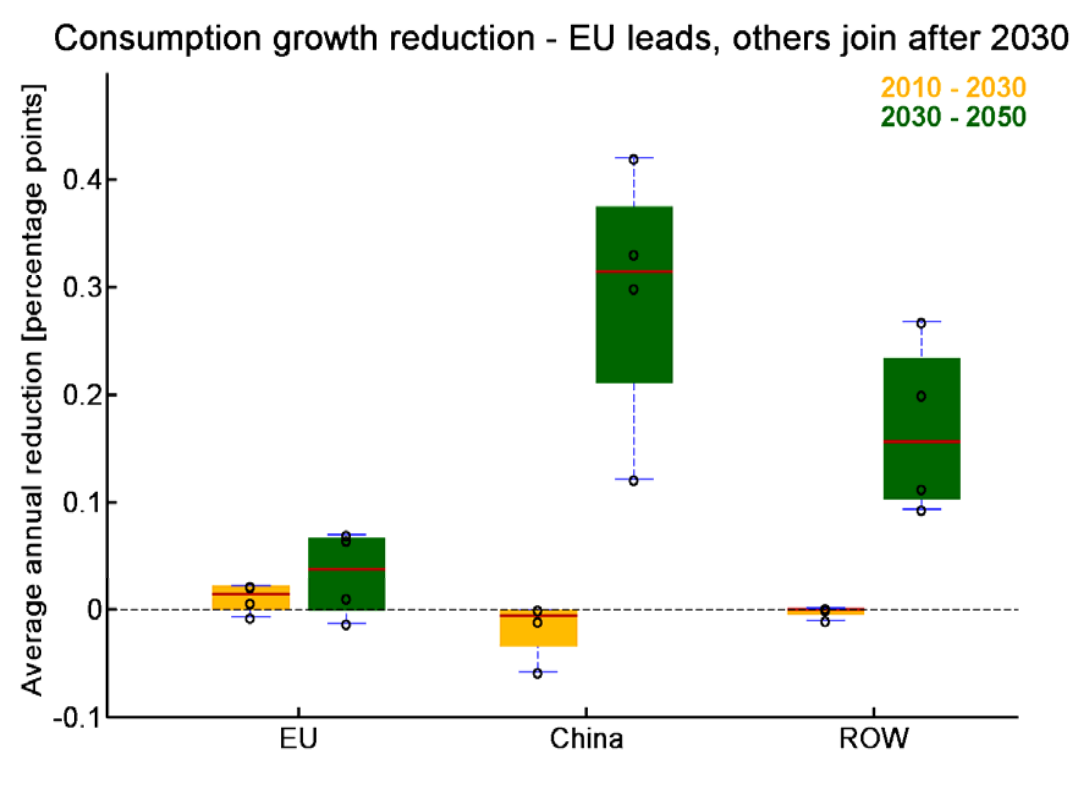


AMPERE

EU can afford to unilaterally commit to stringent emissions reductions

- **EU Roadmap** (-40/-80% in 2030/50) **moderately stronger than reference policy** (-30/-40% in 2030/50)

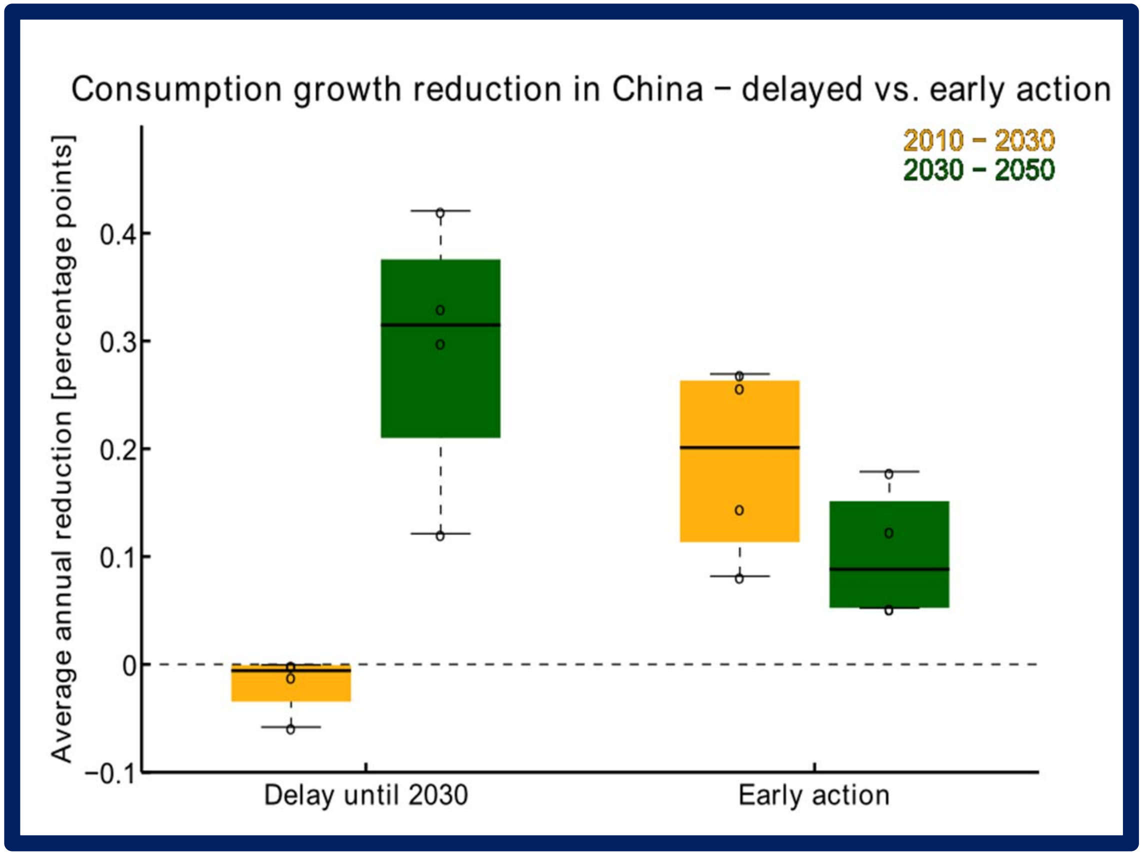
- **Only moderate costs of adopting the roadmap** (0-0.8 percentage points higher than in reference case)



