Long-Term Scenarios: Perspectives, Experience, and Activities

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RITE International Symposium

The frontiers of scenarios for climate change research and assessment

Wednesday, February 09, 2011

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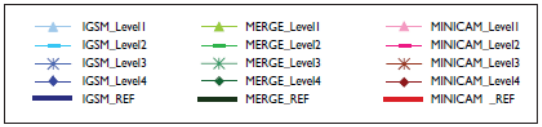
Motivation: Work on the IPCC's 5th Assessment Report (AR5) is beginning. What scenario information will be available for AR5?

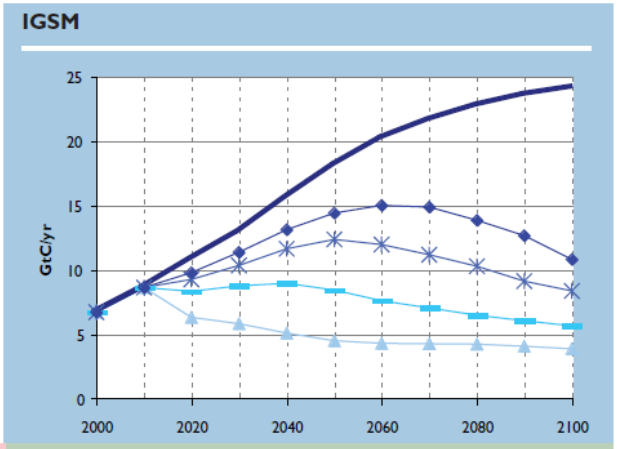
I will focus on **international policy scenarios** and scenarios of **technology deployment**.

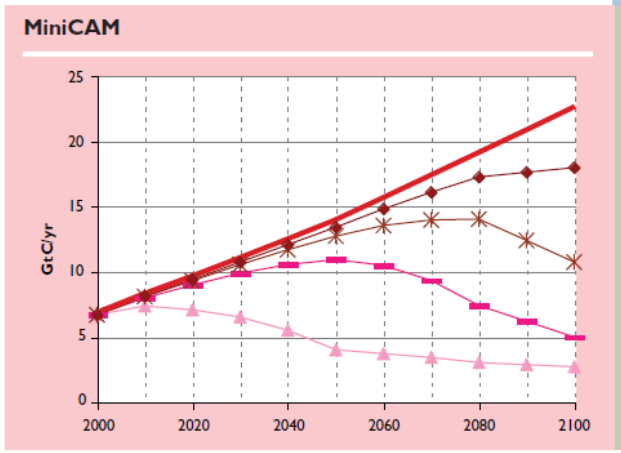
International Climate Policy and Long-Term Scenarios

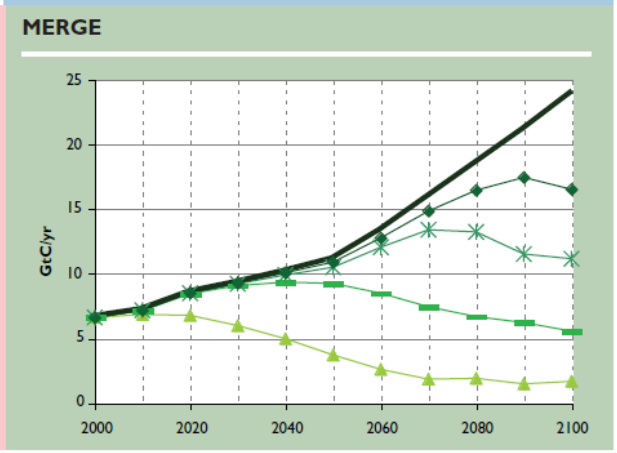
For many years, most stabilization scenarios assumed an idealized international policy environment.

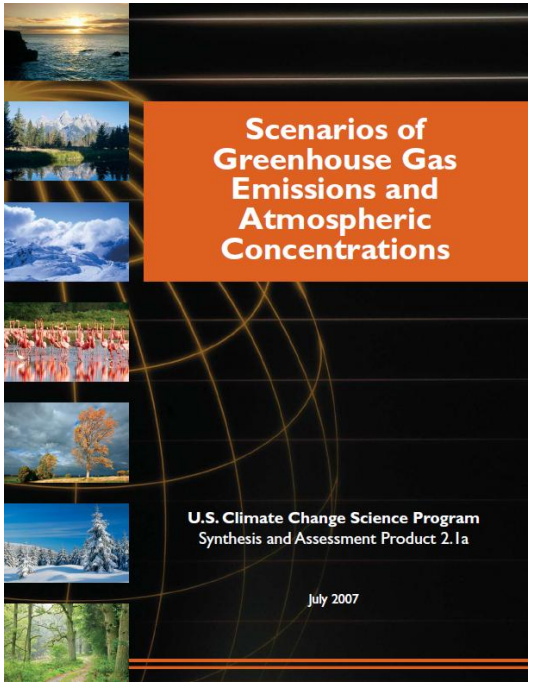
Figure TS.10 Global Emissions of CO_2 from Fossil and other Industrial Sources Across Scenarios (GtC/yr). The tighter the constraint on radiative forcing, the faster carbon emissions must decline from those in the reference scenarios. This is because the stabilization level defines a long-term carbon budget; that is, the remaining amount of carbon that can be emitted in the future. The gradual deflection of the emissions from the reference reflects the assumption of *when* flexibility, with carbon prices rising gradually. Under the most stringent radiative forcing stabilization levels, CO_2 emissions begin to decline immediately or within a matter of decades. Under less stringent radiative forcing stabilization levels, CO_2 emissions do not peak until late in the century or beyond, and they are 1½ to over 2½ times today's levels in 2100.











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The EMF 22 Study represents the state-of-the art in coordinated "2nd-best" international policy scenarios.

- The study was coordinated by the Energy Modeling Forum (EMF) at Stanford University and completed in 2009.
- Ten modeling teams participated in the international scenario component of the study:
  - ETSAP-TIAM (Canada)
  - FUND (E.U.)
  - GTEM (Australia)
  - IMAGE (E.U.)
  - MERGE (U.S.)
  - MESSAGE (E.U.)
  - MiniCAM (U.S.)
  - POLES (E.U.)
  - SGM (U.S.)
  - WITCH (E.U.)

The EMF 22 International Scenarios explored ten possible international approaches to mitigation.

- The ten scenarios are combinations of
  - Three concentration goals based on Kyoto gases
    - (1) 450 CO2-e, (2) 550 CO2-e, and (3) 650 CO2-e
  - Two means of achieving concentration goals
    - (1) not-to-exceed between this century and (2) overshoot through 2100
  - Two international policy regimes
    - (1) Full participation immediately and (2) delayed participation by non-Annex I regions and Russia

