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The role of low-carbon technologies in climate mitigation

Perspectives on feasibility of low climate targets, sector-specific action and mitigation costs based on the EMF27 model inter-comparison project

Volker Krey

krey@iiasa.ac.at

IIASA, International Institute for Applied Systems Analysis

“The purpose of computing is insights, not numbers.”

Richard W. Hamming

Numerical Methods for Scientists and Engineers

McGraw-Hill, 1962

Outline

- Introduction
- Energy Modeling Forum (EMF) 27 Study
- The Influence of Technology Availability on critical Characteristics of Mitigation Strategies
  - Timing of Mitigation
  - Contribution of different Sectors
  - Value of Technology

The EMF27 Model Comparison

- Topic: Global Technology Strategies for Greenhouse Gas Mitigation
- 18 energy-economic and integrated assessment models

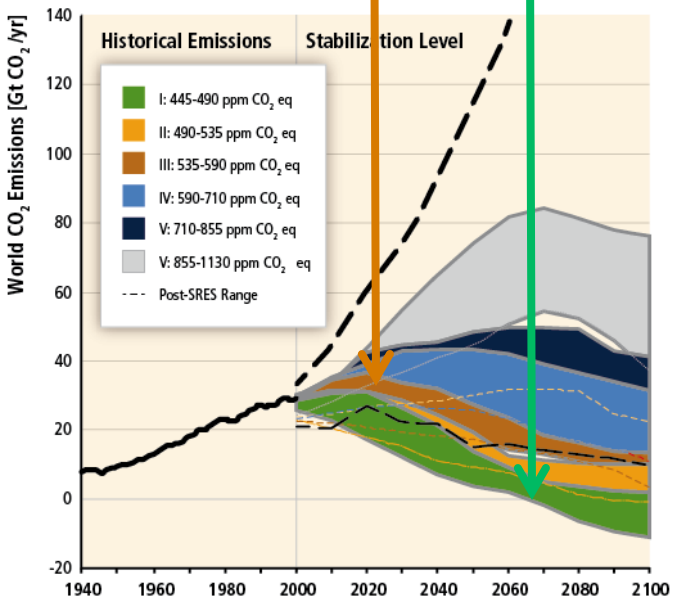
Special Issue in *Climatic Change*

- 11 cross cutting papers:
  study overview, technology, policy, fossil resources, renewable energy, bioenergy, nuclear, CCS, energy efficiency, land-use, non-Kyoto radiative forcing

EMF27 Modeling Protocol

Policy Dimension

- Baseline
- 550 ppm CO2-eq.
- 450 ppm CO2-eq.



Source: IPCC AR4 Synthesis Report, adopted for IPCC SRREN

Technology dimension

- Energy intensity: High/Low
- CCS: On/Off
- Nuclear: On/Off
- Wind/Solar: Opt/Pess
- Bioenergy: High/Low

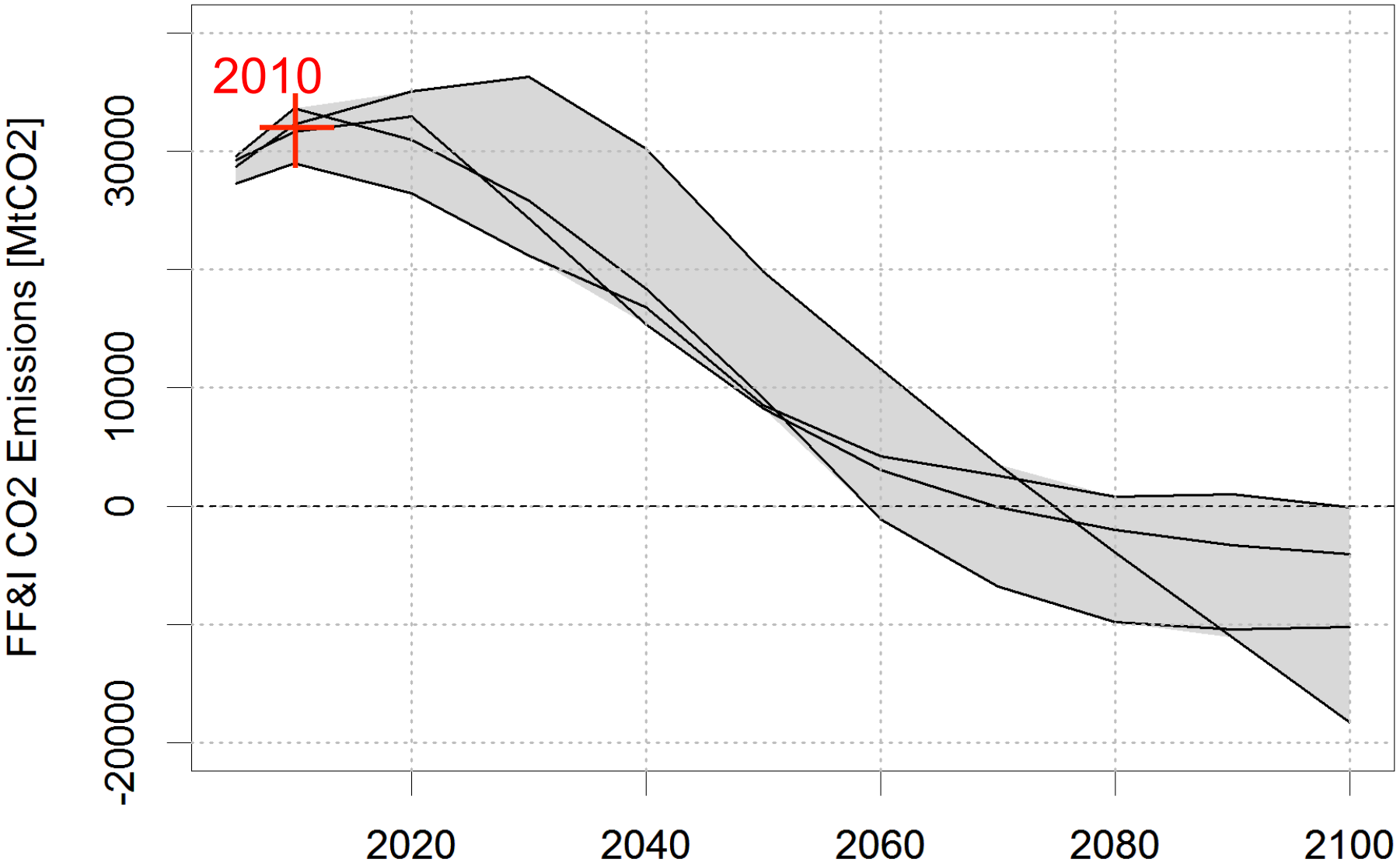
Combinations:

- Conventional
- EERE
- Limited Technology

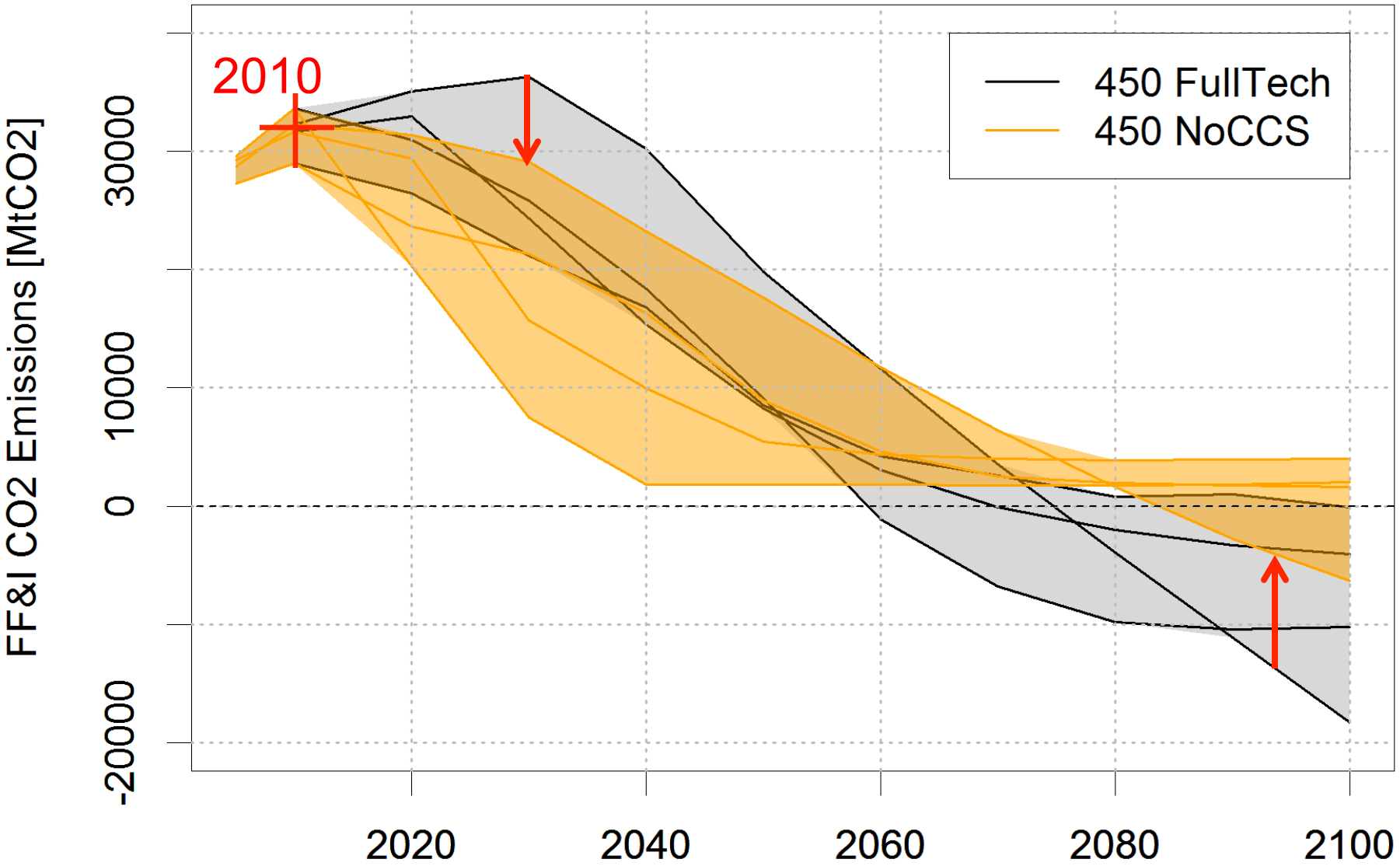
Technology Representation

- coverage of different options similar in the electricity sector
  - coverage of biomass w/ CCS, CSP and geothermal varies
  - ocean energy not represented in most models
- most models have liquid biofuels, but coverage of CCS is less common than in electricity generation
- coverage of hydrogen production and even more so gasification vary considerably across models – w/o and w/ CCS
- compared to earlier studies the option of bioenergy with CCS (BECCS) is much higher

