

**Communicating with policy makers –
informing not confusing?
Two examples from the
Energy Modeling Forum**

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CCI&IA Workshop
Snowmass Colorado
July 30, 2010

Two Examples

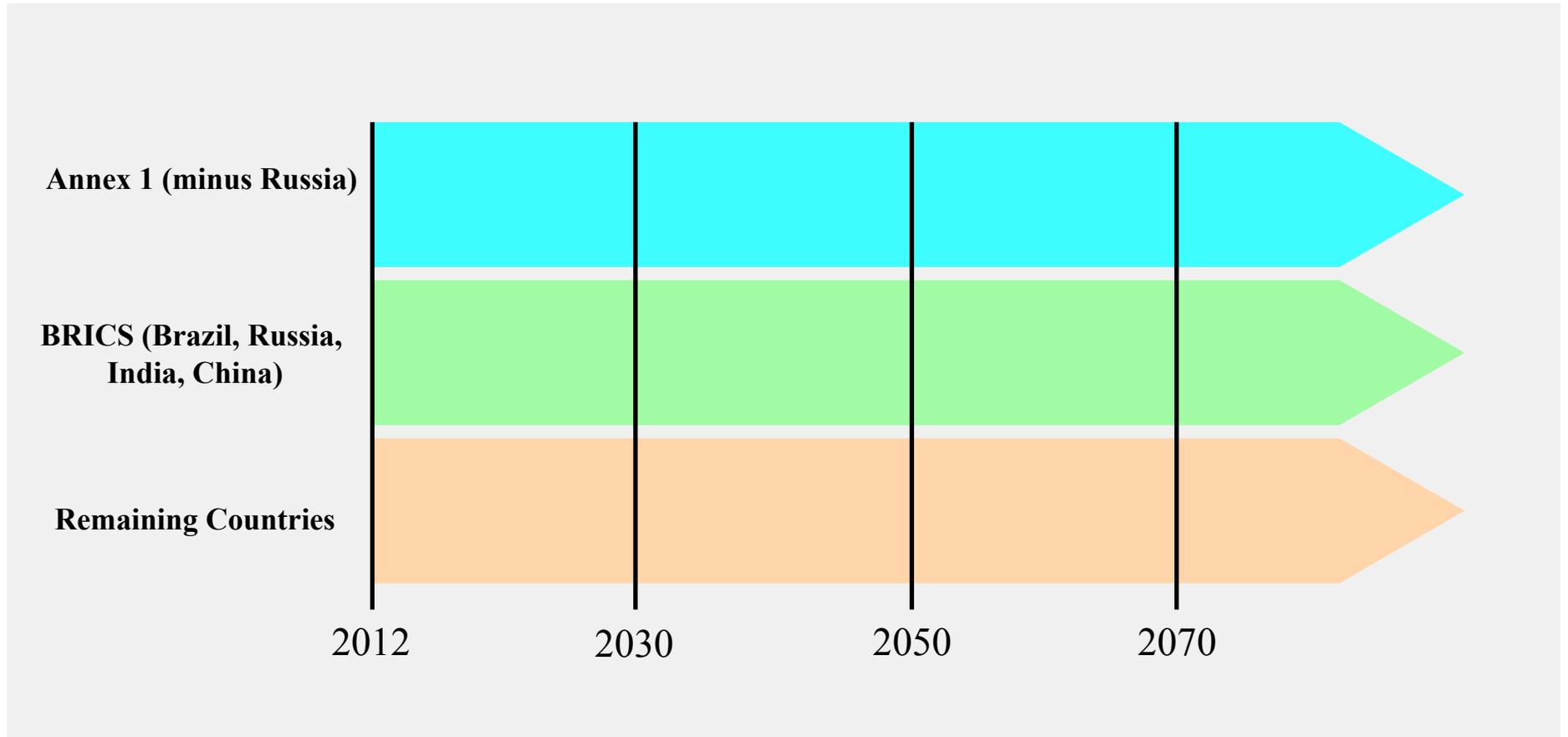
- EMF 22: International CP Transition Scenarios
- EMF 16: The Cost of Kyoto

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

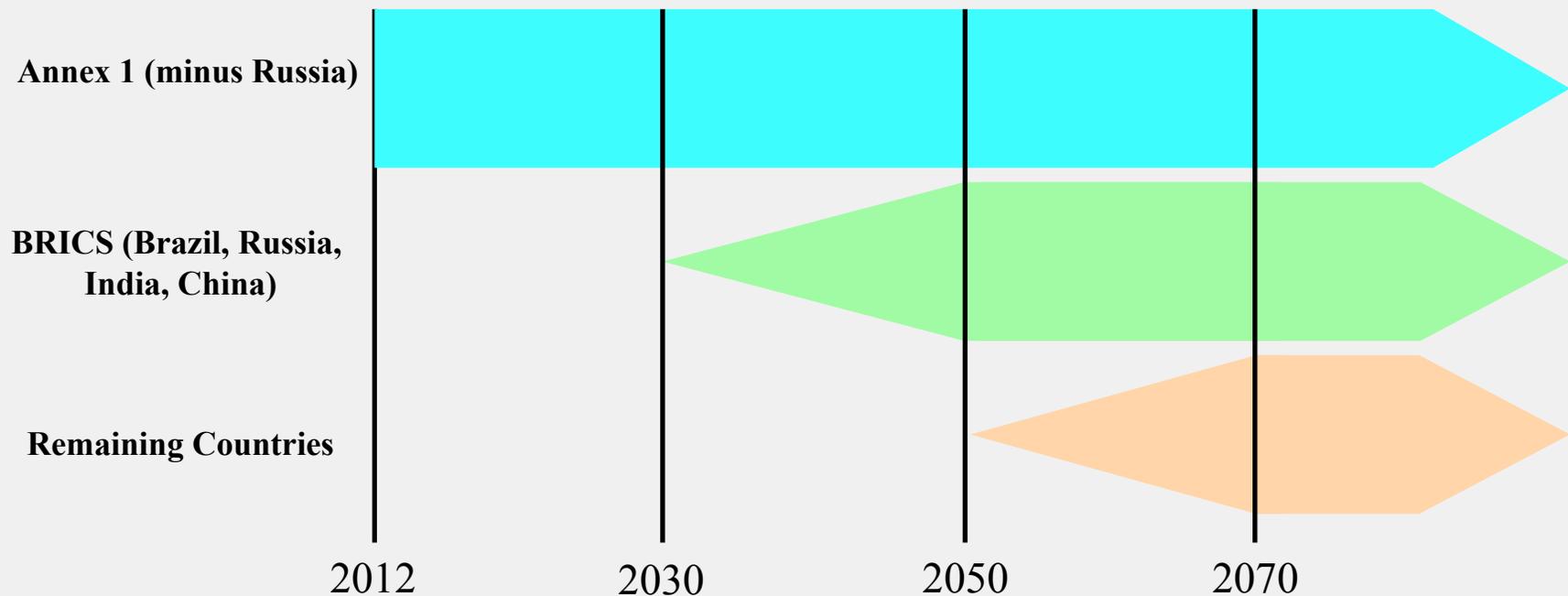
(Leon Clarke, JGCRI)