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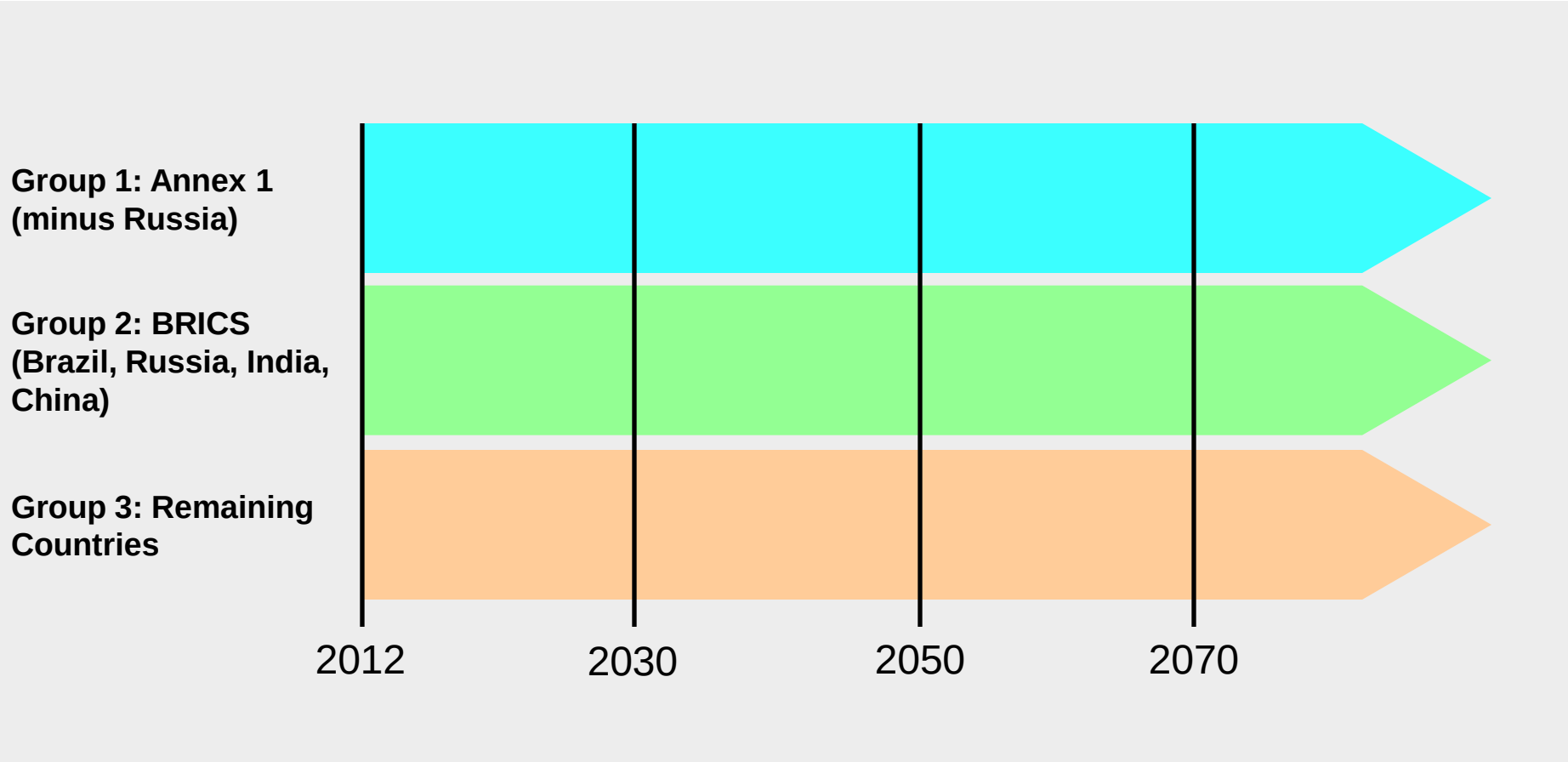
Full Participation: All Countries Begin Reductions Immediately



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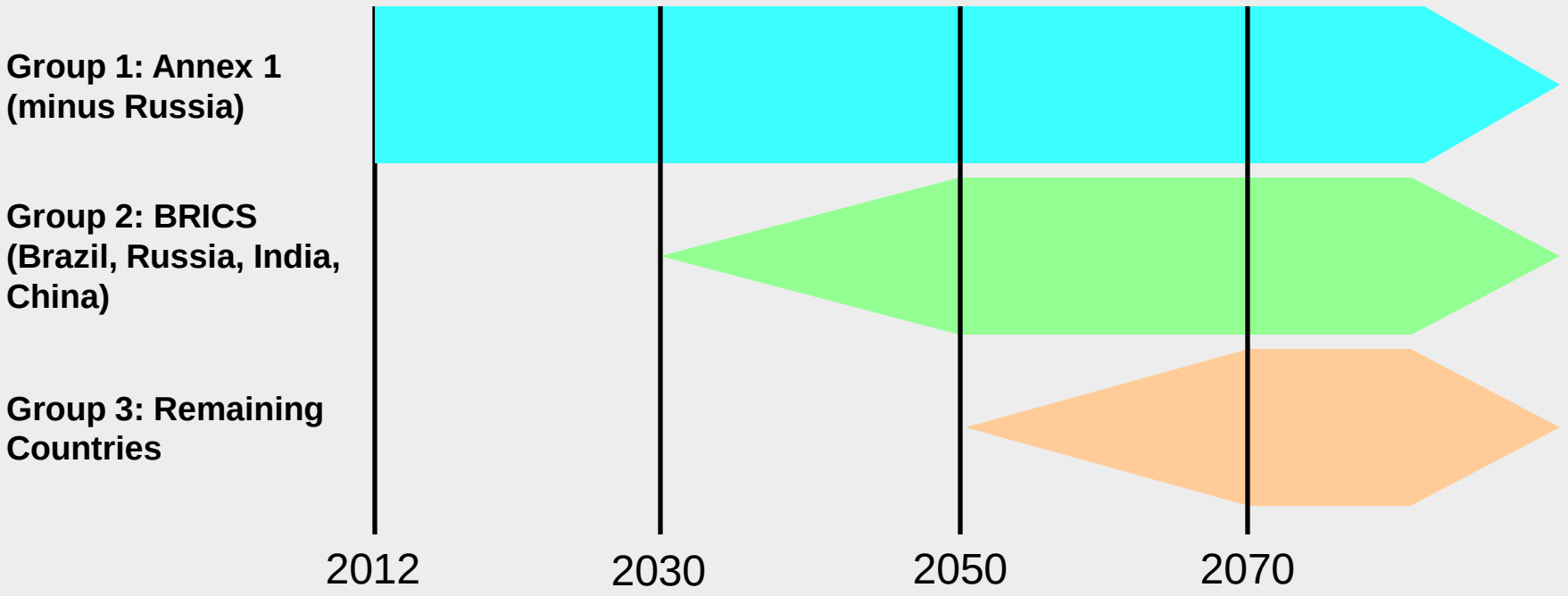
Delayed Participation: Regions Enter the Global Coalition over Time



The delayed participation case explores the potential impacts of a one single possibility for delay in non-Annex I participation – it does not represent any real policy proposal. Mechanisms such as offsets may lead to policy structures that lie between the two cases explored in this study.

The Ten EMF 22 International Scenarios

Model	650 CO2-e		550 CO2-e				450 CO2-e			
	Full	Delay	Full		Delay		Full		Delay	
	Not-to-Exceed	Not-to-Exceed	Not-to Exceed	Overshoot	Not-To-Exceed	Overshoot	Not-to Exceed	Overshoot	Not-To-Exceed	Overshoot
	1	2	3	4	5	6	7	8	9	10