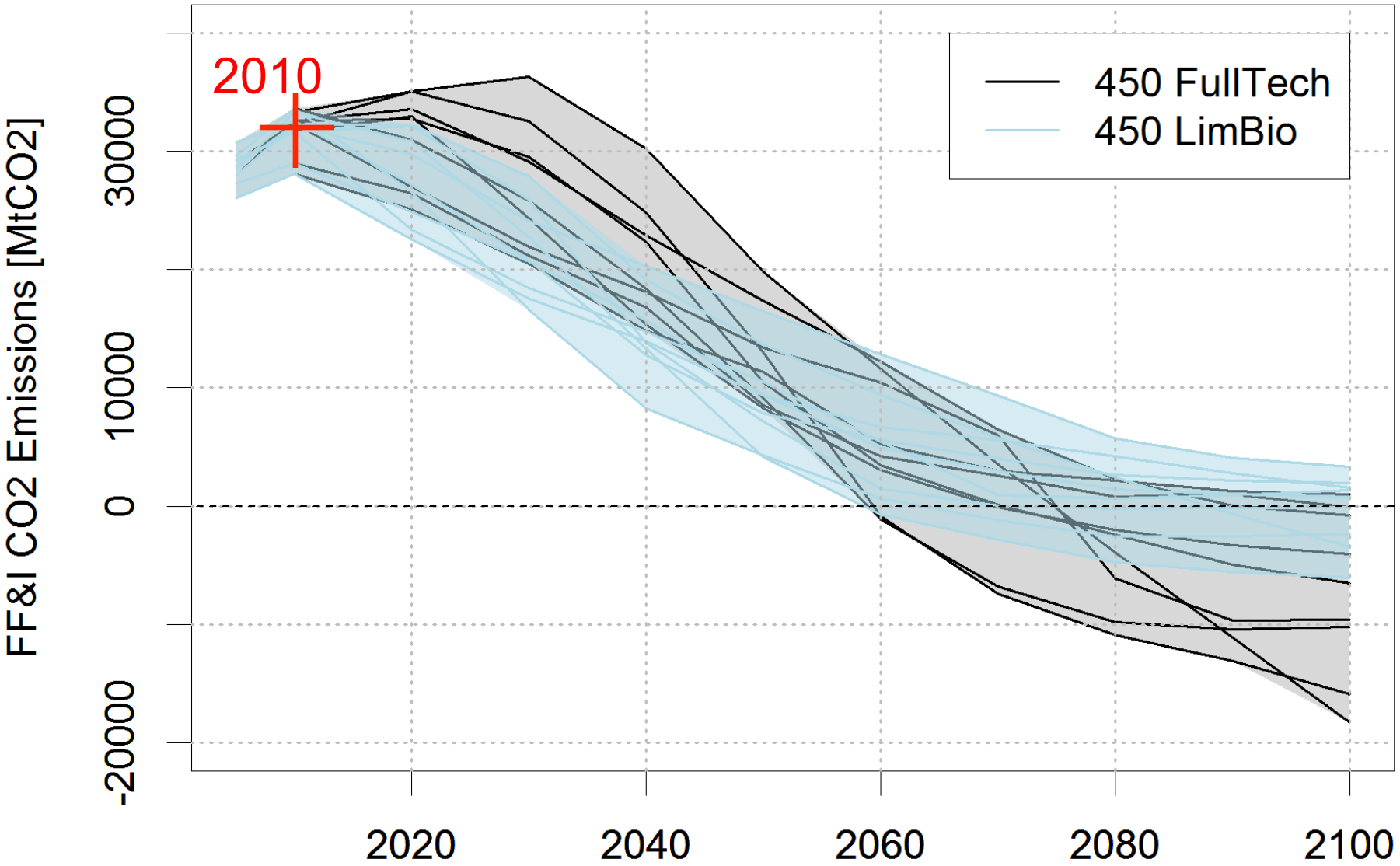
Timing of Mitigation: Full Portfolio



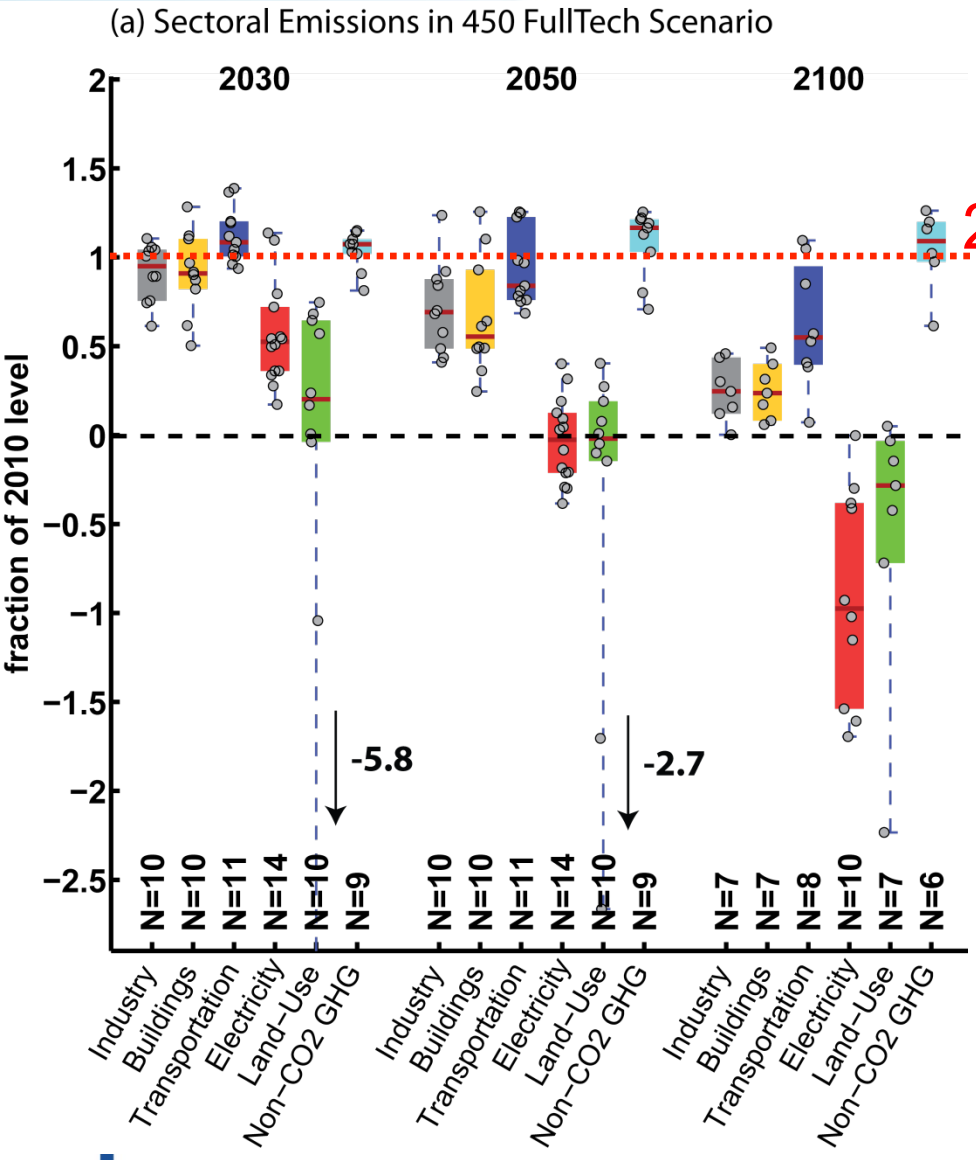
Timing of Mitigation: No CCS



Timing of Mitigation: Limited Biomass



Direct Sectoral Emissions



Climate Target Feasibility

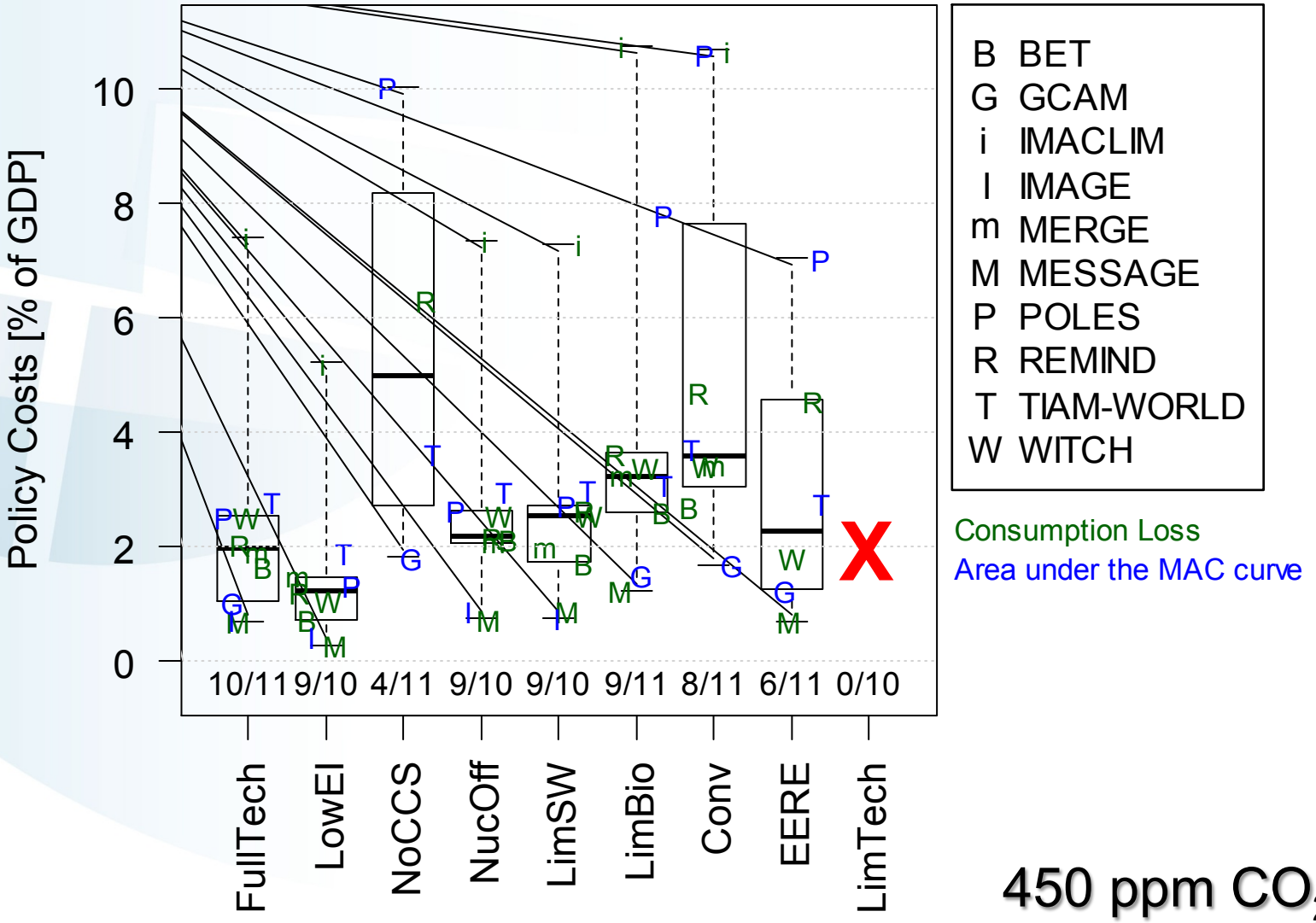
	FullTech	LowEI	NoCCS	NucOff	LimSW	LimBio	Conv	EERE	LimTech
Baseline	13/13	13/13		11/11	11/11	13/13	13/13	13/13	11/11
550 ppm	13/13	13/13	12/12	11/11	11/11	13/13	13/13	12/12	6/9