- 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 1 regions and Russia

Full Participation: All Begin Reductions Immediately

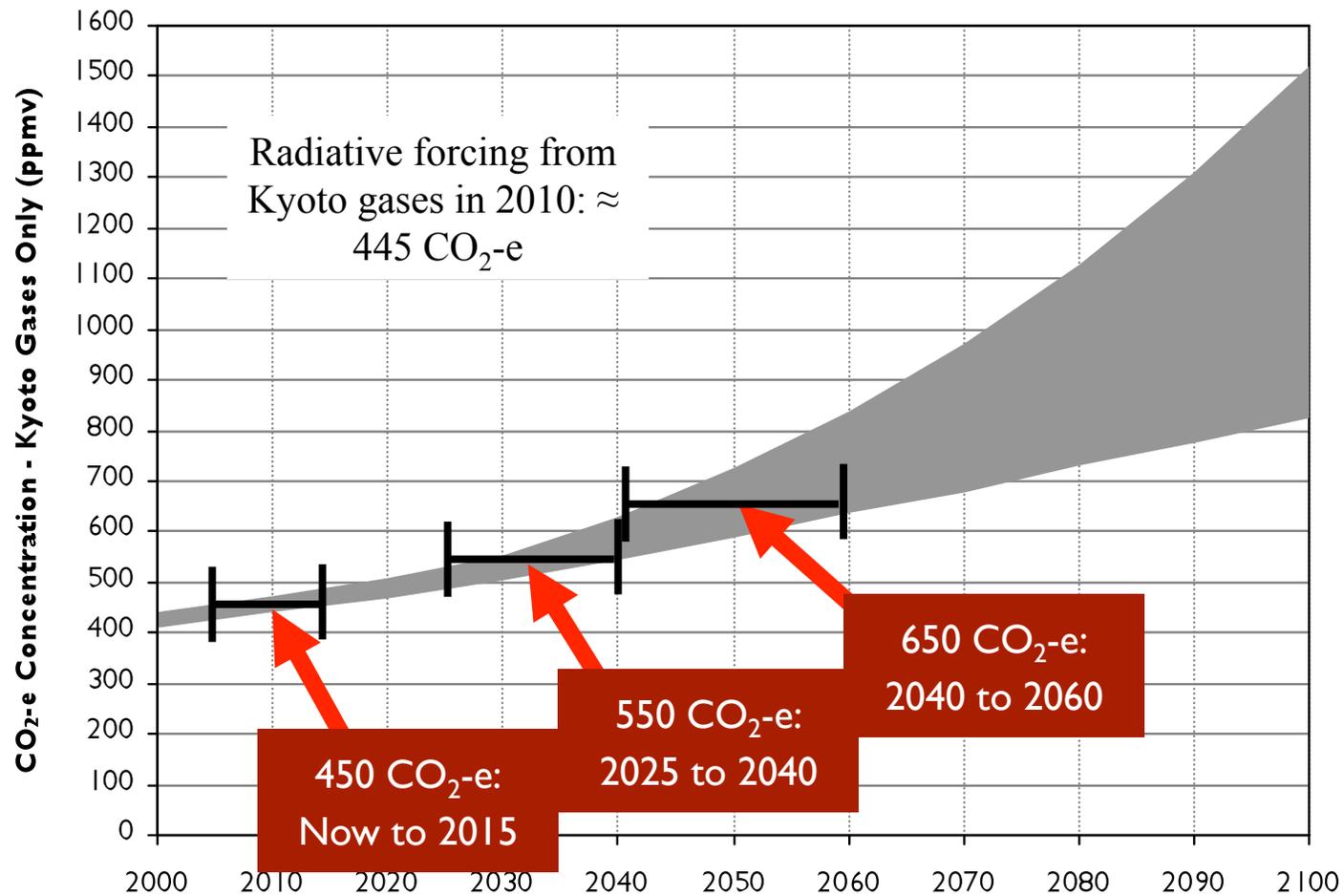


Delayed Participation: Regions Enter the Global Coalition over Time



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.

Without mitigation, CO₂-e concentrations will quickly pass the three long-term goals.

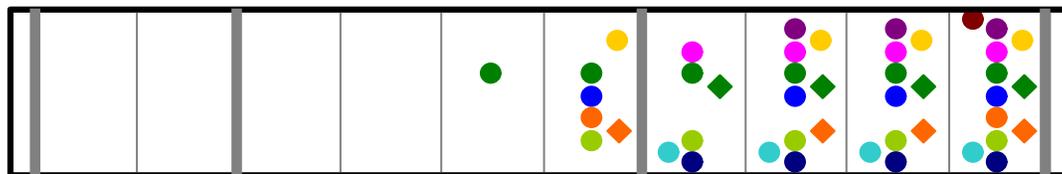
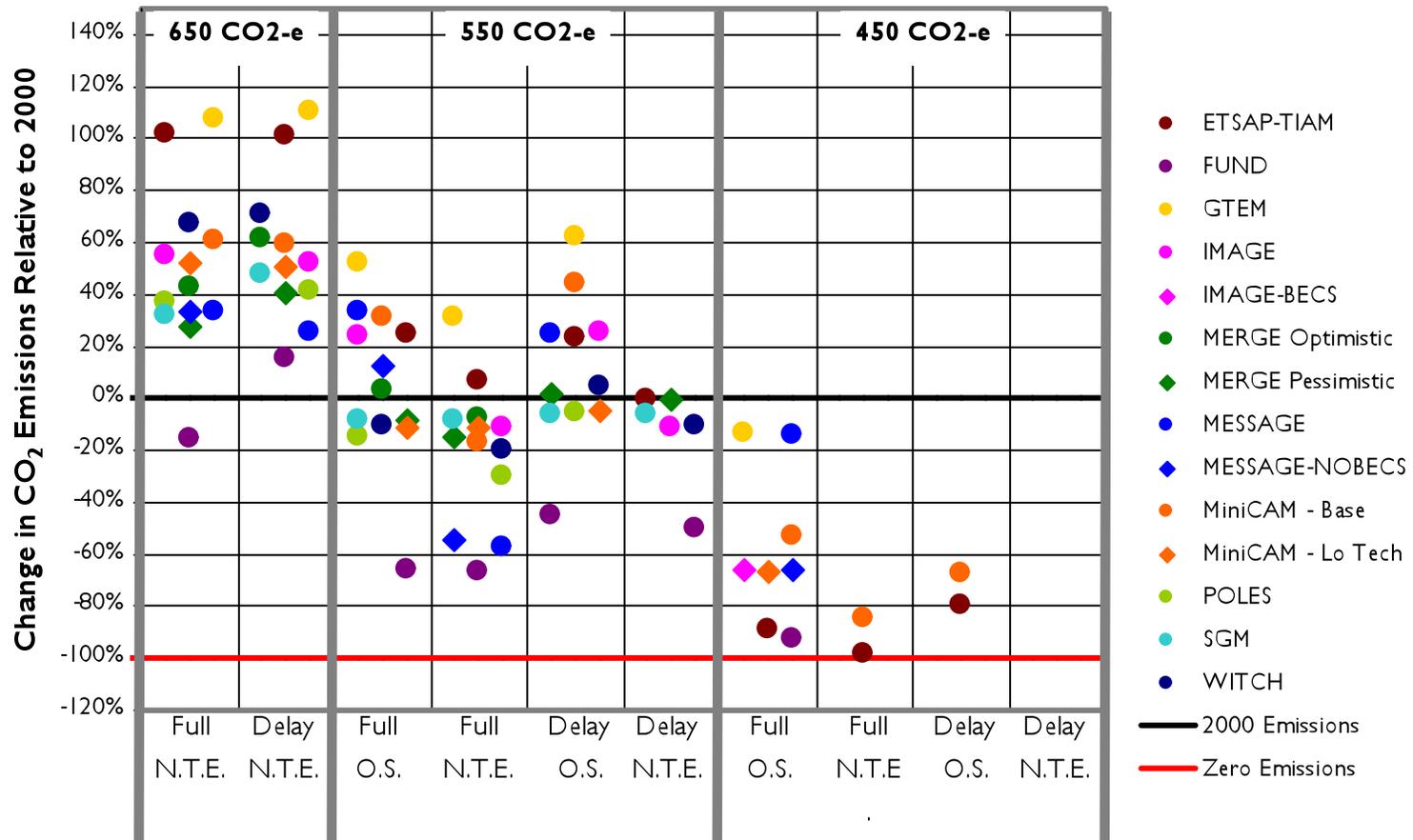


Note: CO₂e Now Growing at 3.5 to 4.5 ppmv per year

Reasons That Models Were Not Able To Provide Particular Scenarios.

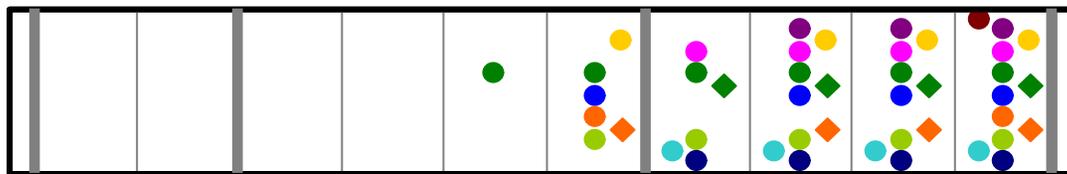
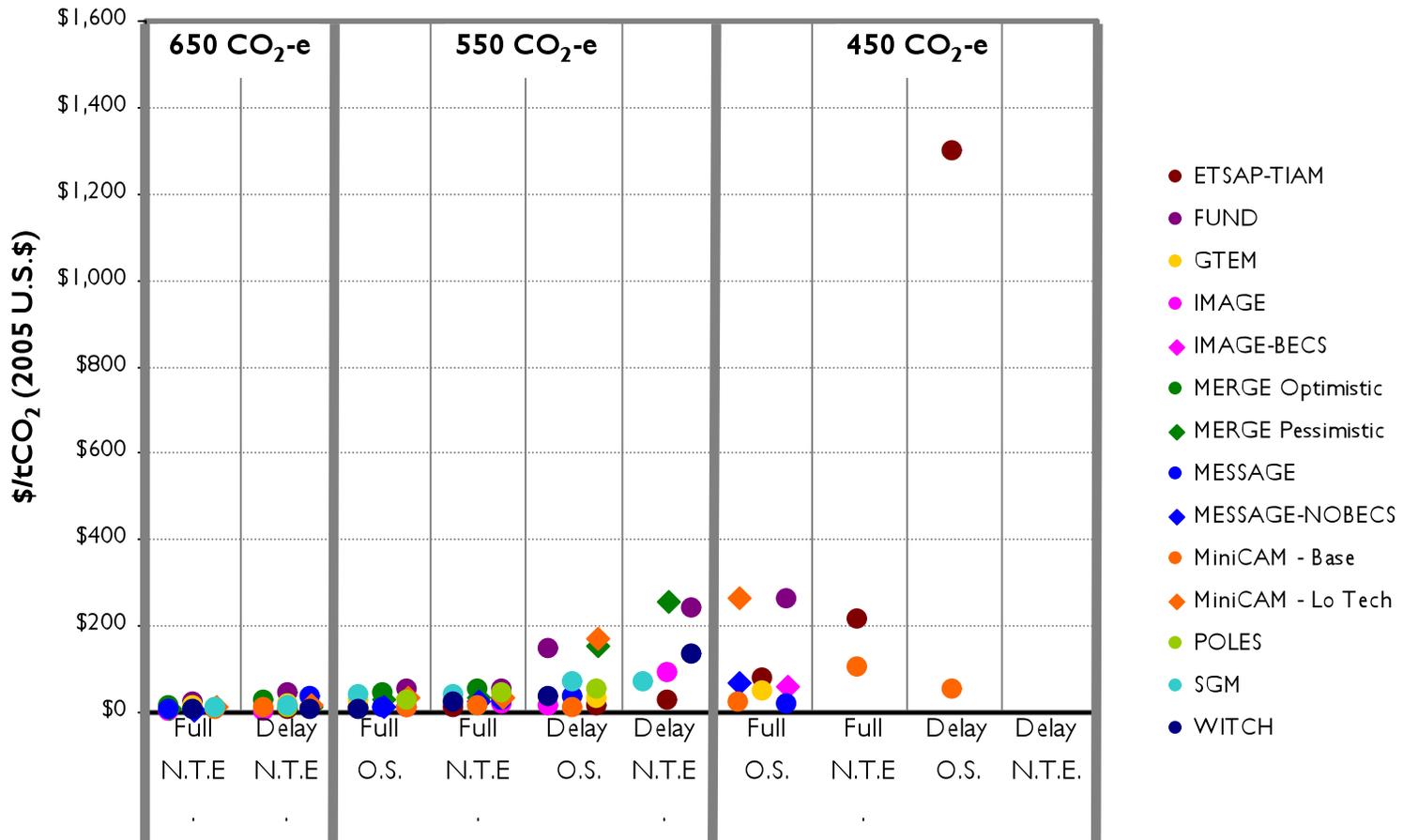
- Physically infeasible (e.g., RF exceeds target before full entry)
- Model could not solve because of the aggressiveness of the constraint (e.g., solution mechanism failed, decline constraints prevent solution, CO₂ price limits in model)
- Initial carbon price above \$1000/tCO₂