Kriegler, Riahi et al. (2014) Tech. For. & Soc. Change, forthcoming

Countries face a trade-off between early vs. delayed action on long term climate targets

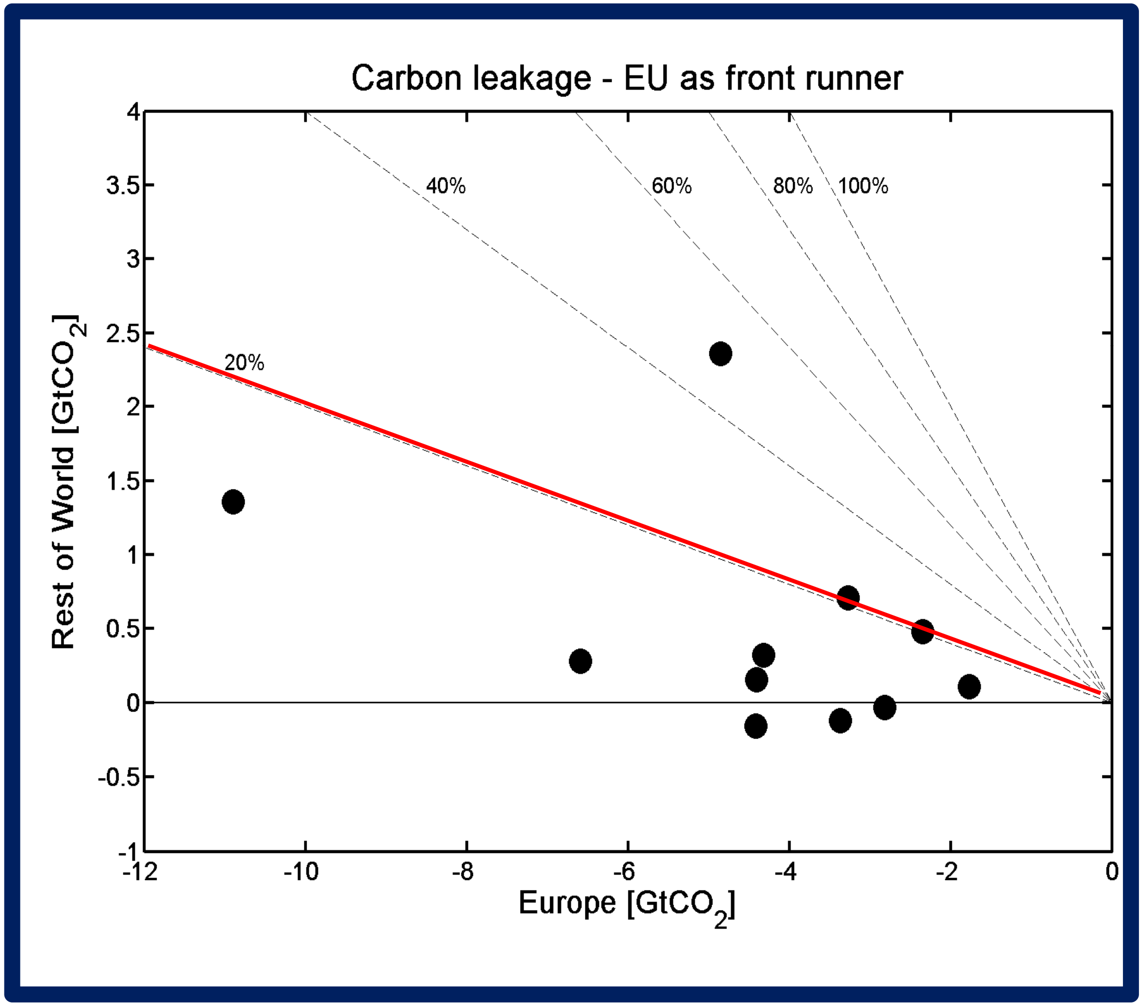
- **Regions need to strengthen action** at some point to reach climate targets.
- **Early movers have higher near term mitigation costs**
- **Late movers face higher transitional impacts later on.**
- **Co-benefits can play large role** (e.g. air quality)