450 ppm	10/11	9/10	4/11	9/10	9/10	9/11	8/11	6/11	0/10

What does feasibility tell us?

- Models cannot produce scenario within comfort zone of modelers (e.g., model does not technically solve, carbon price very high)
- Subjective judgment involved
- Many ”real-life factors” not covered by models

Policy Costs of Climate Mitigation

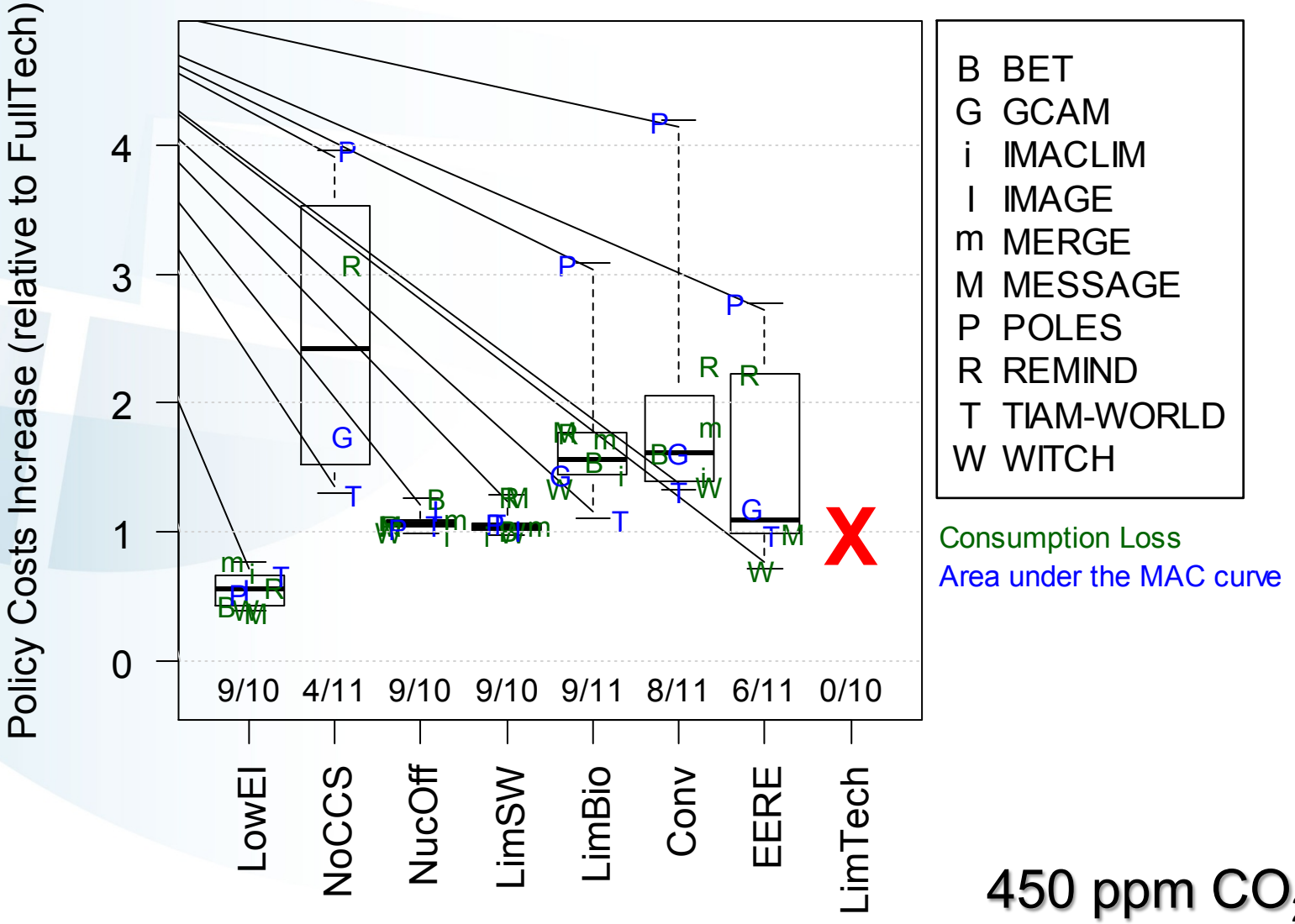
NPV(5%) as fraction of GDP (2010-2100)