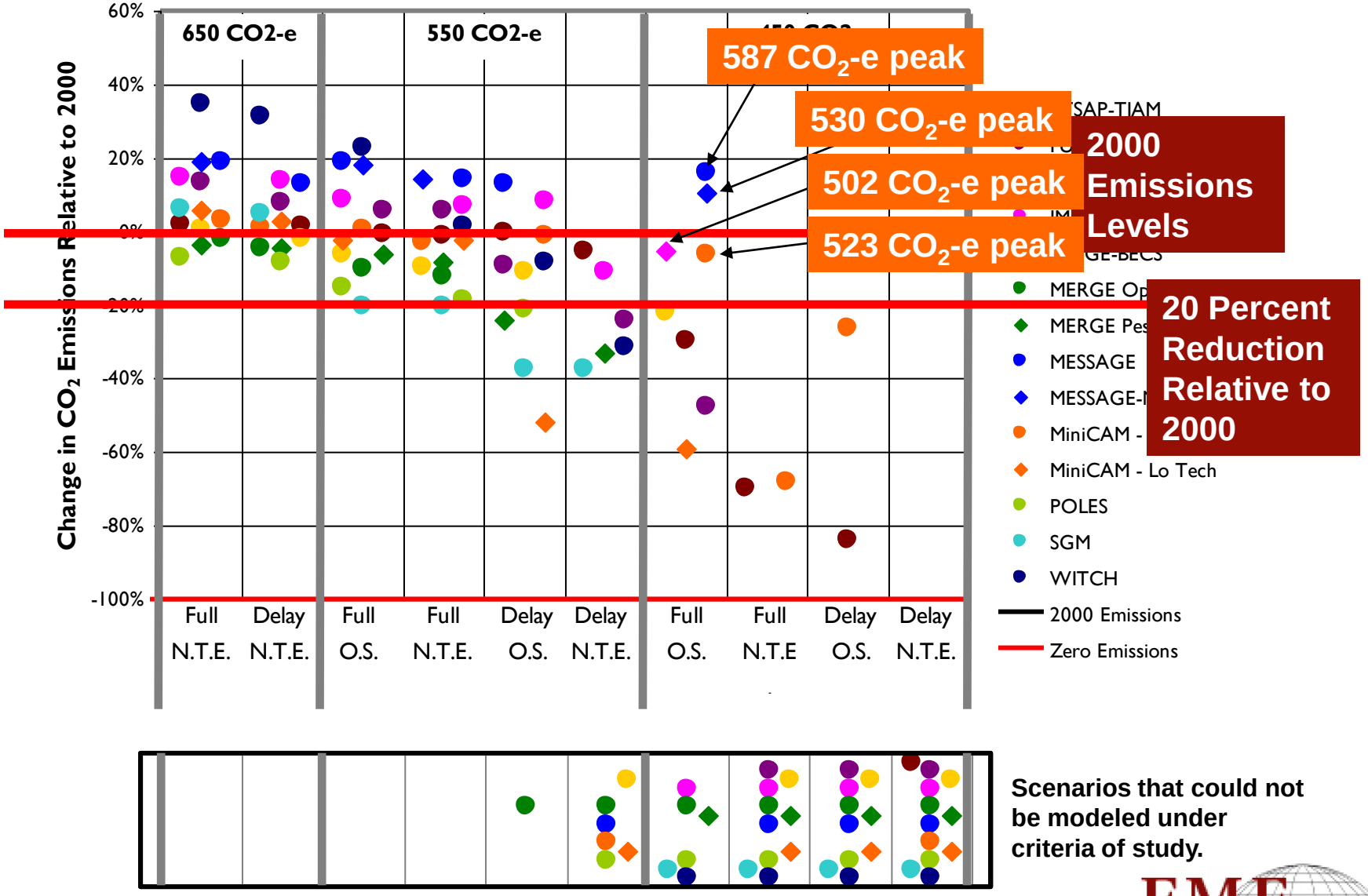
No overshoots were explored for the 650 CO2-e target

Participation has an important influence on the ability to meet long-term goals.

	Model	650 CO2-e		550 CO2-e				450 CO2-e			
				Full		Delay		Full		Delay	
		Full Not-to-Exceed	Delay Not-to-Exceed	Overshoot	Not-to Exceed	Overshoot	Not-To-Exceed	Overshoot	Not-to Exceed	Overshoot	Not-To-Exceed
1	ETSAP-TIAM	+	+	+	+	+	+	+	+	+	XX
2	FUND	+	+	+	+	+	+	+	XX	XX	XX
3	GTEM	+	+	+	+	+	XX	+	XX	XX	XX
4	IMAGE	+	+	+	+	+	+	XX	XX	XX	XX
	IMAGE-BC	-N/A-	-N/A-	-N/A-	-N/A-	-N/A-	-N/A-	+	XX	XX	XX
5	MERGE Optimistic	+	+	+	+	XX	XX	XX	XX	XX	XX
	MERGE Pessimistic	+	+	+	+	+	+	XX	XX	XX	XX
6	MESSAGE	+	+	+	+	+	XX	+	XX	XX	XX
	MESSAGE - NOBECS	+	-N/A-	+	+	-N/A-	-N/A-	+	XX	XX	XX
7	MiniCAM Base	+	+	+	+	+	XX	+	+	+	XX
	MiniCAM LoTech	+	+	+	+	+	XX	+	XX	XX	XX
8	POLES	+	+	+	+	+	XX	XX	XX	XX	XX
9	SGM	+	+	+	+	+	+	XX	XX	XX	XX
10	WITCH	+	+	+	+	+	+	XX	XX	XX	XX
				12	6	8	2	2	0		

EMF

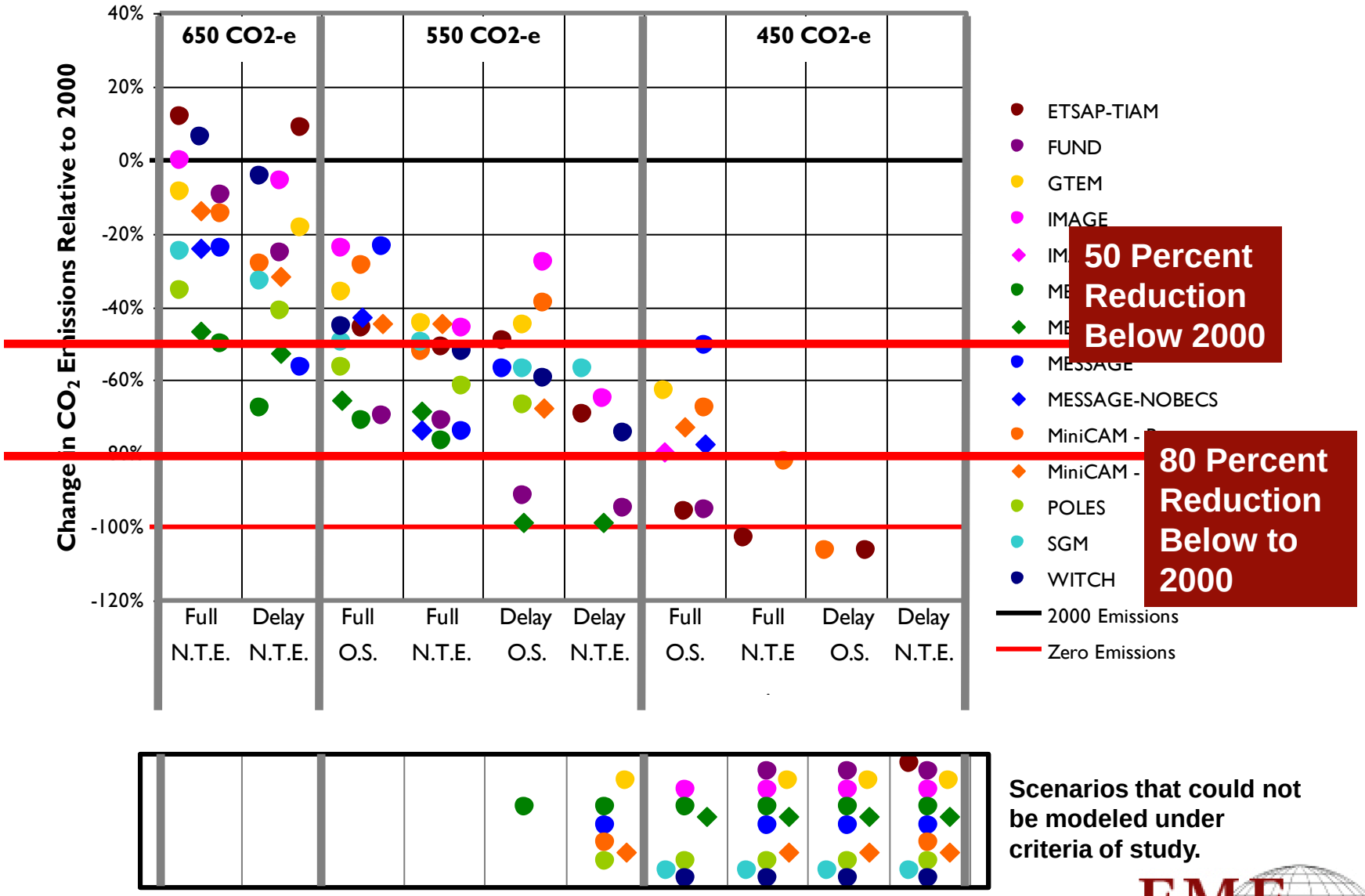
U.S. Emissions Reductions: 2020



Scenarios that could not be modeled under criteria of study.