Kriegler, Riahi et al. (2014) Tech. For. & Soc. Change, forthcoming

Carbon leakage effects are limited if others pursue only moderate action until 2030

- **Carbon leakage rate ~20% or smaller** in all but one model
- **Impact on energy intensive industries** (2010-30 results from GEM-E3):
  - max. 31% leakage rate
  - max. 1.5% output reduction in any sector
- **Impact can be further limited by**
  - protection policies
  - early mover coalitions
  - technology diffusion



Kriegler, Riahi et al. (2014) Tech. For. & Soc. Change, forthcoming

LIMITS in a nutshell

Research project funded by the European Commission: implications of the emissions reductions strategies in the major global economies.

1. Explore the **space of post 2020 climate policies**
2. Assessing the **investment** requirements **and the financing** mechanisms
3. Quantifying the changes in the **energy infrastructure and land use** in the major economies.
4. Evaluating the linkages of climate policies with other pressing social and environmental issues such as **energy security, air pollution and economic development**.

LIMITS

LIMITS team

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www.feem.it

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Universiteit Utrecht (UU), Netherlands
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London School of Economics and Political Science (LSE), United Kingdom
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Energy Research Centre of the Netherlands (ECN), Netherlands
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Joint Research Centre, Institute for Environment and Sustainability, European Commission (JRC-IES), Italy
ies.jrc.ec.europa.eu

Central European University (CEU), Hungary
www.ceu.hu

Energy Research Institute of the National Development and Reform Commission (NDRC-ERI), China
www.eri.org.cn