450 ppm CO_2e

Policy Costs of Climate Mitigation

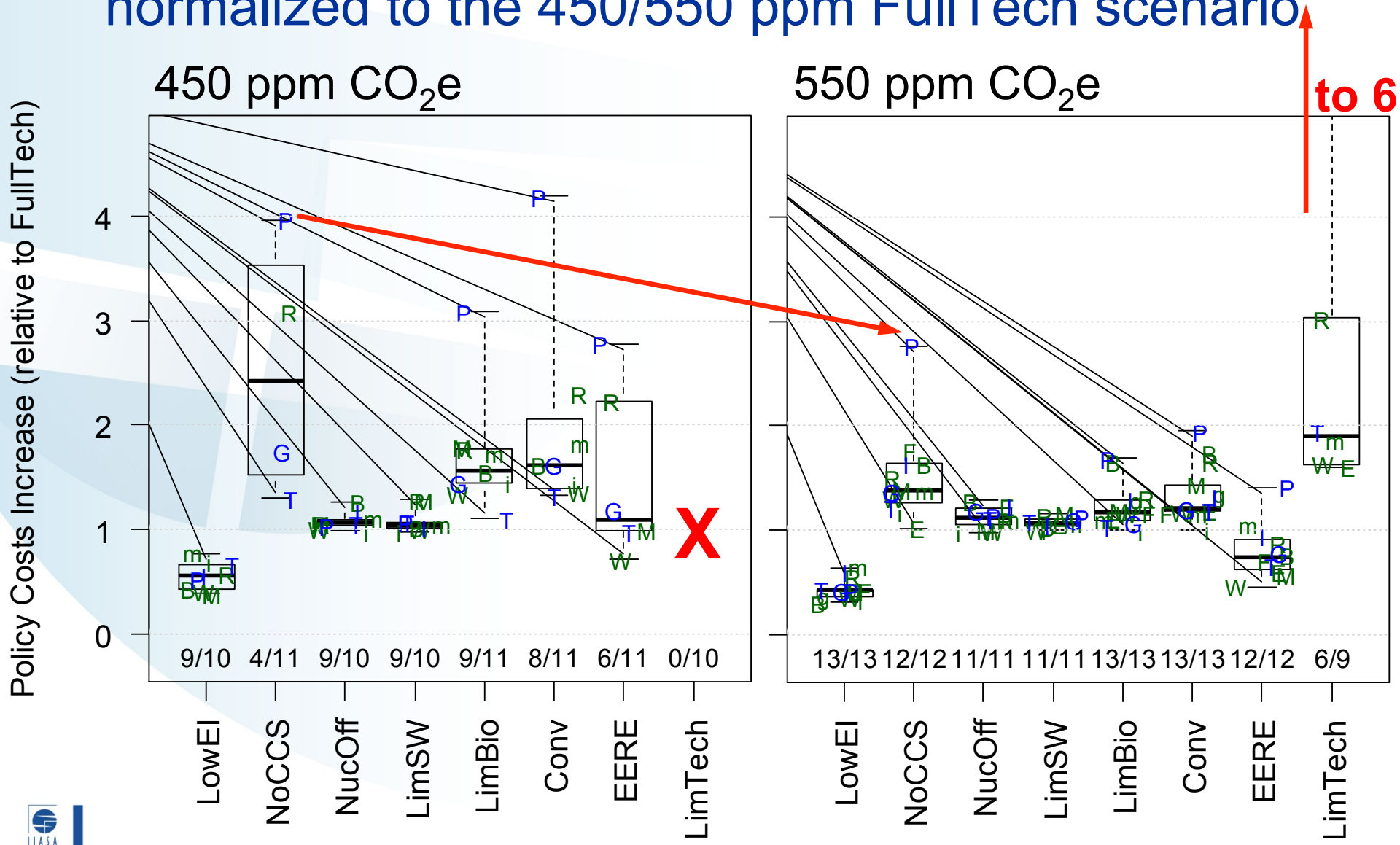
normalized to the 450 ppm FullTech scenario



450 ppm CO_2e

Policy Costs of Climate Mitigation

normalized to the 450/550 ppm FullTech scenario



Conclusions

- All technologies are valuable, but some are more valuable
- The value and importance of technology increases with the stringency of the climate target
- The timing of mitigation and the burden that different sectors will have to carry critically depend on future availability of Carbon Dioxide Removal (CDR) technologies – policy implications
- “Betting on CDR technologies” might be risky – there is (almost) no way back