EMF

U.S. Emissions Reductions: 2050



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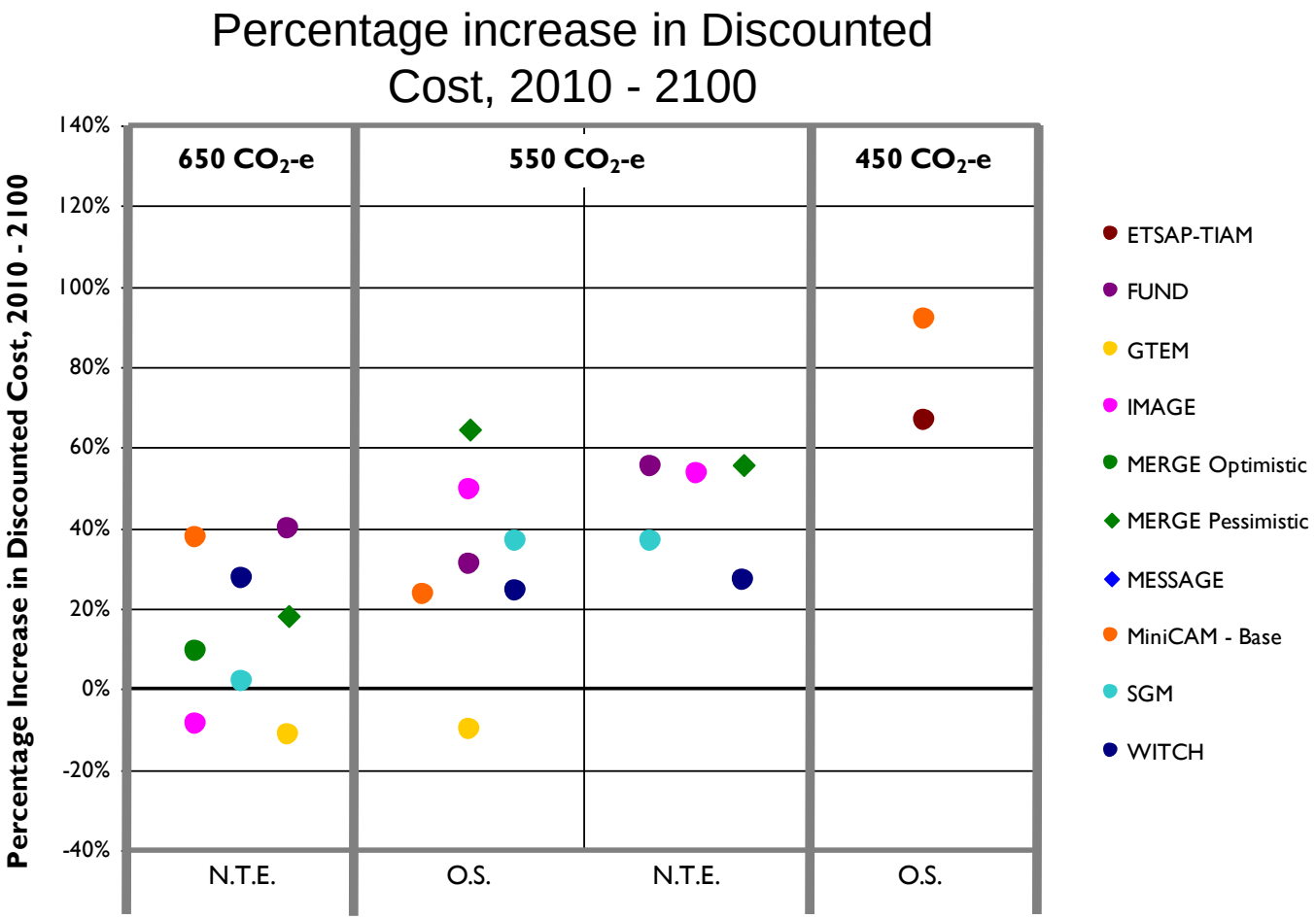
EMF

The Cost of Delay: China



Note: Costs are not included for ETSAP-TIAM not-to-exceed 650 ppmv CO2-e [1087%], ETSAP-TIAM overshoot 550 ppmv CO2-e [-793%], ETSAP-TIAM not-to-exceed [-636%], MESSAGE not-to-exceed 650 ppmv CO2-e [558%], MESSAGE overshoot 550 ppmv CO2-e [256%]. Large relative costs in these models for the less aggressive climate-action cases are due in part to the small magnitude of the costs in general for these climate-action cases.

Note: Cost metrics vary across models, and may include consumption losses, GDP losses, or total policy cost (area under the MAC curve).

What international policy scenarios will be available for the IPCC's 5th Assessment Report?

- The theme of 2nd-best international policies has been, or is being, carried forward in a number of studies. Examples include
  - EMF 22 (EMF)
  - The RoSE Project (PIK)
  - EMF 24 (EMF)
  - RECIPE (PIK)
- We will have an excellent set of these scenarios to draw on at the time of AR5.

- Key Areas of Development
  - Better representation of **regional circumstances** that influence ability and approach to mitigation or related policies.
  - Representation not only of heterogeneous commitments, but also **heterogeneous policy instruments**, particularly in the near-term.

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Real-world policies may be real-complicated

An illustrative multi-track regime: Targets + Policy Commitments

	Electricity	Transportation	Industry	Buildings
Australia/New Zealand, Canada, Europe, Former Soviet Union, Japan, United States	Economy-Wide Carbon Constraint CO2 emissions relative to 2005 (80%, 50%, 20%)			
Africa	Power Sector Carbon Intensity Relative to 2005 (NA, 70%, 25%)	Biofuels Target: Share of refined liquids (NA, NA, 10%) Fuel Economy Standard Increase in mpg over 2005 (NA, NA, 40%)	Industry Carbon Constraint Reduction from BAU (NA, NA, 65%)	
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Latin America	Power Sector Carbon Intensity Relative to 2005 (NA, 70%, 25%)	Biofuels Target: Share of refined liquids (5%, 7.5%, 20%) Fuel Economy Standard Increase in mpg over 2005 (20%, 45%, 150%)	Industry Carbon Constraint Reduction from BAU (NA, 30%, 75%)	Building Energy Efficiency Constraint Increase over 2005 (NA, 20%, 80%)
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Africa, China, India, Korea, Latin America, Middle East, Southeast Asia	Crediting % of emissions reductions sold to developed world (50%, 25%, 0%)			