Global Emissions Reductions: 2050



Scenarios that could not be modeled under criteria of study.

Annex 1 2020 Carbon Prices

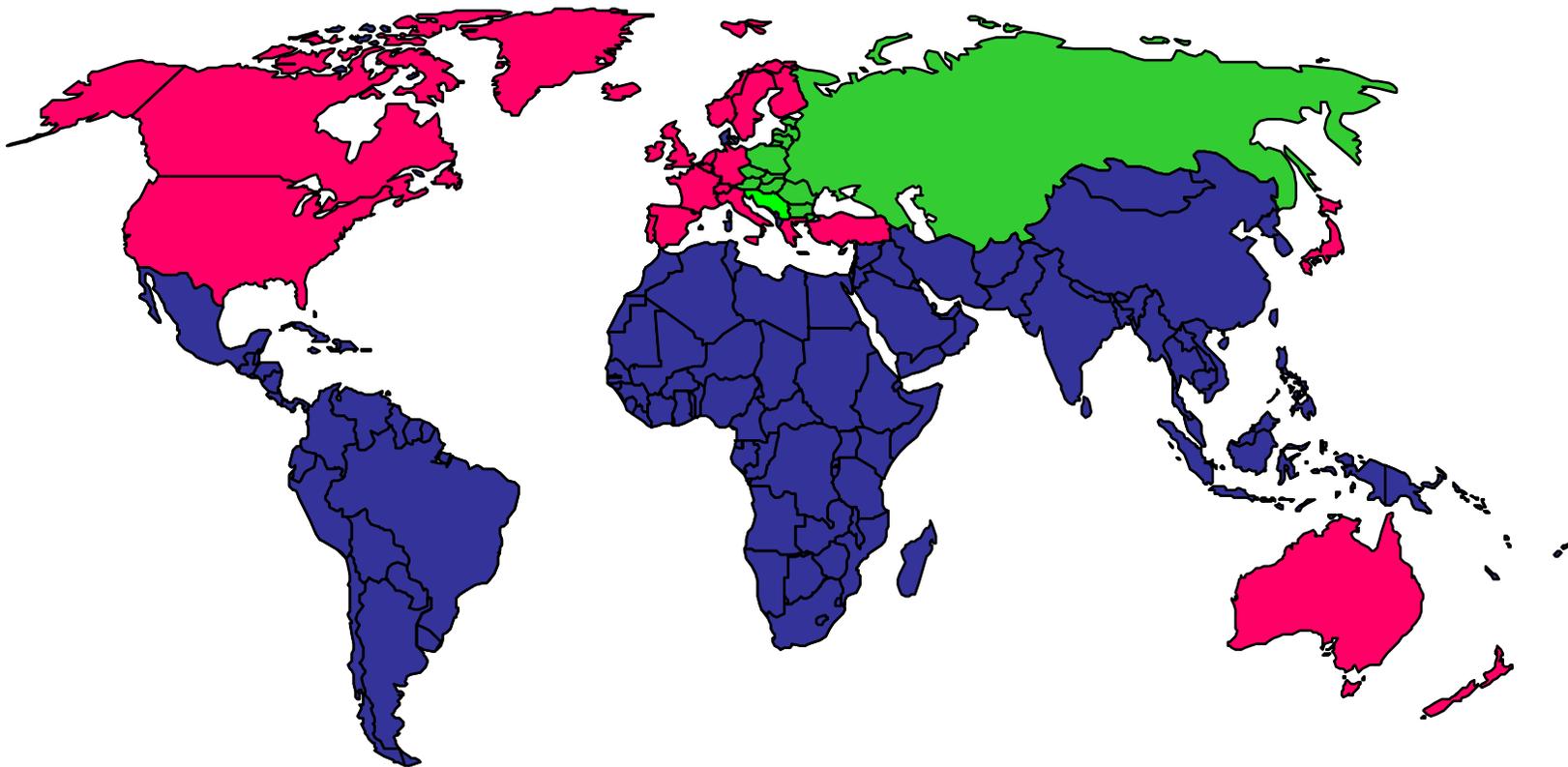


Scenarios that could not be modeled under criteria of study.

EMF 16 & Aftermath
The Cost of Kyoto

Regions That Have Reduction Obligations Under the Kyoto Protocol

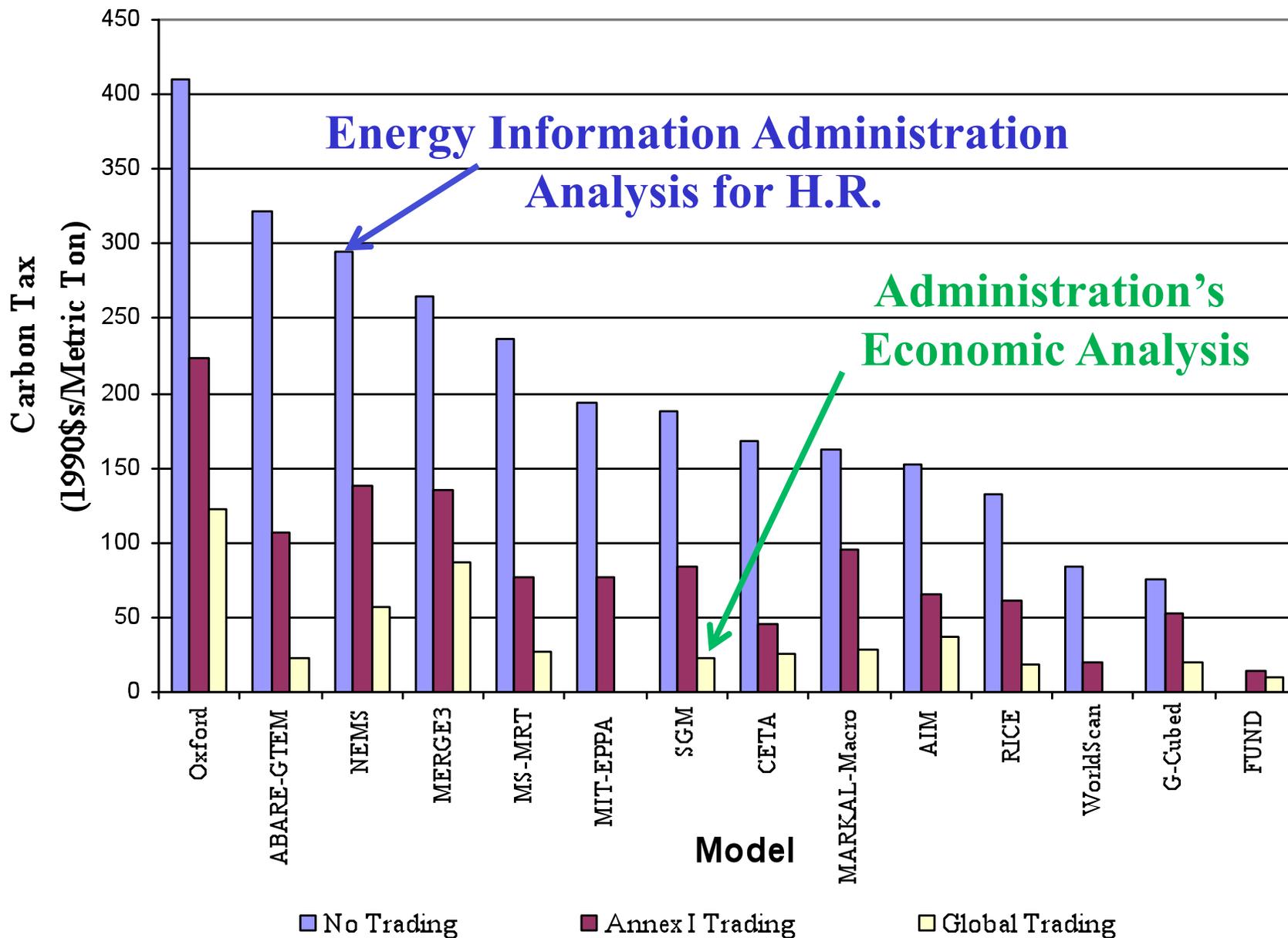
ANNEX I = ANNEX II plus Economies in Transition