Some Thoughts and Questions

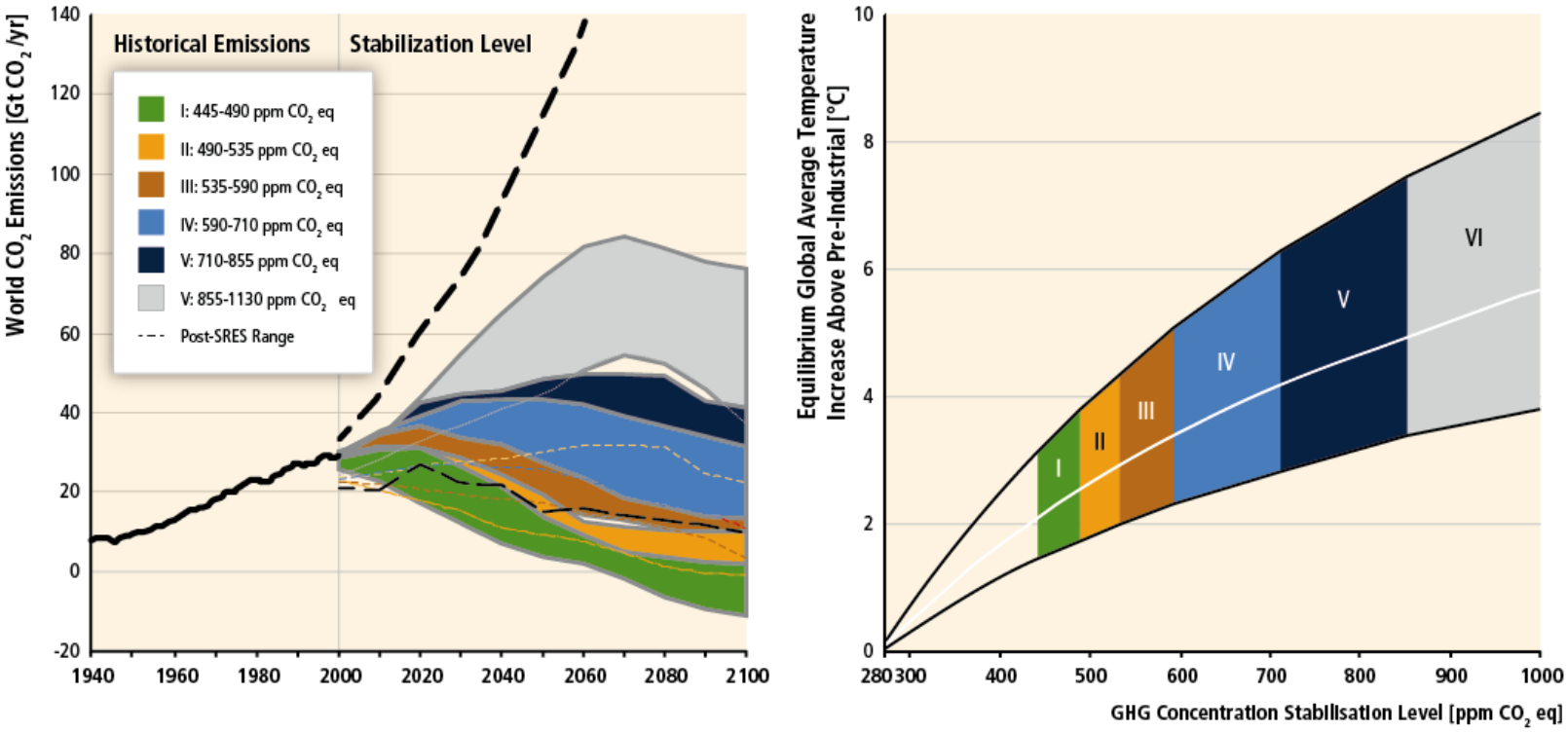
- Many known (and unknown?) unknowns related to CDR deployment (session on Friday)
- How to address the CDR technology lock-in from a risk management perspective?
- Does the demand side (e.g. efficiency) have the silver bullet?

Thank you!

Reference

Krey V., G. Luderer, L. Clarke, and E. Kriegler (In Press). Getting from here to there – energy technology transformation pathways in the EMF27 scenarios. Climatic Change, EMF27 Special Issue, http://dx.doi.org/10.1007/s10584-013-0947-5.

IPCC AR4 Stabilization Categories



GHG emissions resulting from the provision of energy services contribute significantly to the increase in atmospheric GHG concentrations.

Source: IPCC AR4 Synthesis Report, adopted for IPCC SRREN

Modeling Teams in EMF27

- AIM/End-Use (Japan)
- BET (Japan)
- DNE21+ (Japan)
- EC-IAM (Canada)
- ENV-Linkages (OECD)
- FARM (U.S./Germany)
- GCAM (U.S.)
- GCAM-IIM (U.S./India)
- GRAPE (Japan)
- IMACLIM (France)
- IMAGE (Netherlands)
- MERGE (U.S.)
- MESSAGE (Austria)
- Phoenix (U.S.)
- POLES (France)
- REMIND (Germany)
- TIAM-World (Canada)
- WITCH (Italy)

	Electricity											Liquids			
	Fossil w/o CCS	Fossil w/CCS	Nuclear Power	Bioenergy w/o CCS	Bioenergy w/CCS	Hydro	Wind	Solar PV	Solar CSP	Geothermal	Ocean	Fossil w/o CCS	Fossil w/CCS	Bioliquids w/o CCS	Bioliquids w/CCS
AIM-Enduse	+	+	+	+	+	+	+	+	-	+	-	-	-	+	-
BET	+	+	+	+	+	+	+	+	-	+	-	+	-	+	-
DNE21+	+	+	+	+	+	+	+	+	-	+	-	+	-	+	-
EC-IAM	+	+	+	+	-	+	+	+	(+)	(+)	-	+	-	+	-
ENV-Linkages	+	+	+	+	-	+	(+)	(+)	(+)	(+)	-	+	-	-	-
FARM	+	+	+	+	+	+	+	+	(+)	-	-	-	-	-	-
GCAM	+	+	+	+	+	+	+	+	+	+	-	+	+	+	+
GRAPE	+	+	+	+	+	+	+	+	-	-	-	+	-	+	-
IMACLIM	+	+	+	+	+	+	+	-	-	-	-	+	+	+	-
IMAGE	+	+	+	+	+	+	+	+	-	-	-	-	-	+	+
MERGE	+	+	+	+	+	+	+	+	(+)	-	-	+	-	+	-
MESSAGE	+	+	+	+	+	+	+	+	+	+	-	+	+	+	+
Phoenix	+	+	+	+	-	+	+	+	-	+	-	-	-	+	-
POLES	+	+	+	+	+	+	+	+	+	+	-	+	+	+	+
ReMIND	+	+	+	+	+	+	+	+	+	+	-	+	+	+	+
TIAM-WORLD	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
WITCH	+	+	+	+	+	+	+	+	-	-	-	-	-	+	-