Indian Institute of Management (IIM), India
www.iimahd.ernet.in

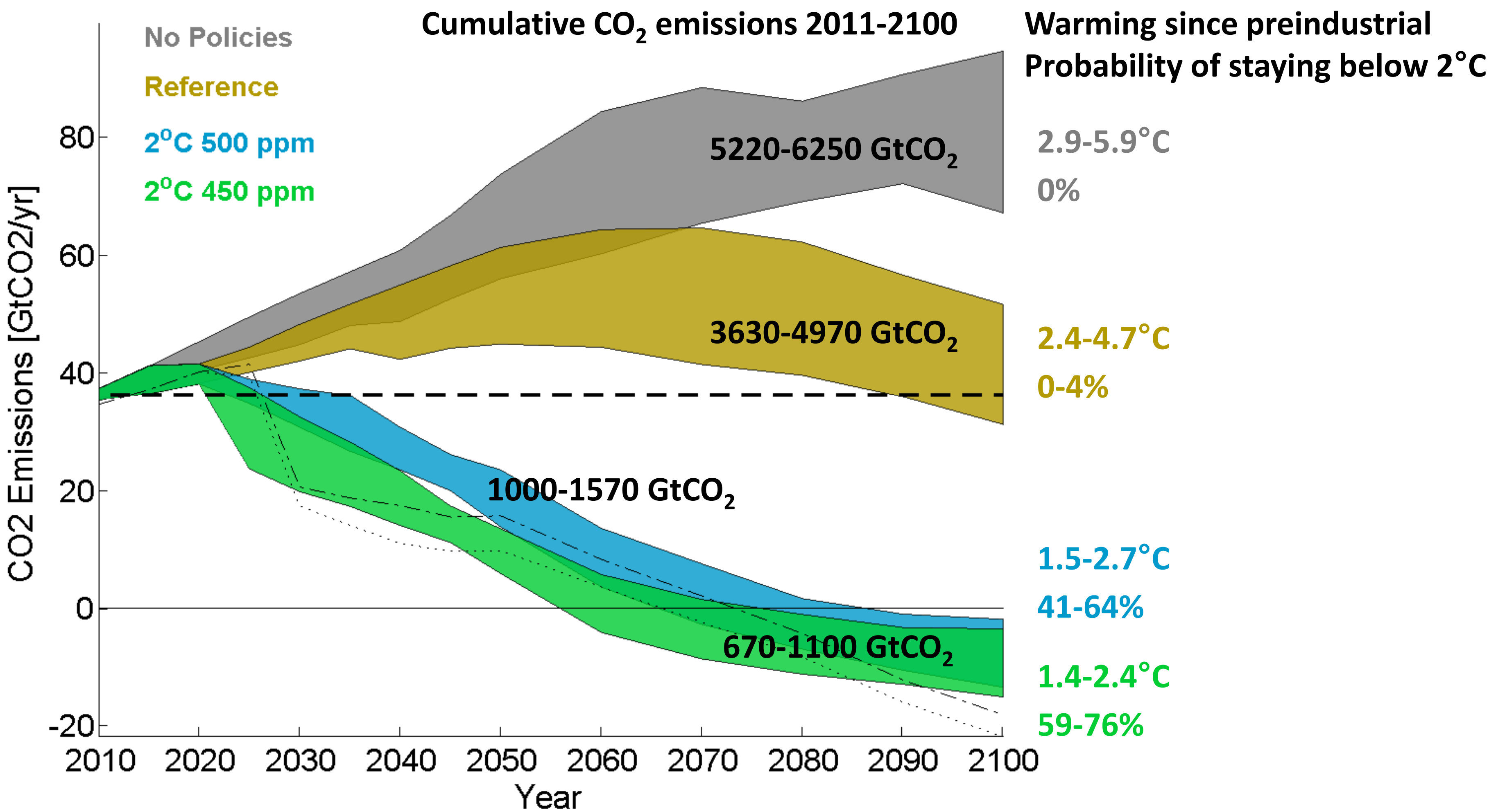
ASSOCIATED RESEARCH ORGANISATIONS

Pacific Northwest National Laboratory, Joint Global Change Research Institute at the University of Maryland (PNNL), USA
www.pnnl.gov

National Institute for Environmental Studies (NIES), Japan
www.nies.go.jp

	IAMs and tools
FEEM	WITCH/GLOBIOM
IIASA	MESSAGE/GLOBIOM
PIK	REMIND/MagPIE/PRIDE
Utrecht	IMAGE
LSE	Theoretical and applied economics
ECN	TIAM-ECN
JRC	TM5 FAST
CEU	Energy economics
ERI	IPAC
IIM	GCAM-IIM and Markal India
PNNL	GCAM
NIES	AIM

LIMITS Durban Platform Scenarios



Kriegler et al. (2013) What does the 2°C target imply for a global climate agreement in 2020? *Climate Change Economics 4(4), 1340008*.