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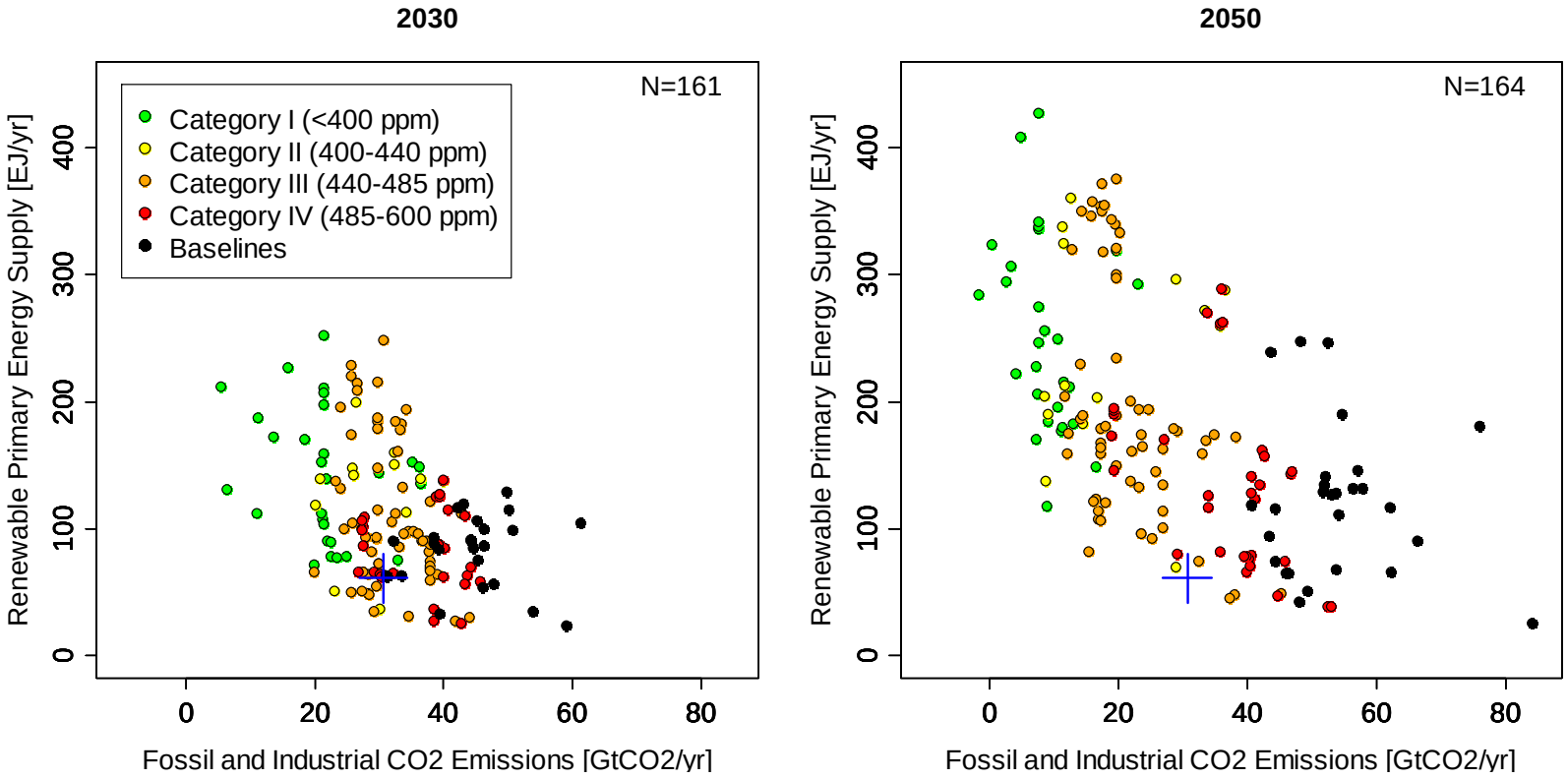
Technology and Scenarios

There is a robust set of scenarios to draw on to understand technology deployment and stabilization.



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From Krey, V., and L. Clarke, 2011: The Role of Renewable Energy and Climate Mitigation: A Synthesis of Lessons for Recent Scenarios. *Climate Policy*, forthcoming.

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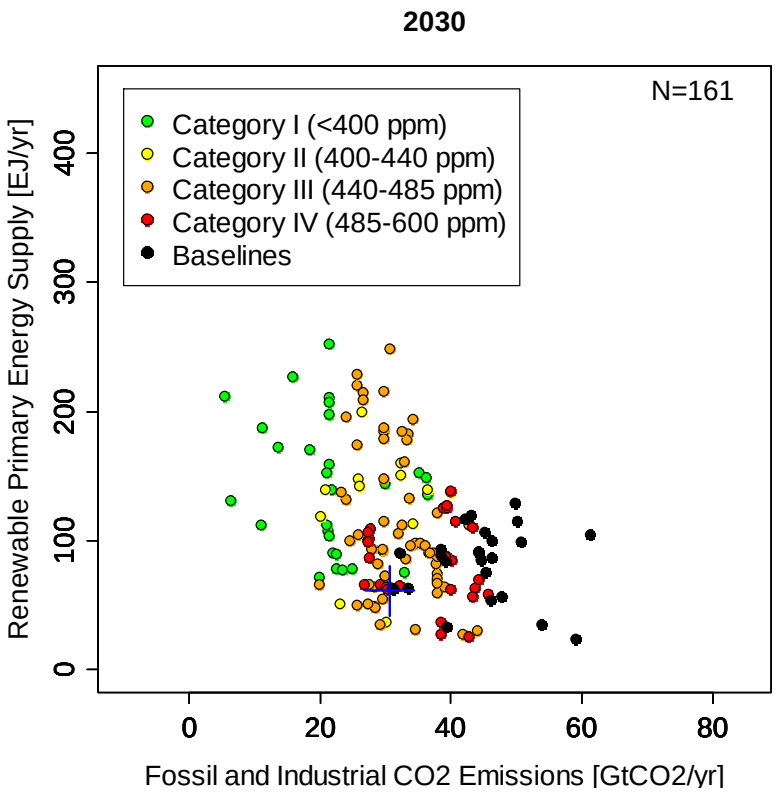