	Gases				Hydrogen						Transport	
	Fossil w/o CCS	Fossil w/CCS	Bioenergy w/o CCS	Bioenergy w/CCS	Fossil w/o CCS	Fossil w/CCS	Bioenergy w/o CCS	Bioenergy w/CCS	Electrolysis	Thermochemical	Electric Vehicles	Hydrogen Vehicles
AIM-Enduse	+	-	+	-	+	+	+	+	-	-	+	+
BET	-	-	+	-	-	-	-	-	+	-	+	-
DNE21+	+	-	-	-	+	+	+	+	+	-	+	+
EC-IAM	-	-	-	-	-	-	-	-	-	-	+	+
ENV-Linkages	-	-	-	-	-	-	-	-	-	-	(+)	-
FARM	-	-	-	-	-	-	-	-	-	-	(+)	-
GCAM	+	-	+	-	+	+	+	+	+	+	+	+
GRAPE	+	-	-	-	-	+	-	-	+	-	+	+
IMACLIM	-	-	-	-	-	-	-	-	-	-	+	-
IMAGE	-	-	-	-	+	+	+	+	+	-	-	+
MERGE	-	-	-	-	-	-	-	-	-	-	+	-
MESSAGE	+	+	+	+	+	+	+	+	+	-	+	-
Phoenix	+	-	-	-	-	-	-	-	-	-	+	-
POLES	-	-	-	-	+	+	+	+	+	+	+	+
ReMIND	+	+	+	+	+	+	+	+	+	-	+	+
TIAM-WORLD	-	-	+	+	+	+	+	+	+	-	+	+
WITCH	-	-	-	-	-	-	-	-	-	-	-	-

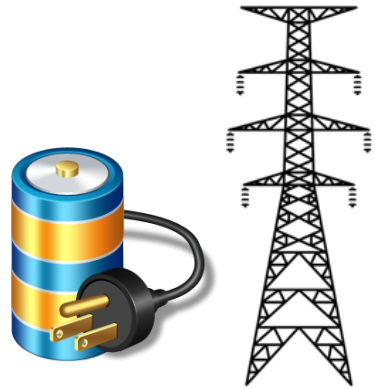
Some Generic Insights about Mitigation in the Energy Sector