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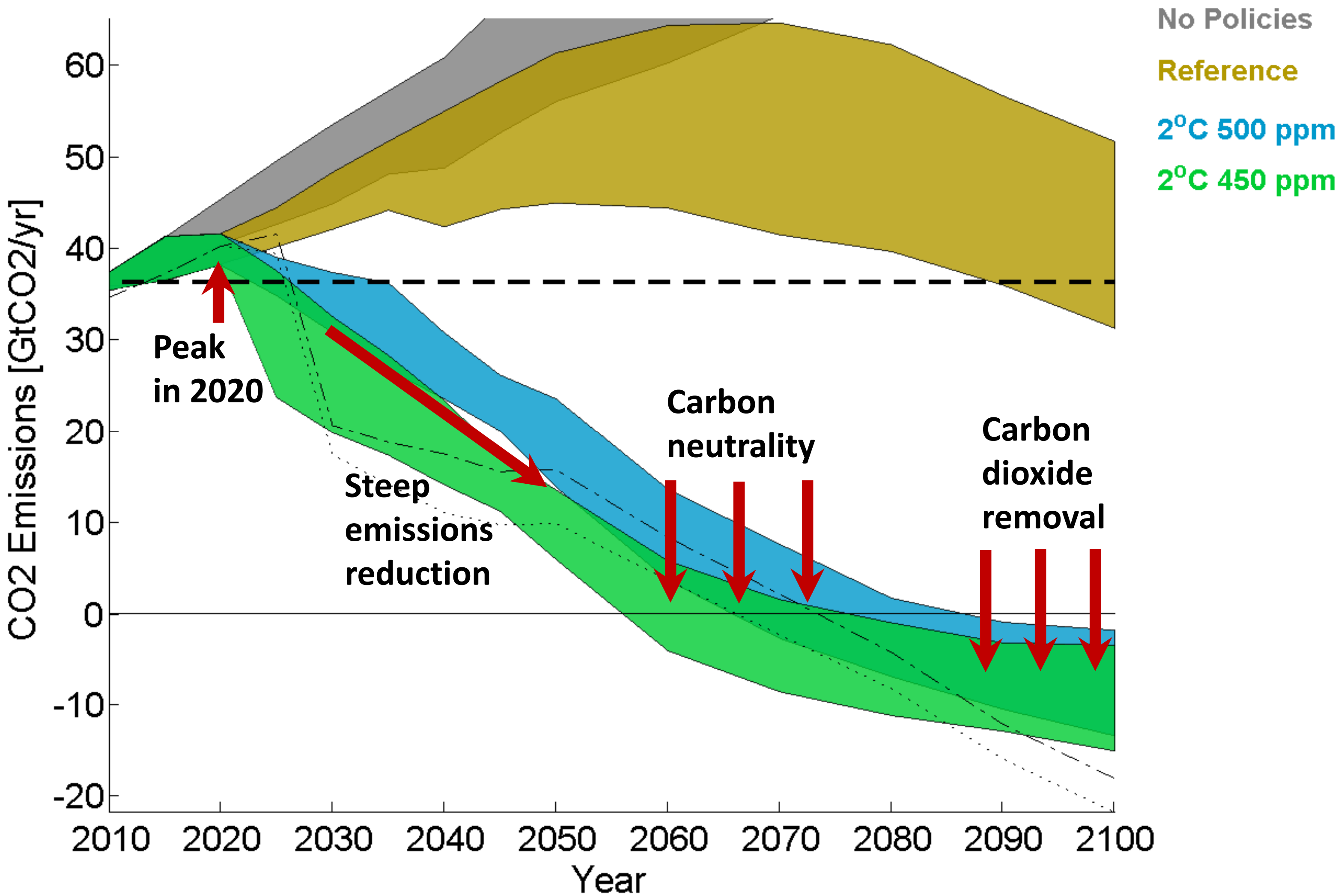
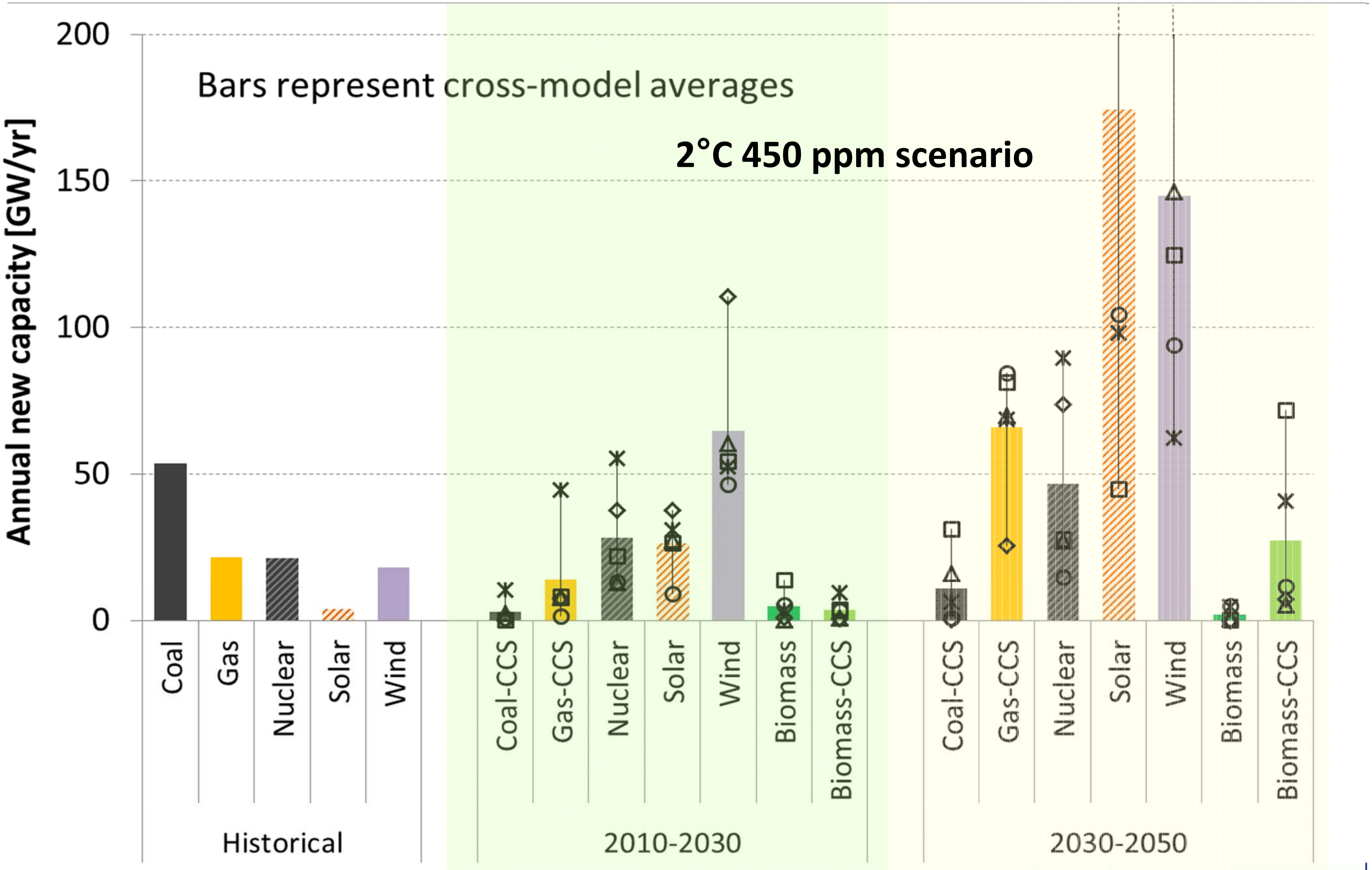
Structure of Durban 2°C pathways