3 Assumptions About International Emissions Trading

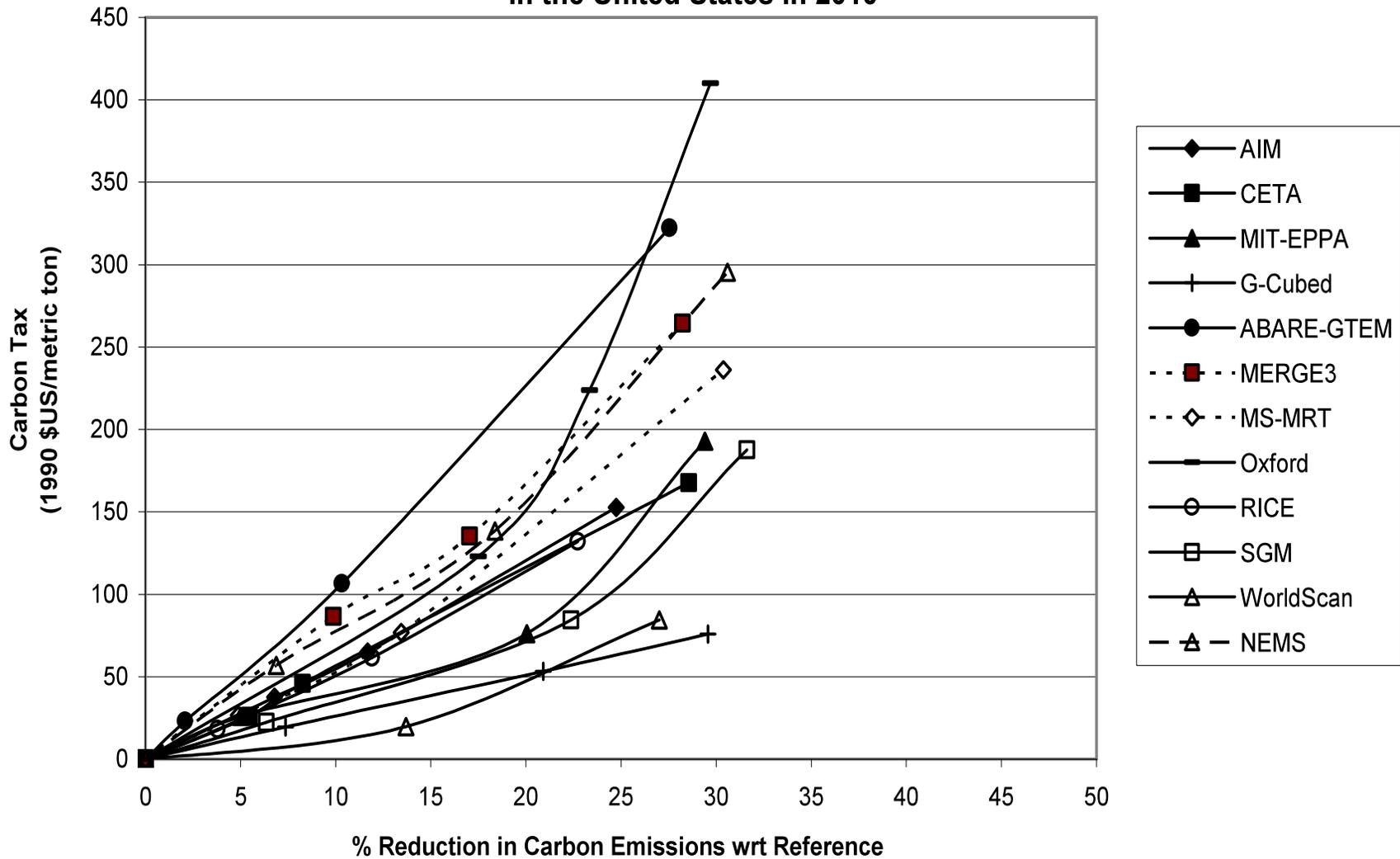
- **No emissions trading.**
- **Trading within Annex 1 only.**
- **Full global trading.**

Year 2010 Carbon Tax Comparison for the United States

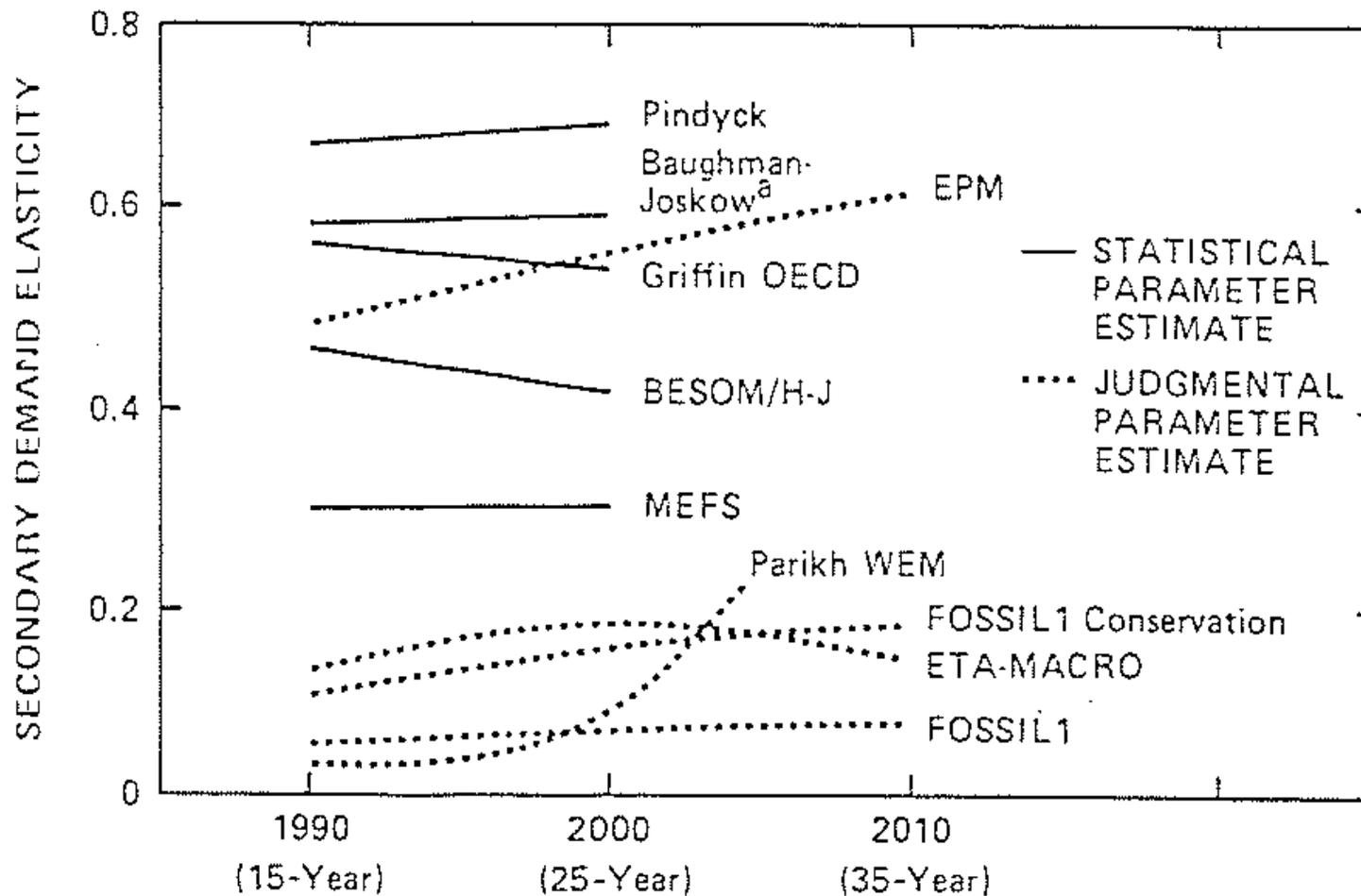


The Substitution in the Models

Marginal Cost of Carbon Emission Reductions
in the United States in 2010



Demand Side Characterizations From EMF 4



Lessons Learned

- Drive Model Comparisons With Policy Scenarios
- Augment With Diagnostic Scenarios
- Should Do Both Policy and Diagnostic Scenarios
- Pick Appropriate Experts to Provide Exogenous Inputs
- Need for Flexible/Multi-Stage Approach
- Range of Mean Projections Not A Measure of Uncertainty, Need Some Sensitivities
- Hard to Construct Meta-Models