A Generic Mitigation Strategy

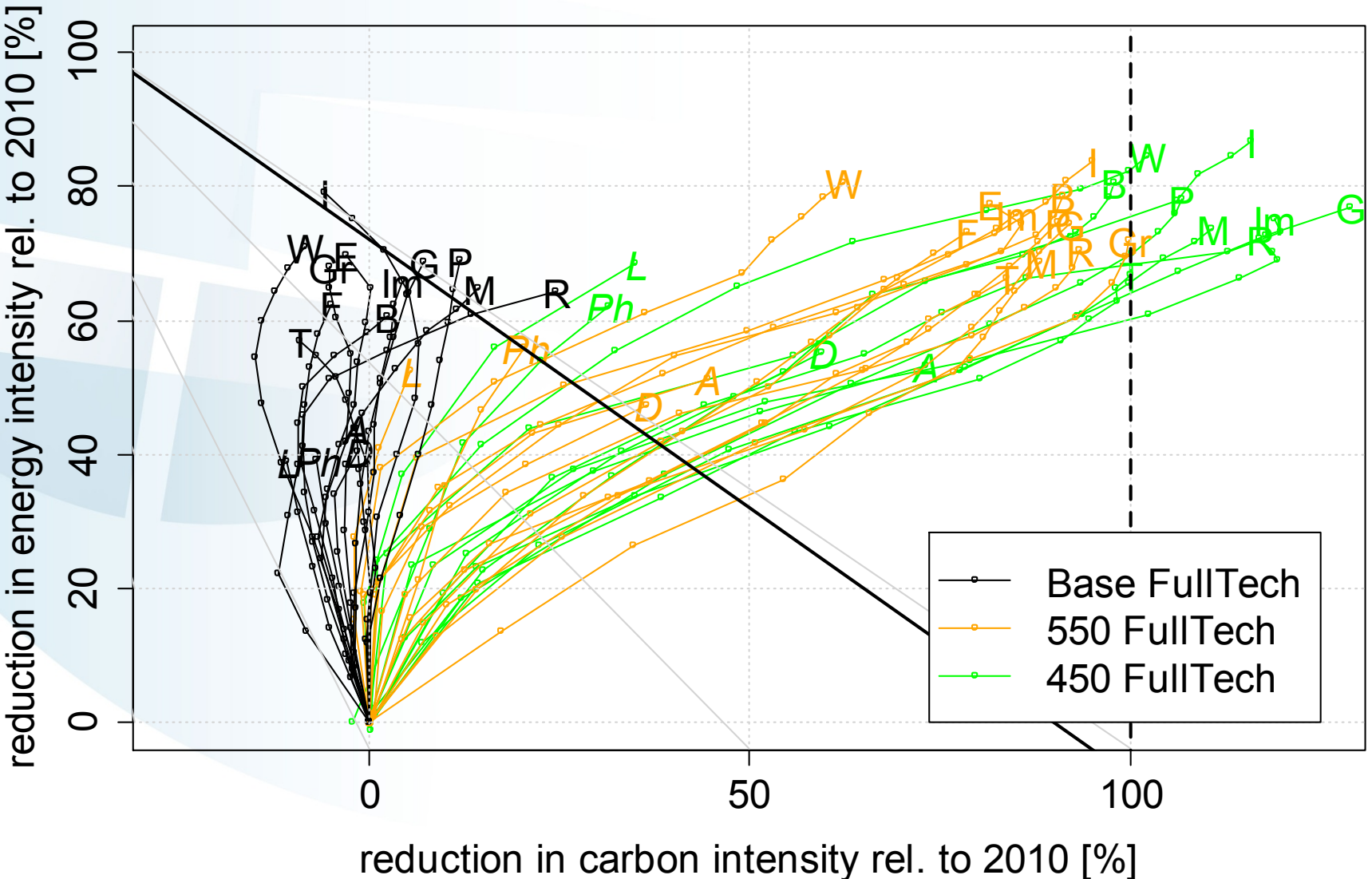
1. Decarbonize Energy Supply

2. Reduce Energy Demand

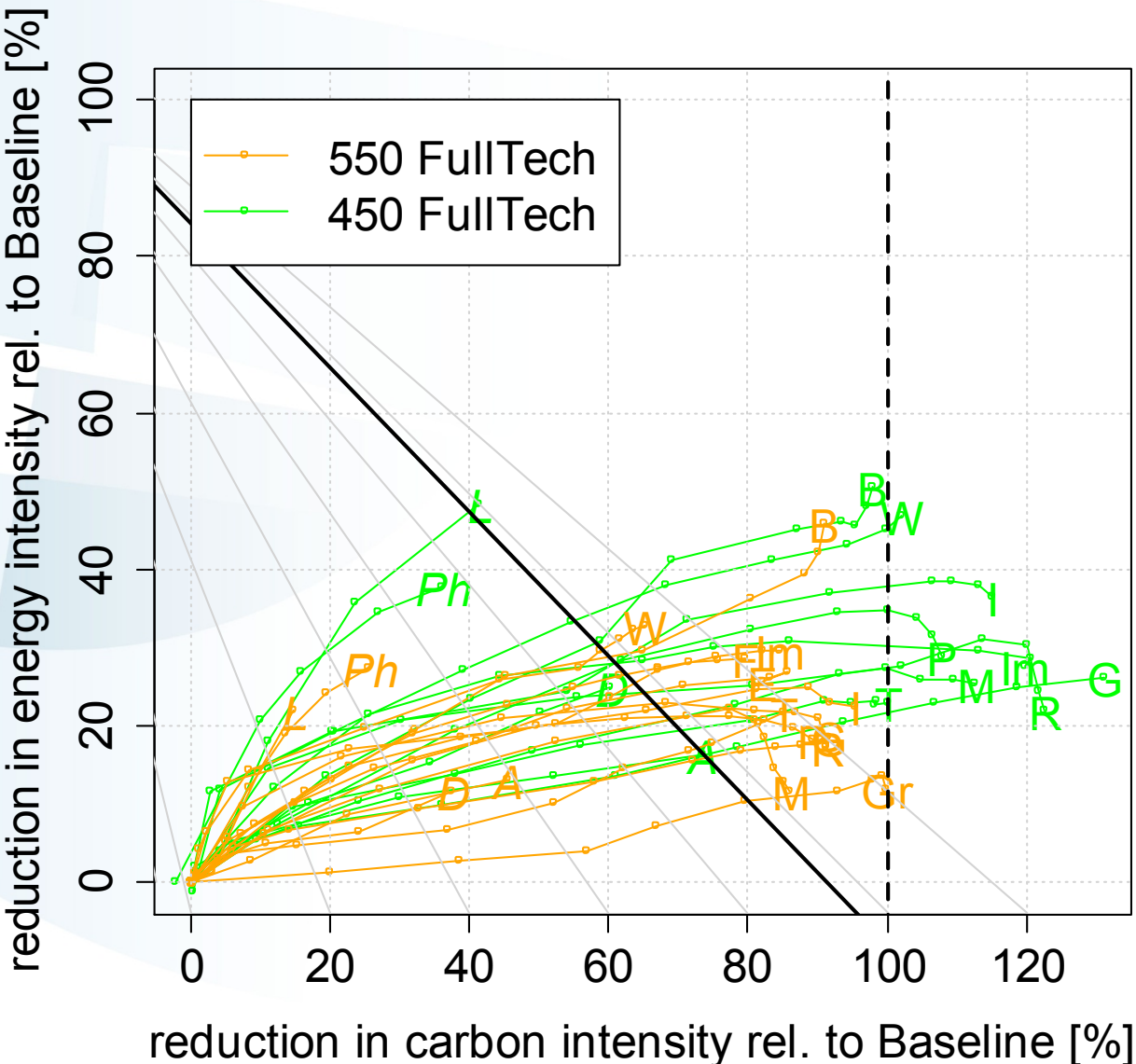
3. Switch to Low-Carbon Fuels



Energy vs. Carbon Intensity

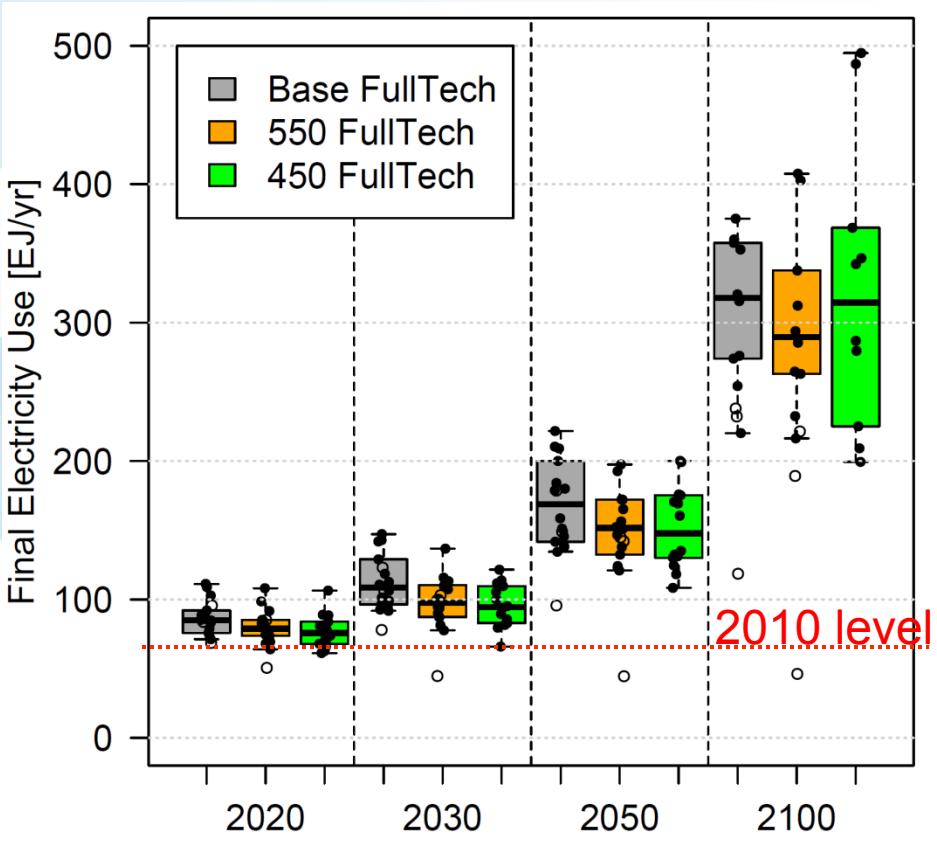


Energy vs. Carbon Intensity



Fuel Switching to Electricity, …

(a) Final Electricity Use



(b) Final Electricity Share