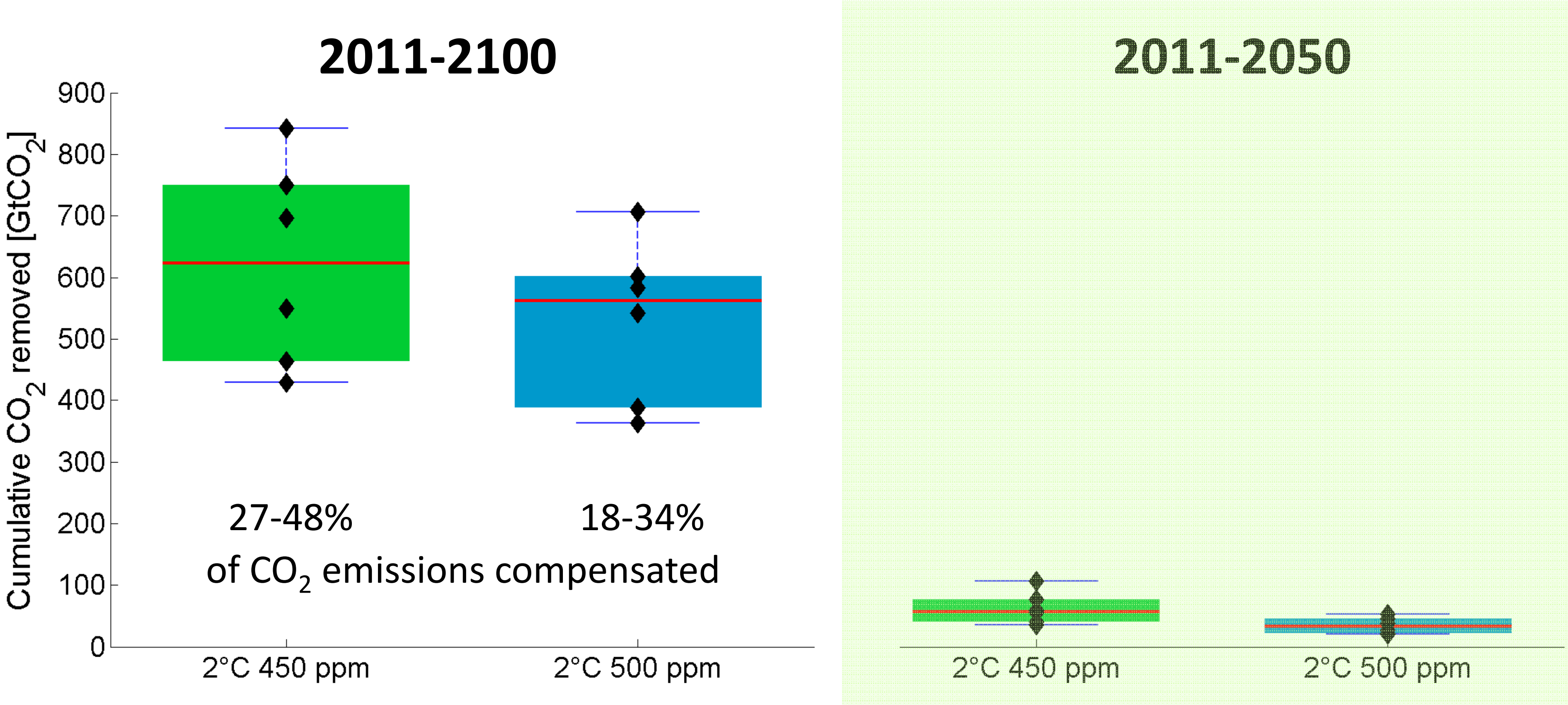
Low Carbon Technology Deployment



van der Zwaan et al. (2013) A Cross-Model Comparison of Global Long-Term Technology Diffusion under a 2°C Climate Change Control Target. *Climate Change Economics 4(4), 1340013*.