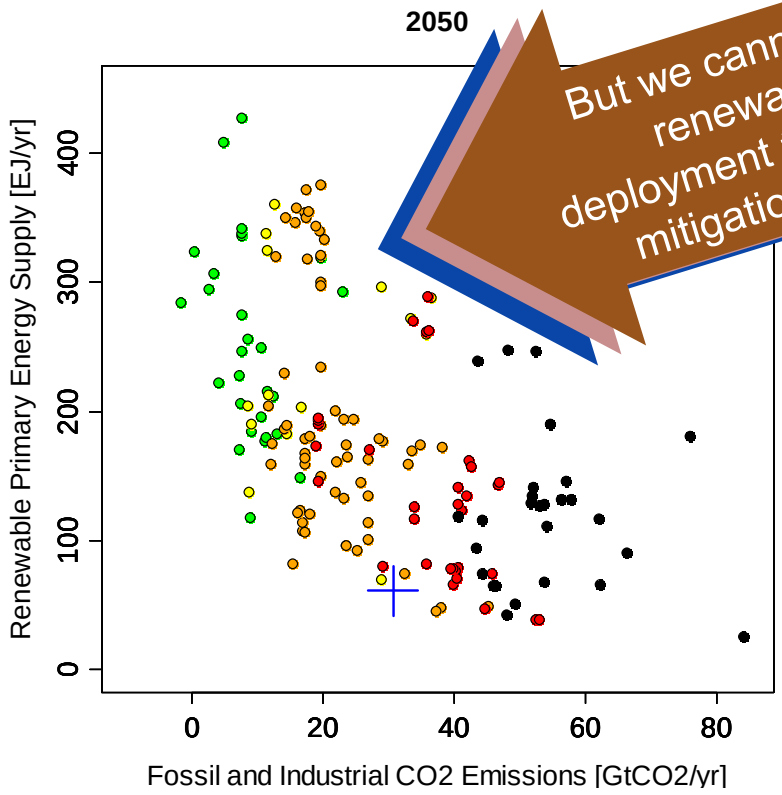

But we cannot link renewable deployment to specific mitigation goals

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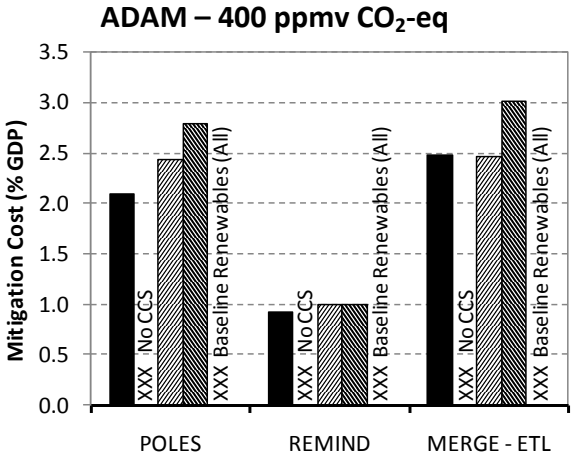
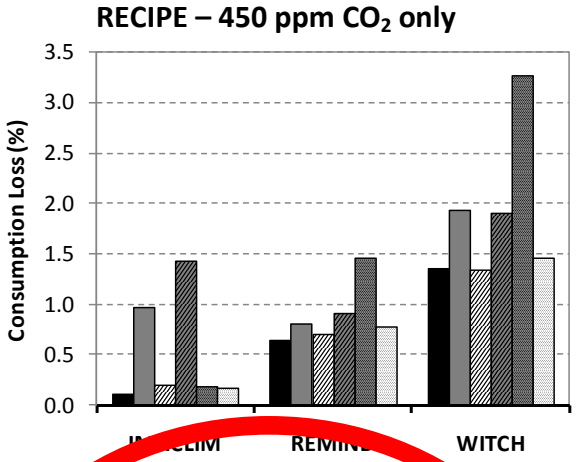
ADAM and RECIPE: Effect of technology constraints on mitigation costs

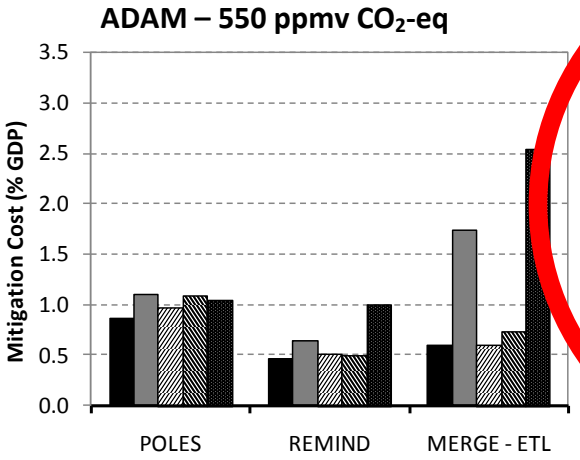
Some goals are not possible without a full technology portfolio

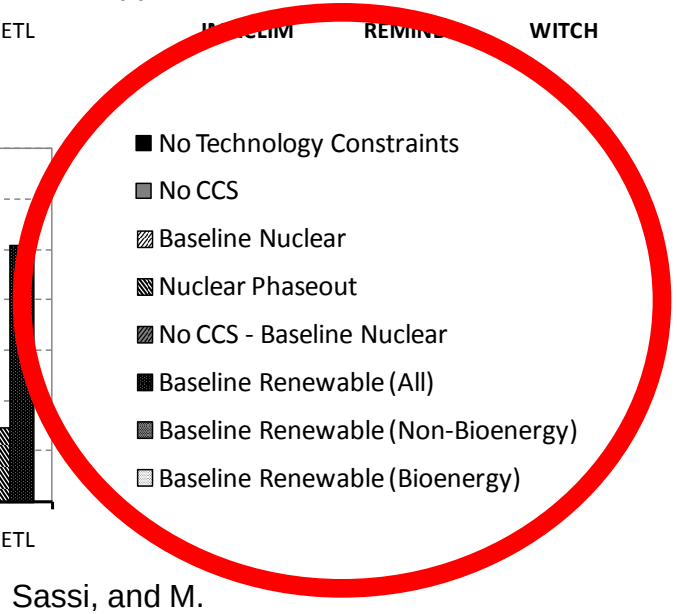
Costs are higher without a full technology portfolio

The economic costs of constraining renewables are on par with those from constraining nuclear nad CCS









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One way folks are exploring different pathways is through scenarios of technology variation.

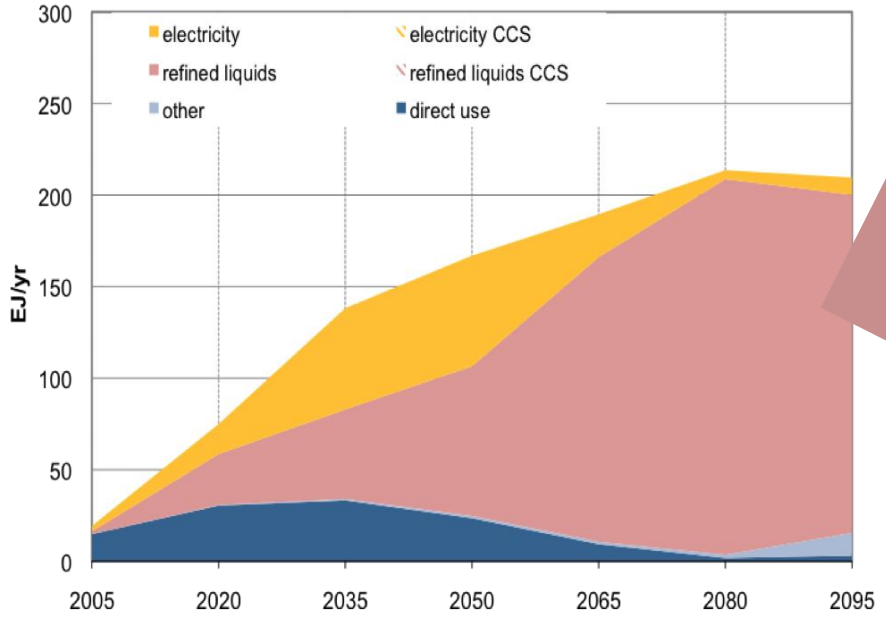
Legend: No BioCCS

Model		650 CO2-e		550 CO2-e				450 CO2-e			
		Full	Delay	Full		Delay		Full		Delay	
		Not-to-Exceed	Not-to-Exceed	Overshoot	Not-to Exceed	Overshoot	Not-To-Exceed	Overshoot	Not-to Exceed	Overshoot	Not-To-Exceed
1	ETSAP-TIAM	+	+	+	+	+	+	+	+	+	XX
2	FUND	+	+	+	+	+	+	+	XX	XX	XX
3	GTEM	+	+	+	+	+	XX	+	XX	XX	XX
4	IMAGE	+	+	+	+	+	+	XX	XX	XX	XX
	IMAGE-BC	-N/A-	-N/A-	-N/A-	-N/A-	-N/A-	-N/A-	+	XX	XX	XX
5	MERGE Optimistic	+	+	+	+	XX	XX	XX	XX	XX	XX
	MERGE Pessimistic	+	+	+	+	+	+	XX	XX	XX	XX
6	MESSAGE	+	+	+	+	+	XX	+	XX	XX	XX
	MESSAGE - NOBECS	+	-N/A-	+	+	-N/A-	-N/A-	+	XX	XX	XX
7	MiniCAM Base	+	+	+	+	+	XX	+	+	+	XX
	MiniCAM LoTech	+	+	+	+	+	XX	+	XX	XX	XX
8	POLES	+	+	+	+	+	XX	XX	XX	XX	XX
9	SGM	+	+	+	+	+	+	XX	XX	XX	XX
10	WITCH	+	+	+	+	+	+	XX	XX	XX	XX
				12	6	8	2	2	0		