Thank You

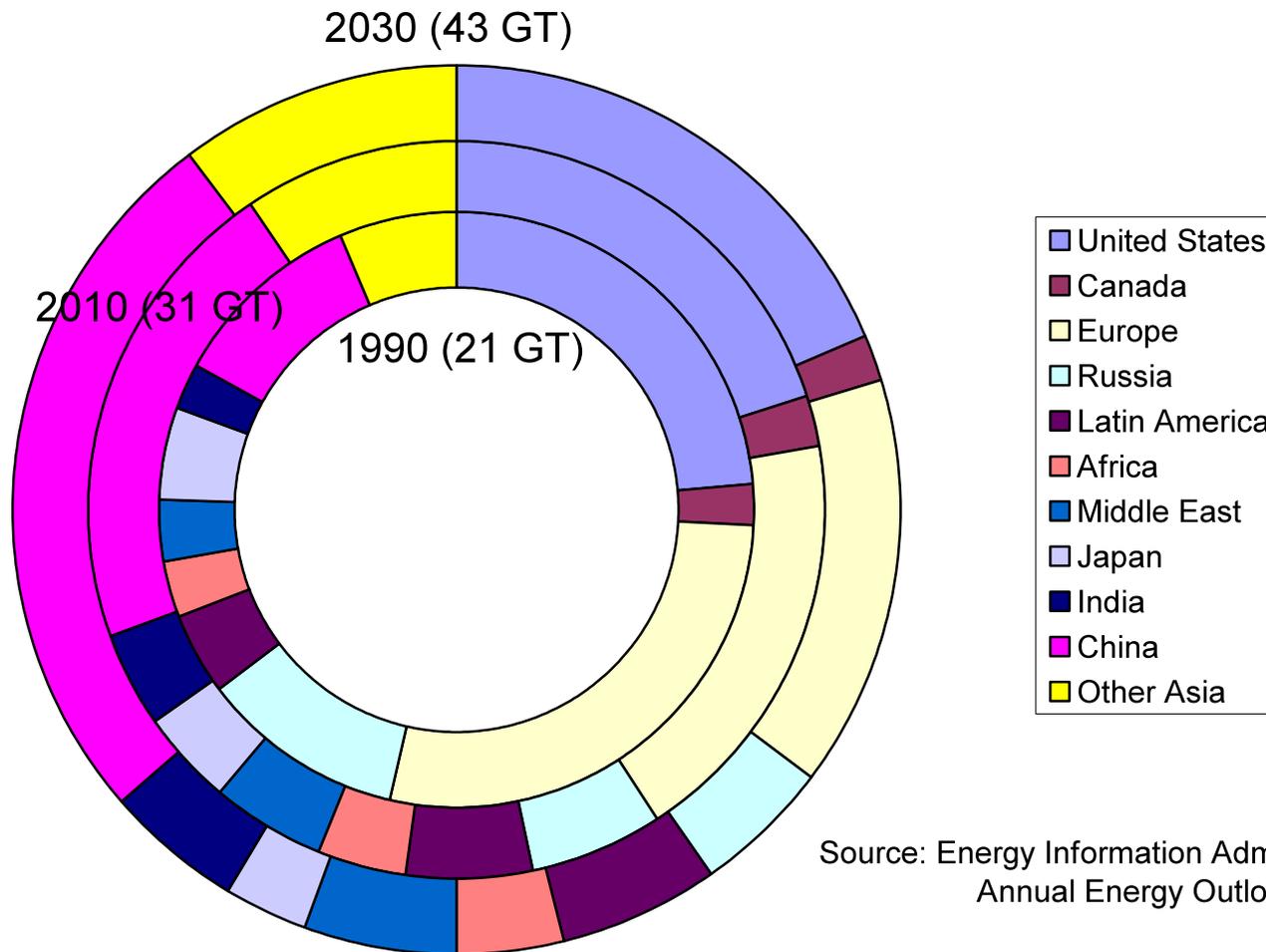
The Ten EMF 22 International Scenarios

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

Global Carbon Emission (GT CO₂)



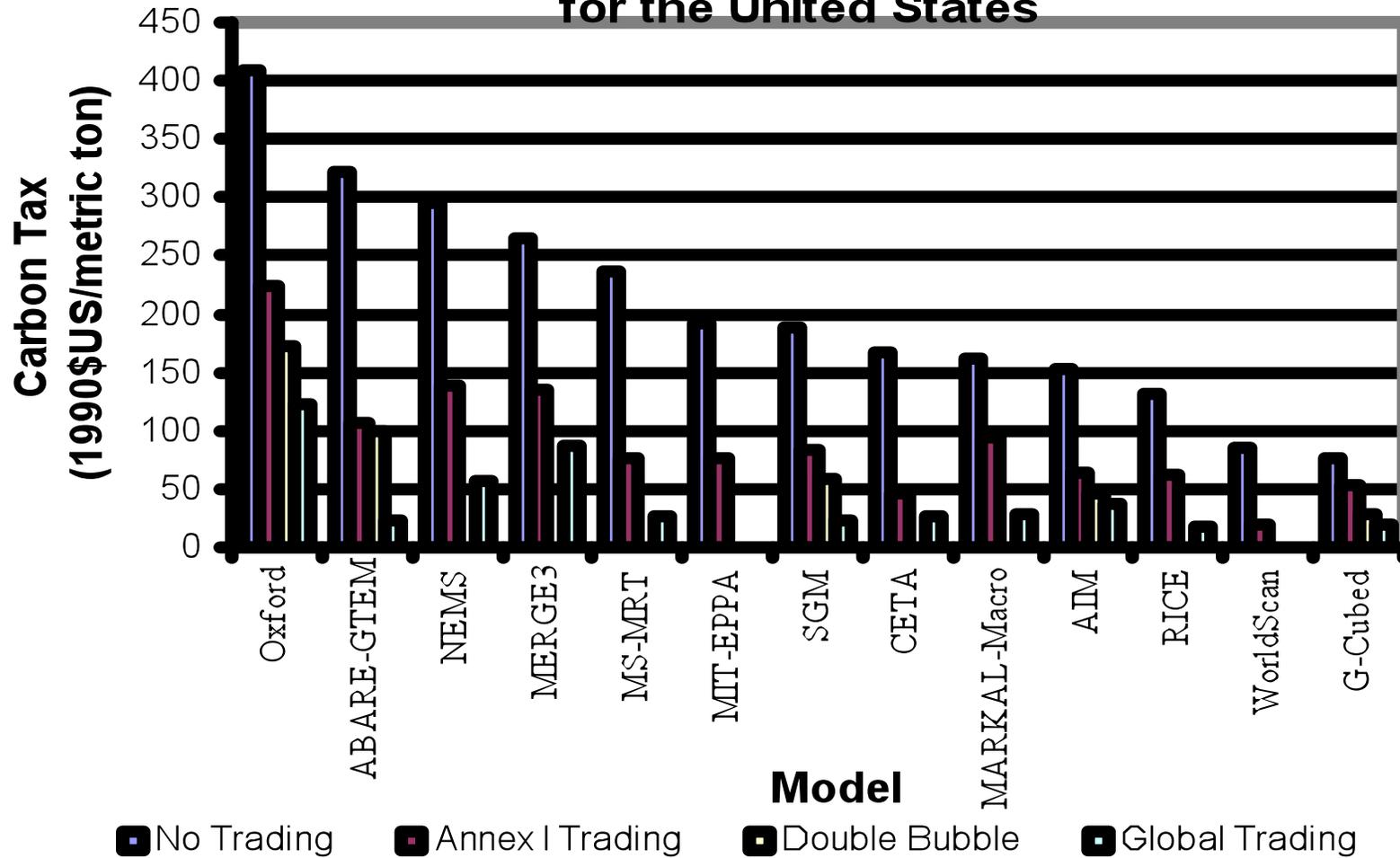
Source: Energy Information Administration
Annual Energy Outlook - 2007