Carbon Dioxide Removal

Deployment of Bioenergy with CCS



Relevant after 2050 to achieve carbon neutrality and net negative CO_2 emissions

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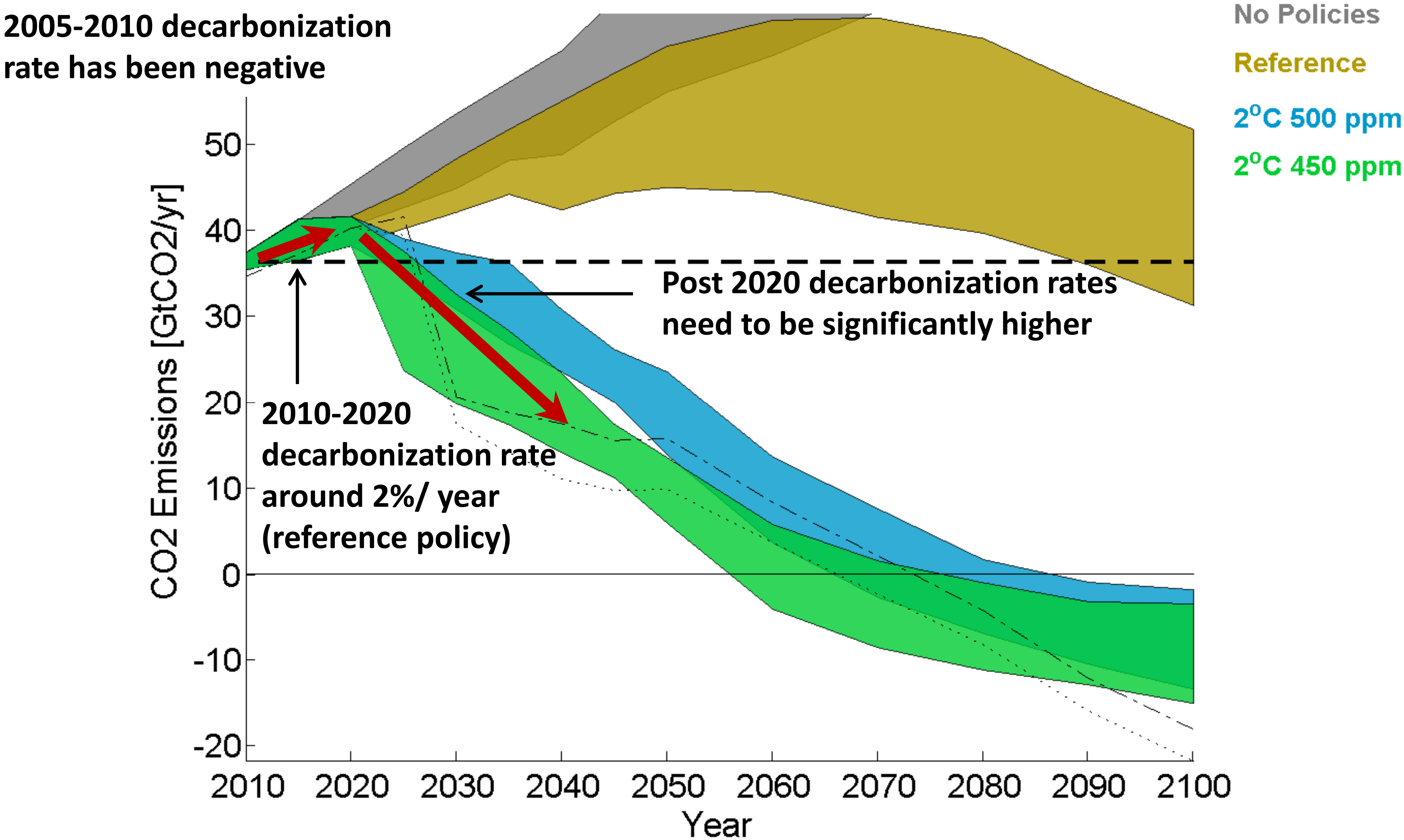
The challenge of „breaking the trend“