BioCCS is not the only reason that models could or could not produce particular scenarios

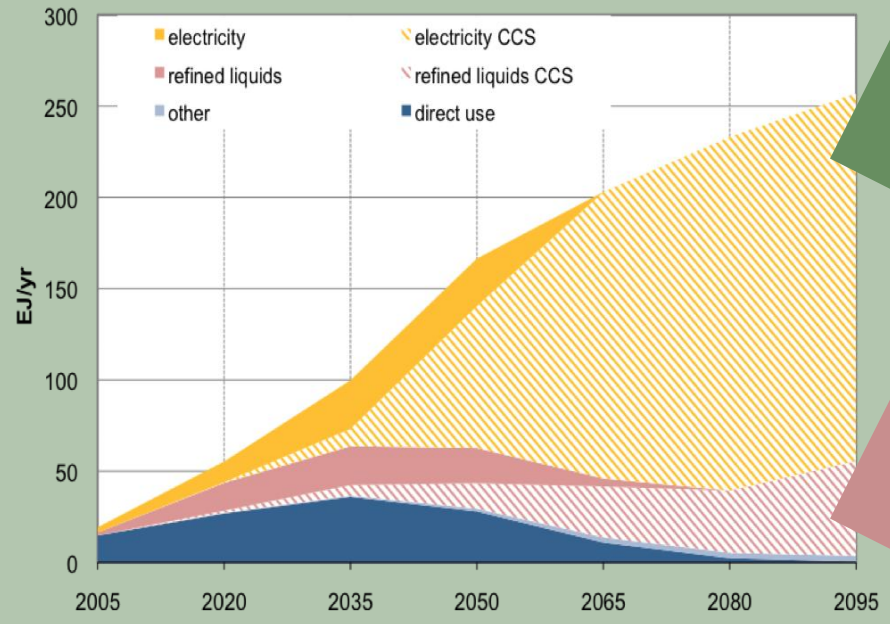
Where bioenergy will be used in the long-term depends on the technologies available, particularly CCS

Without CCS



Without CCS bioenergy is used to fuel transport

With CCS



With CCS bioenergy is used to produce electricity

Biofuel refineries also use CCS

What technology stories will be available from scenarios for the IPCC's 5th Assessment Report?

- There is a very rich set of scenarios with technology variations available for AR5.
  - Examples include EMF 24, RoSE, ADAM, RECIPE, GEA, and probably more.
  - A number of studies are producing scenarios that combine technology variations with 2nd-best international policies.

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Combined policy and technology scenarios are being produced.

Technology Dimension									
	Default	**Single technologies changed**					**Conventional vs. renewable**		**Frozen technology**
Energy Intensity	Ref	Low	Ref	Ref	Ref	Ref	Ref	Low	Frozen
CCS	On	On	Off	On	On	On	On	Off	Off
Nuclear energy	On	On	On	Off	On	On	On	Off	Frozen
Wind & Solar	Adv	Adv	Adv	Adv	Cons	Adv	Cons	Adv	Frozen
Bioenergy potential	High	High	High	High	High	Low	Low	High	Frozen
Policy Dimension									
Baseline	R2G1	R2G2		R2G3	R2G4	R2G5	R2G6	R2G7	R2G8
450 CO2e	R2G9	R2G10	R2G11	R2G12	R2G13	R2G14	R2G15	R2G16	
550 CO2e	R2G17	R2G18	R2G19	R2G20	R2G21	R2G22	R2G23	R2G24	R2G25
G8	R2G26							R2G27	
Muddling through	R2G28							R2G29	

EMF 24 International Scenarios Design – 2nd Round

EMF

What technology stories will be available from scenarios for the IPCC's 5th Assessment Report?

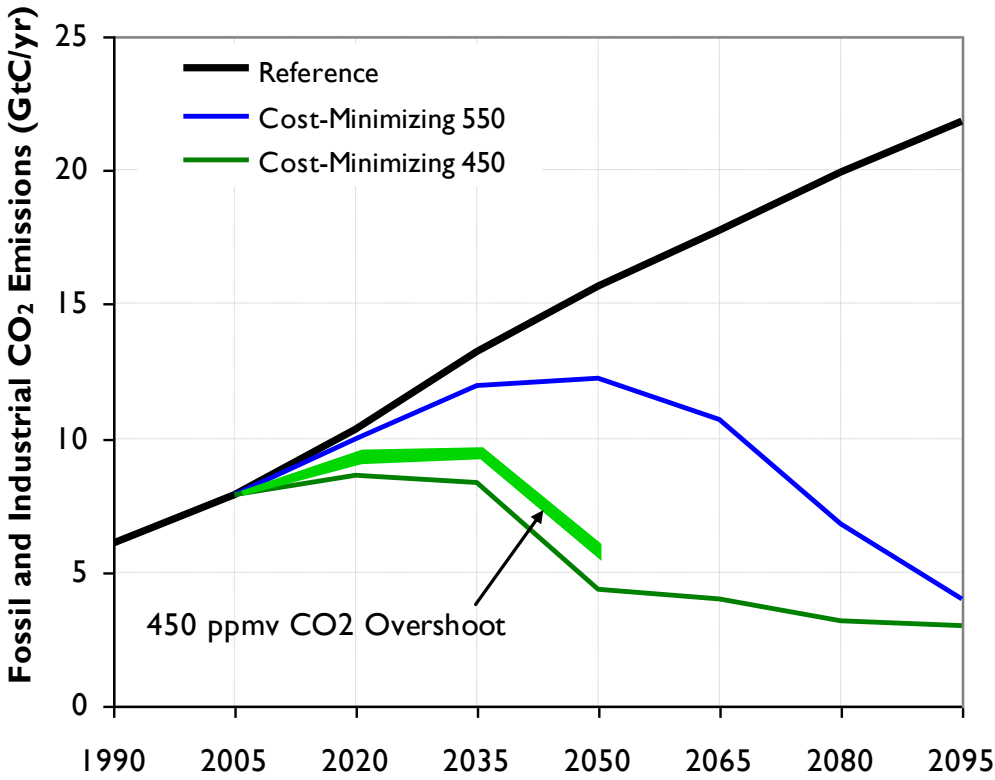
- There is a very rich set of scenarios with technology variations available for AR5.
  - New examples include EMF 22, EMF 24, RoSE, ADAM, RECIPE, GEA, and probably more.
  - A number of studies are producing scenarios that combine technology variations with 2nd-best international policies.
- Improved IAMC data collection facilities will help us to mine the information from all of these scenarios.
- But there is still a lot more to do on technology.
  - We still need better representations of technology in models (e.g., representations of intermittent renewables, of renewable supplies, etc.).
  - We need more research on what sorts of technology assumptions make sense – what is the supply of technology.
  - We need a better way to compare assumptions across models – but this is very, very hard.
  - It would be good if scenarios of technology variation are not just about removing technologies or constraining to baseline.