Four Kinds of Mitigation Policy Flexibilities

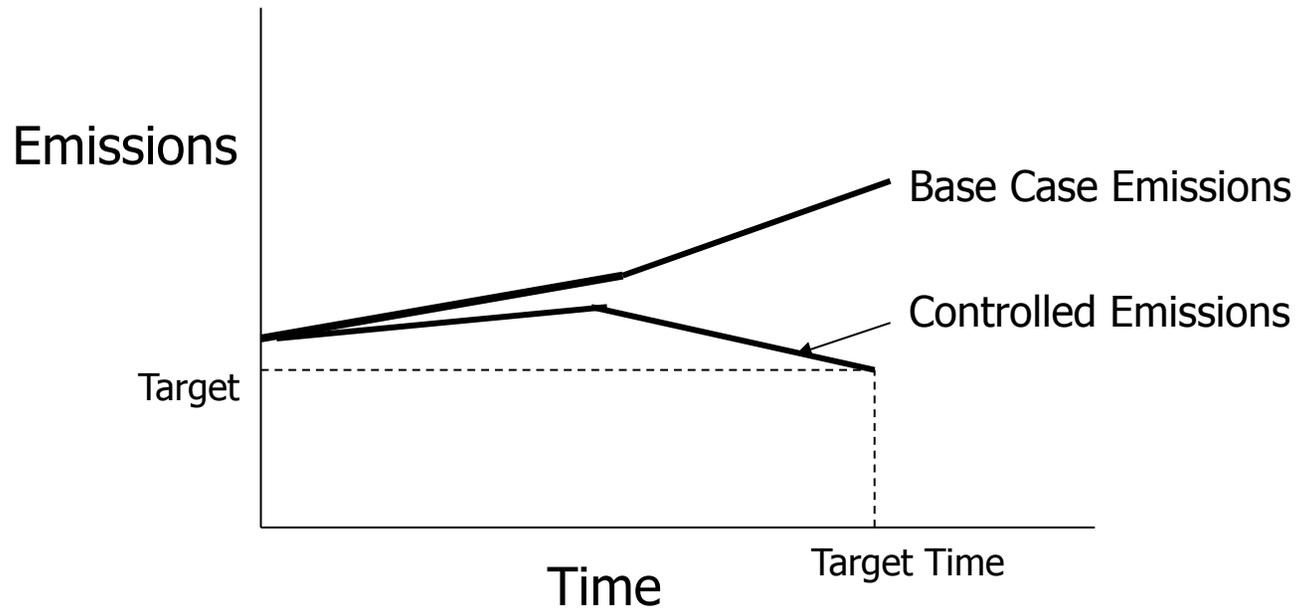
- Where Flexibility
- When Flexibility
- How Flexibility
- What Flexibility

Benefits of International Emissions Trading

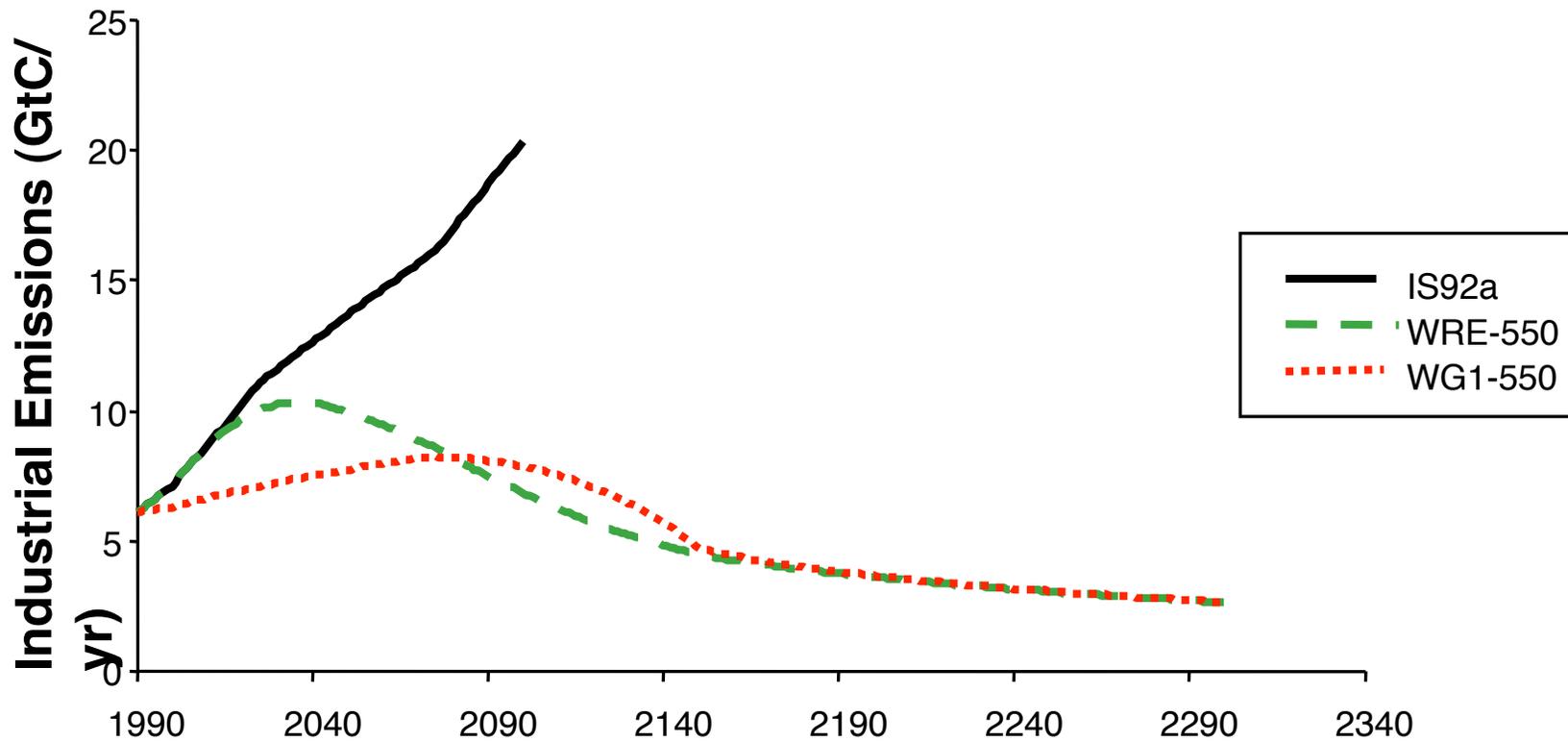
Year 2010 Carbon Tax Comparison
for the United States



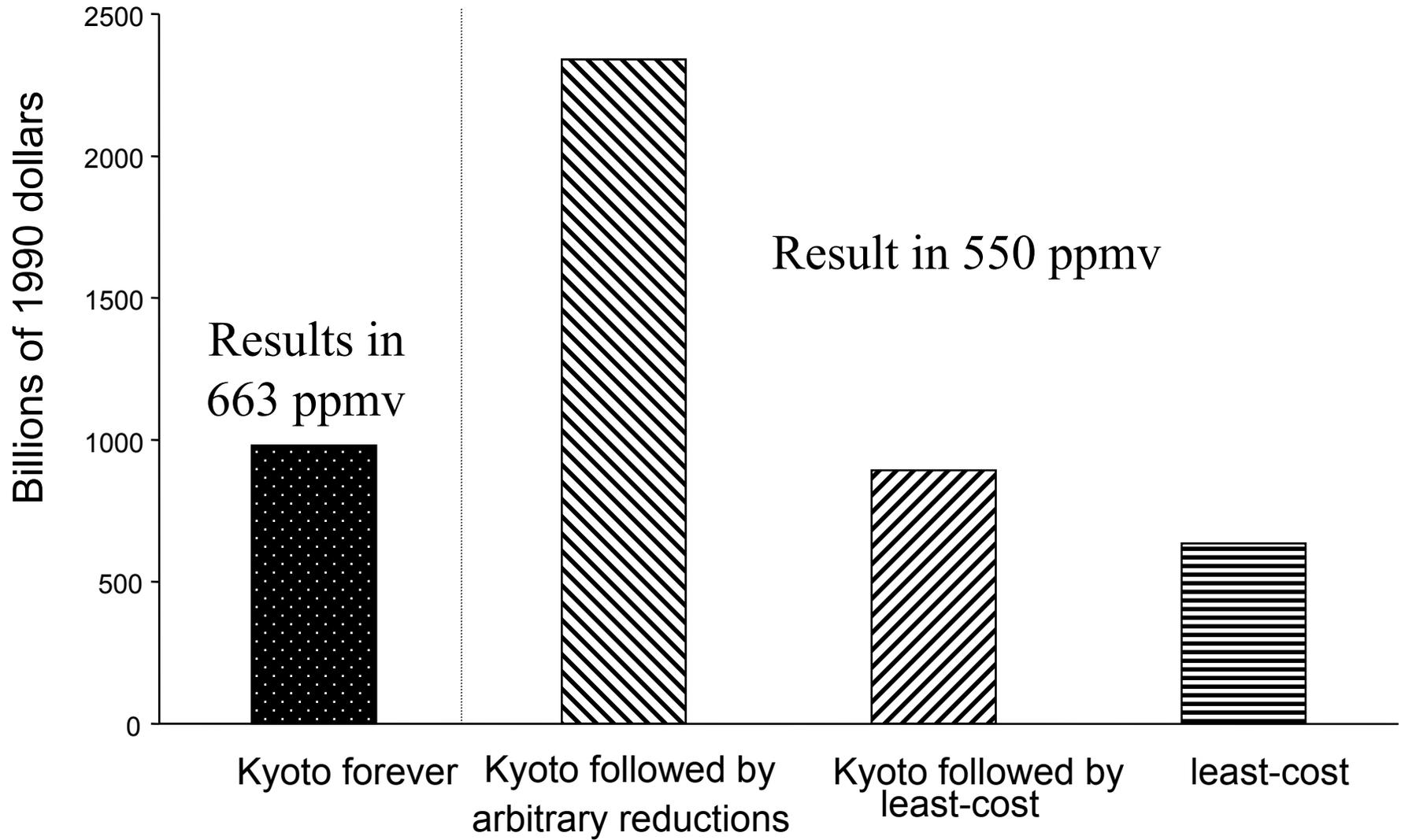
The Emissions Mitigation Challenge



Alternative Emission Paths for Stabilizing Atmospheric Concentrations of CO₂ at 550 ppmv (Parts Per Million by Volume)