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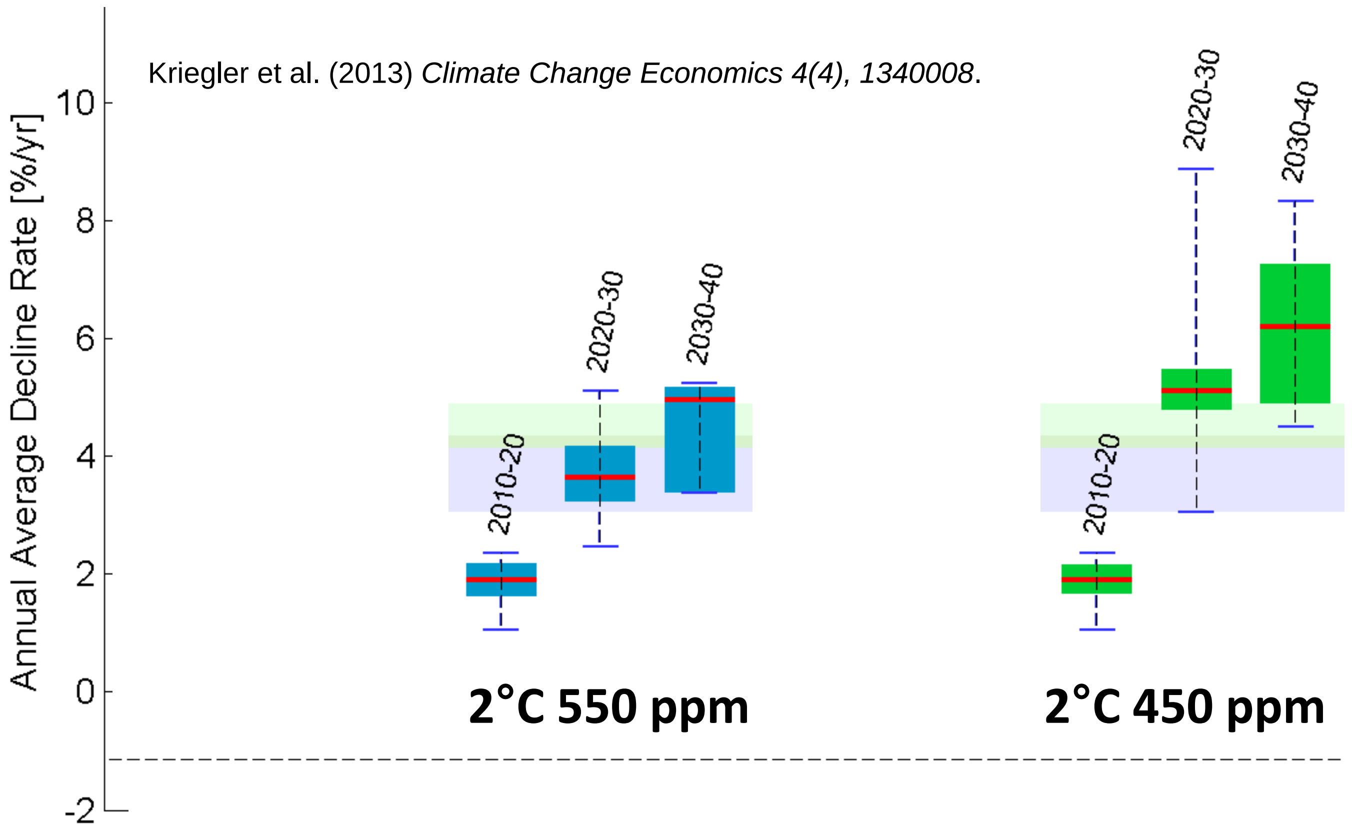
Trend break in decarbonization rates

Rate of reduction in carbon intensity of GDP (2010-2040)



2020-30 decarbonization rate:

450 ppm immediate action

500 ppm immediate action

2005-2010 decarbonization rate

Trend break in 2020 - 450 ppm: ca. 2-3 percentage points

500 ppm: ca. 1-2 percentage points

Summary of Key Messages

- A global climate agreement that leads to peak and decline of global emissions shortly after 2020 can keep the 2°C target within reach.
- Reaching the 2°C target will require a significant upscaling of low carbon technologies in the next decades, and deployment of carbon dioxide removal technologies in the long term.
- The significance of 2015-2030 climate policies lie in preparing the ground for steep emissions reductions thereafter (2030-2050).
- Delaying the global peak of emissions by a decade, as a result of a failure to implement a comprehensive global climate agreement by 2020, will likely put the 2°C target out of reach.

ROSE study on the role of population, economic growth, fossil fuel availability and delayed action for achieving concentration targets

Special issue in Climate Change

Delayed action (Luderer et al.), Energy security (Cherp et al.), African development & emissions (Calvin et al.), Fossil fuel markets (Bauer et al.), Fossil fuel and biofuel interactions (Calvin et al.), Drivers of energy investment (DeCian et al.), China energy transformation (Chen et al.)

5 participating models (4 x global, 1 x China)

GCAM, IPAC, REMIND, WITCH, China-TIMES

For more information on the RoSE study: www.rose-project.org

Funded by Stiftung Mercator