A brief digression about a “Mosaic World” of policy approaches.

Exploring "multi-track" pathways to long-term goals.

Objective: visualize and assess illustrative "multi-track" architectures integrating different types of mitigation commitments

- Economy-wide targets
- Policy-based commitments
  - National-level sectoral targets/standards
- Sectoral agreements
  - Sector-specific policies applied across regions
- Funds for adaptation and technology



Can these sorts of non-idealized policy approaches be applied in a manner consistent with long-term climate goals?

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Real-world policies may be real-complicated

An illustrative multi-track regime: Targets + Policy Commitments

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Real-world policies may be real-complicated

An example from our work on multi-track regimes

	Electricity	Transportation	Industry	Buildings
Australia/New Zealand, Canada, Europe, Former Soviet Union, Japan, United	Economy-Wide Carbon Constraint CO2 emissions relative to 2005 (80%, 50%, 20%)			
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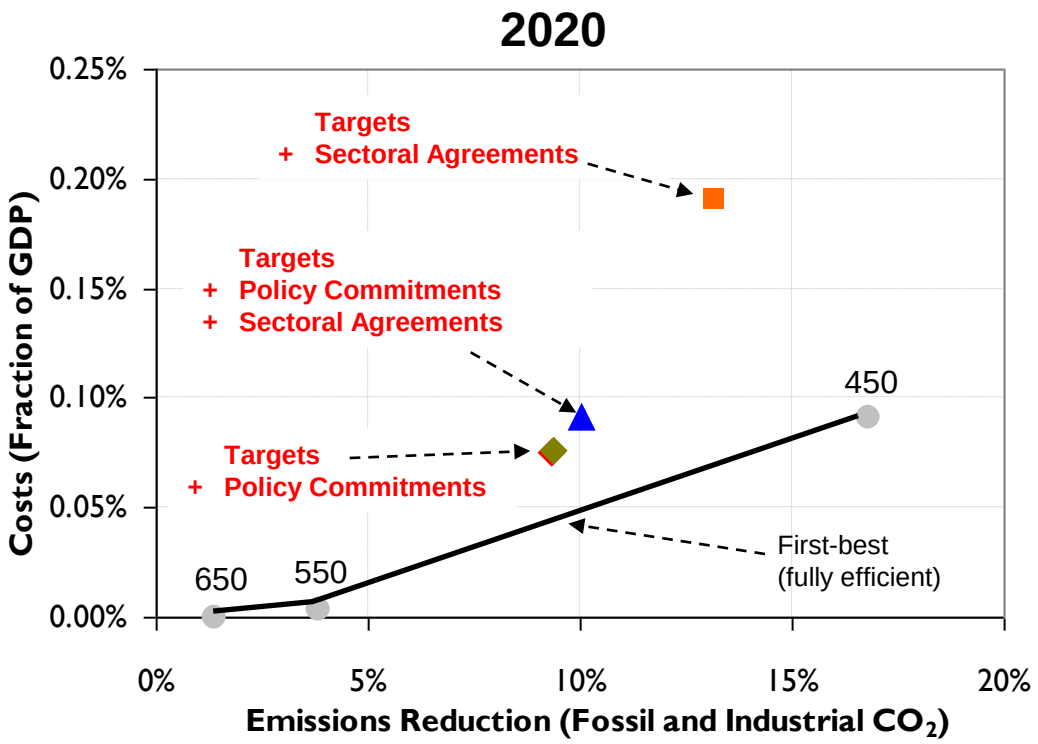
Multi-track regimes lead to less efficient allocation of emissions mitigation, across regions, sectors, and technologies.



- Inefficient policies are ….inefficient.
- The devil is in the details of the policy itself.

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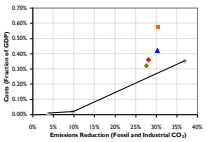
Multi-track regimes lead to less efficient allocation of emissions mitigation, across regions, sectors, and technologies.

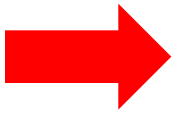
It becomes increasingly challenging to use these policy structures as mitigation becomes more stringent

The 450 ppmv overshoot pathway with Targets & Policy Commitments could not be met without either **expanding coverage** of the multi-track policy or **transitioning to a fully-efficient regime**

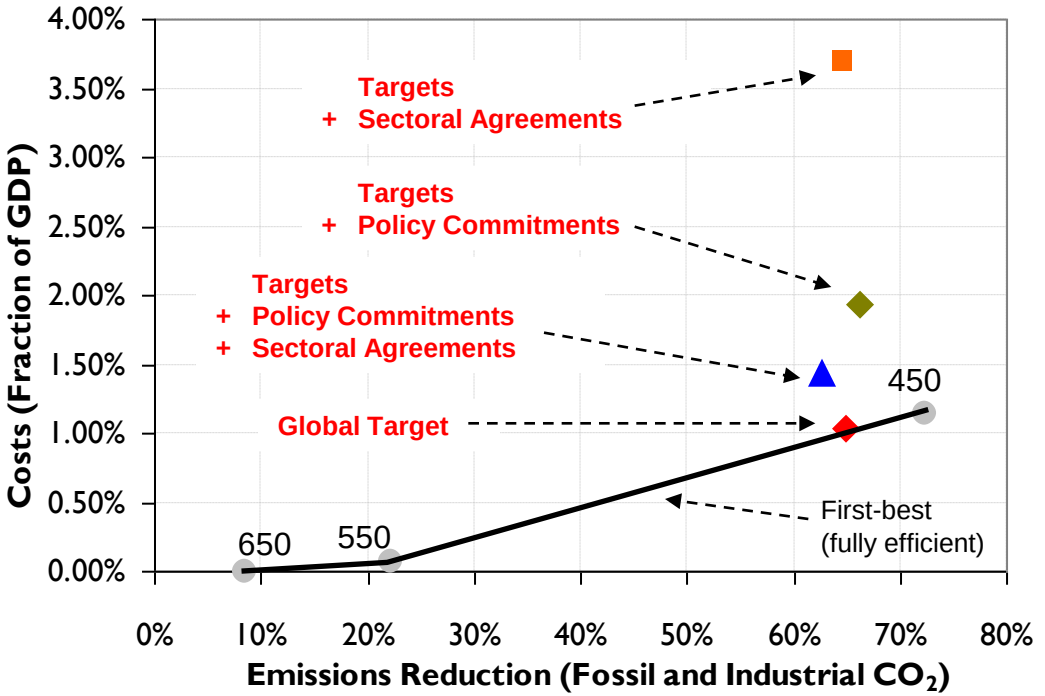
2020

2035





2050



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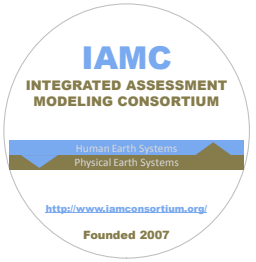
There is a lot going on.

Some Highlights of Ongoing Activities

- The **RCP** and **Shared Socioeconomic Pathways** work to link mitigation, science, and impacts.
- Development of **regional scenarios** through studies like the Asian Modeling Exercise, the Low Carbon Societies Project, and even EMF 24.
- Work on **development, demographics, and urbanization**, for example, in the Asian Modeling Exercise.
- An enormous amount of work by teams to incorporate **land use and agriculture** explicitly in models to better consider impacts/adaptation and mitigation in unified platforms.
- Efforts to try to better bring in **uncertainty** are getting started.
- **Standardized data collection** methods and the **community database**.

- The emergence of the **Integrated Assessment Modeling Consortium (IAMC)** has been enormously valuable to for facilitating coordination and identifying priorities for the integrated assessment community.



Questions?