Global Consumption Losses through 2100 Discounted to 1990 at 5% --
Kyoto Forever Vs. Three Scenarios for Stabilizing Concentrations at 550ppmv



Four Kinds of Mitigation Policy Flexibilities

- Where Flexibility
- When Flexibility
- How Flexibility
- What Flexibility

World Primary Energy in 550 ppm Case in 2100

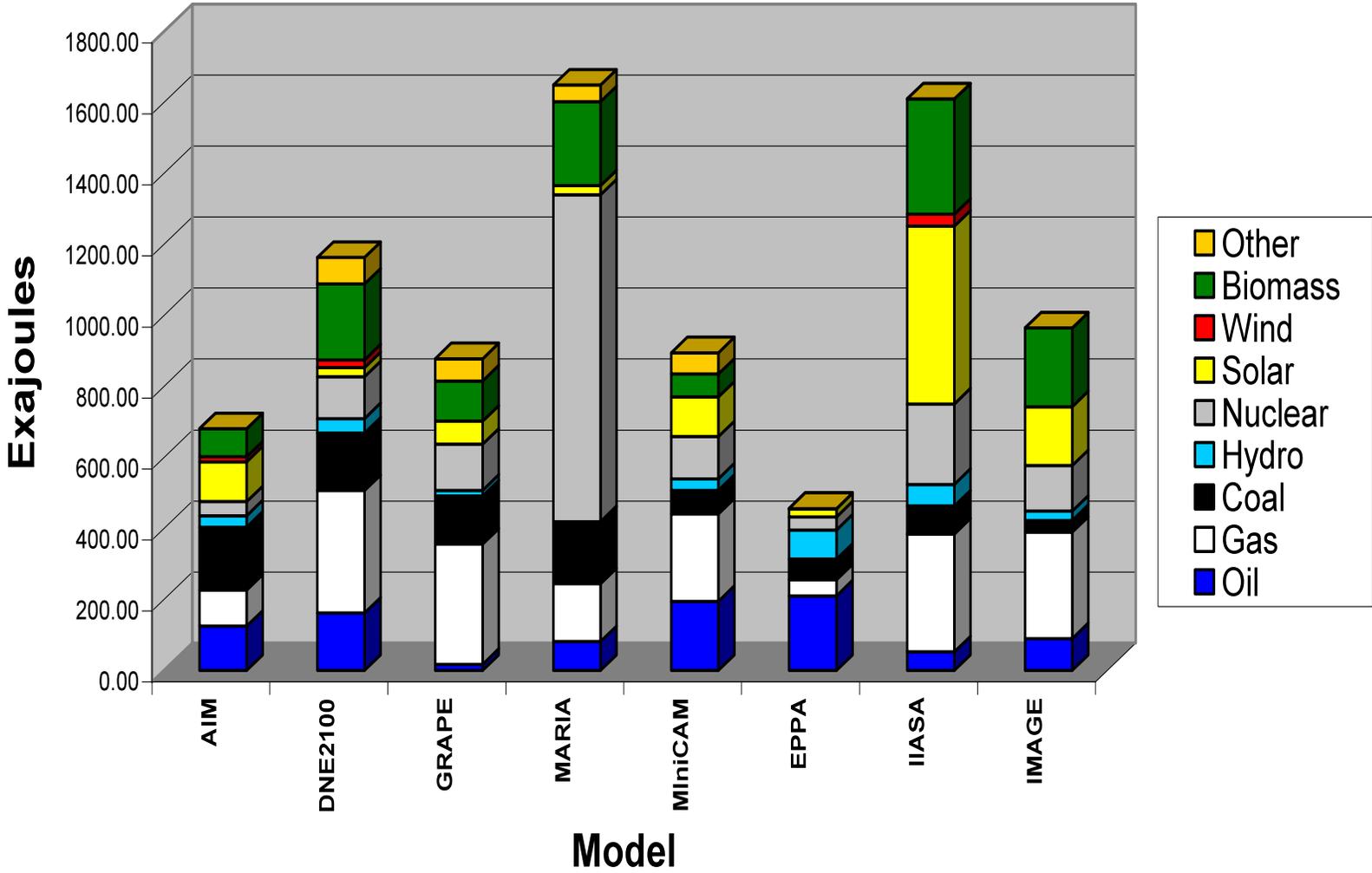
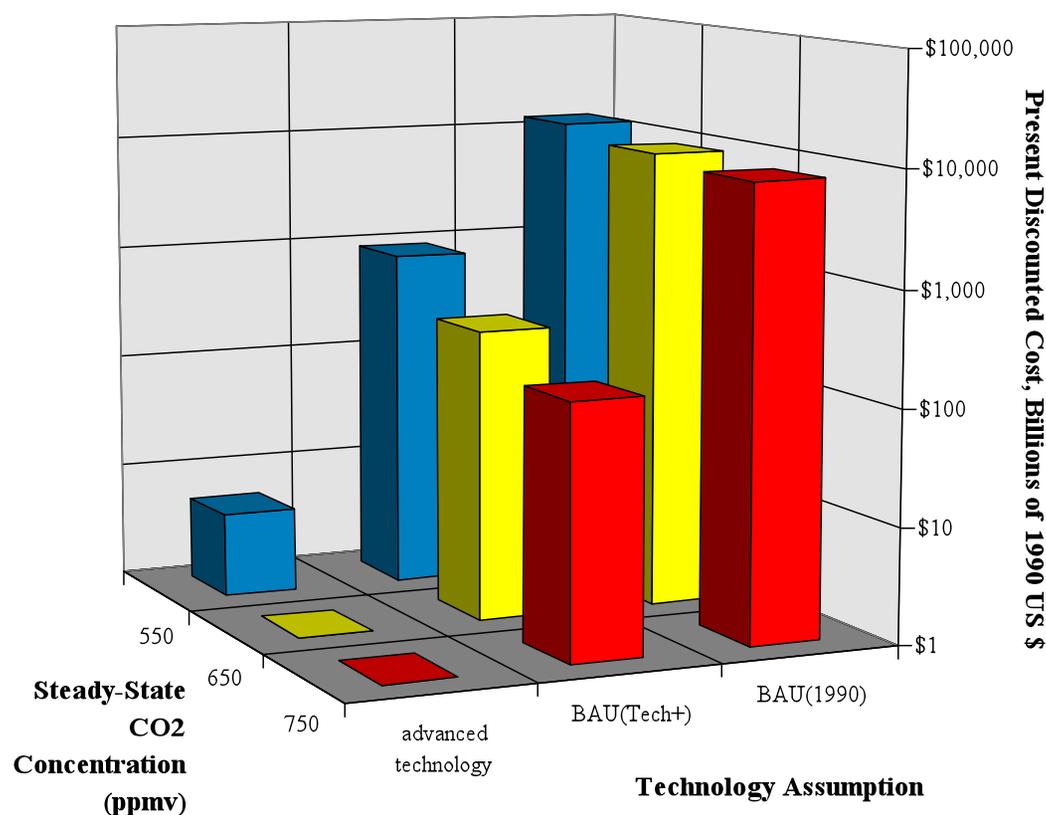


Table 1: Technology Assumptions

Technology	units	1990 Base	Year 2100	
			Mini- CAM B2	Mini- CAM B2 AT
US Automobiles	mpg	18	60	100
Land-based Solar Electricity	1990 c/kWh	61	5.0	5.0
Nuclear Power	1990 c/kWh	5.8	5.7	5.7
Biomass Energy	1990\$/gj	\$7.70	\$6.30	\$4.00
Hydrogen Production (CH ₄ feedstock)	1990\$/gj	\$6.00	\$6.00	\$4.00
Fuel Cell	mpg (equiv)	43	60	98
Fossil Fuel Power Plant Efficiency (Coal/Gas)	%	33	42/52	60/70
Capture Efficiency	%	90	90	90
Carbon Capture Power Penalty (Coal)	%	25	15	5
Carbon Capture Power Penalty (Gas)	%	13	10	3
Carbon Capture Capital Cost (Coal)	%	88	63	5
Carbon Capture Capital Cost (Gas)	%	89	72	3
Geologic Disposal (CO ₂)	\$/tC	37.0	37.0	23.0

The VALUE OF DEVELOPING ENERGY TECHNOLOGY

(Present Discounted Costs to Stabilize the Atmosphere)



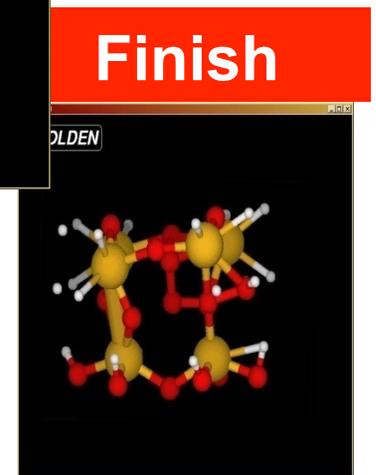
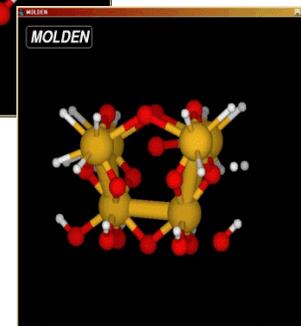
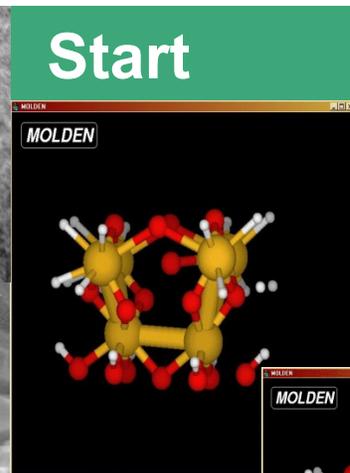
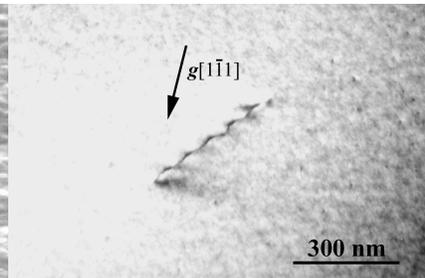
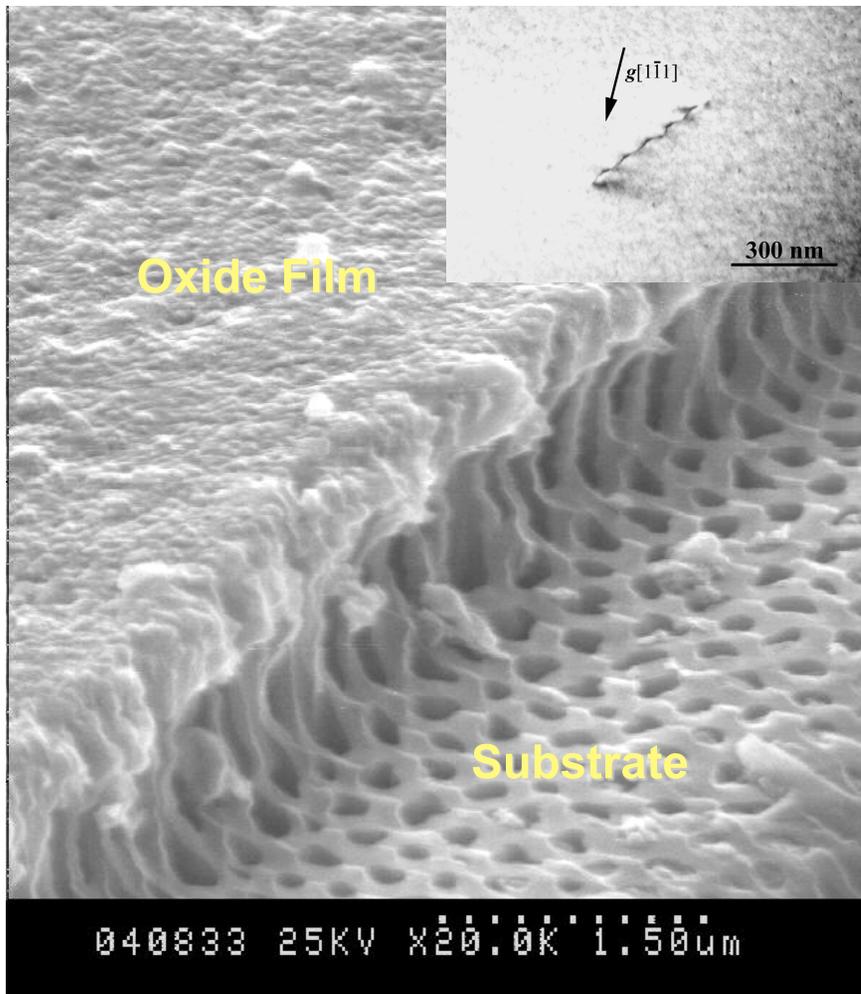
Minimum Cost
Based on Perfect
Where & When
Flexibility
Assumption.
Actual Cost
Could be An
Order of
Magnitude
Larger.

Global Climate and Energy Project (GCEP)

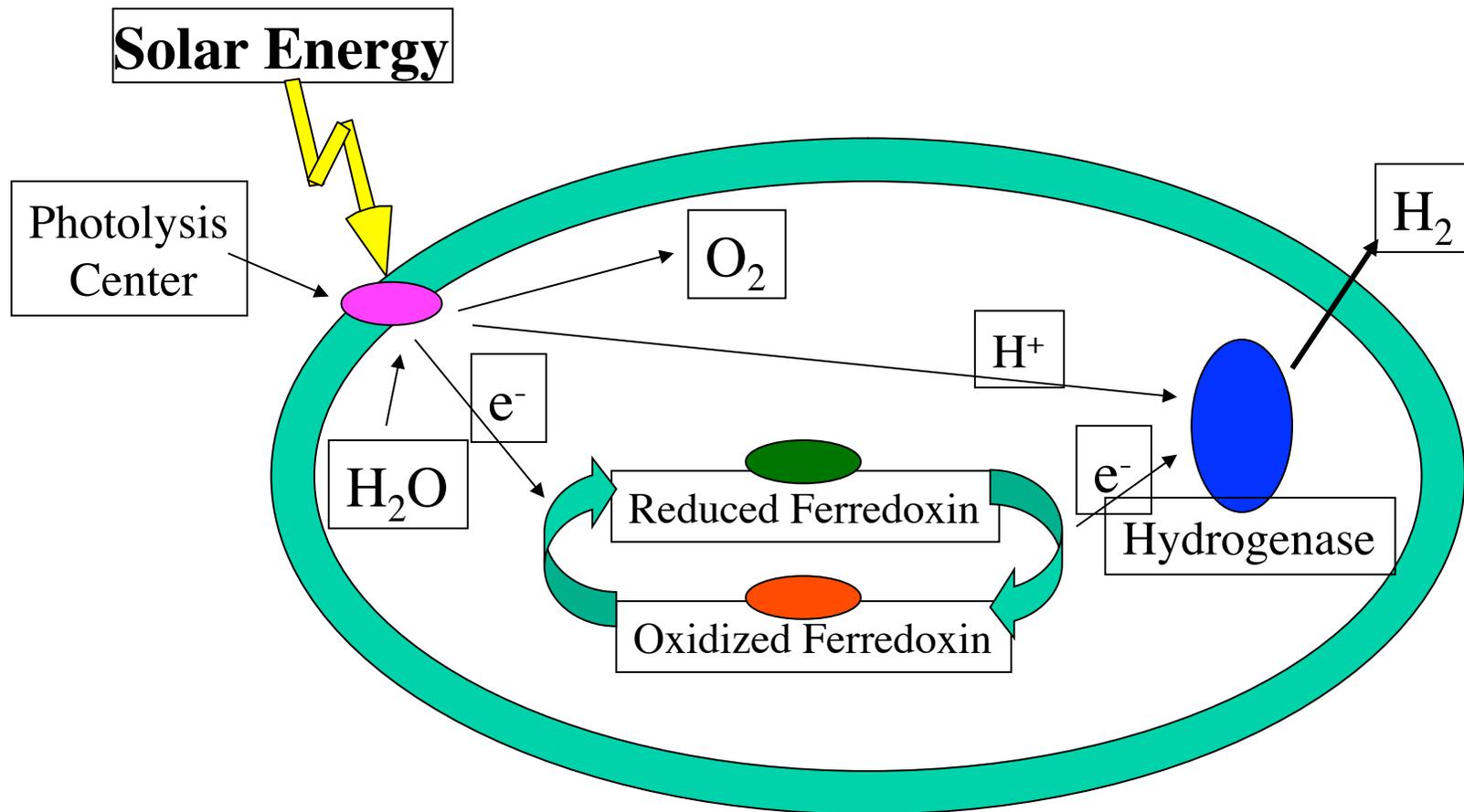
- A new project has been established at Stanford, with industry support
- (ExxonMobil, Schlumberger, GE, and Toyota), to investigate how to reduce emissions of greenhouse materials.
- The approach: look broadly across primary energy sources, transformations, and uses.
- Ask where university-based pre-commercial research can reduce barriers to implementing energy systems that have substantially lower greenhouse emissions.

50 Nanometer Membrane on Porous Substrate

Science: QM Simulations Implanted Ion Highways

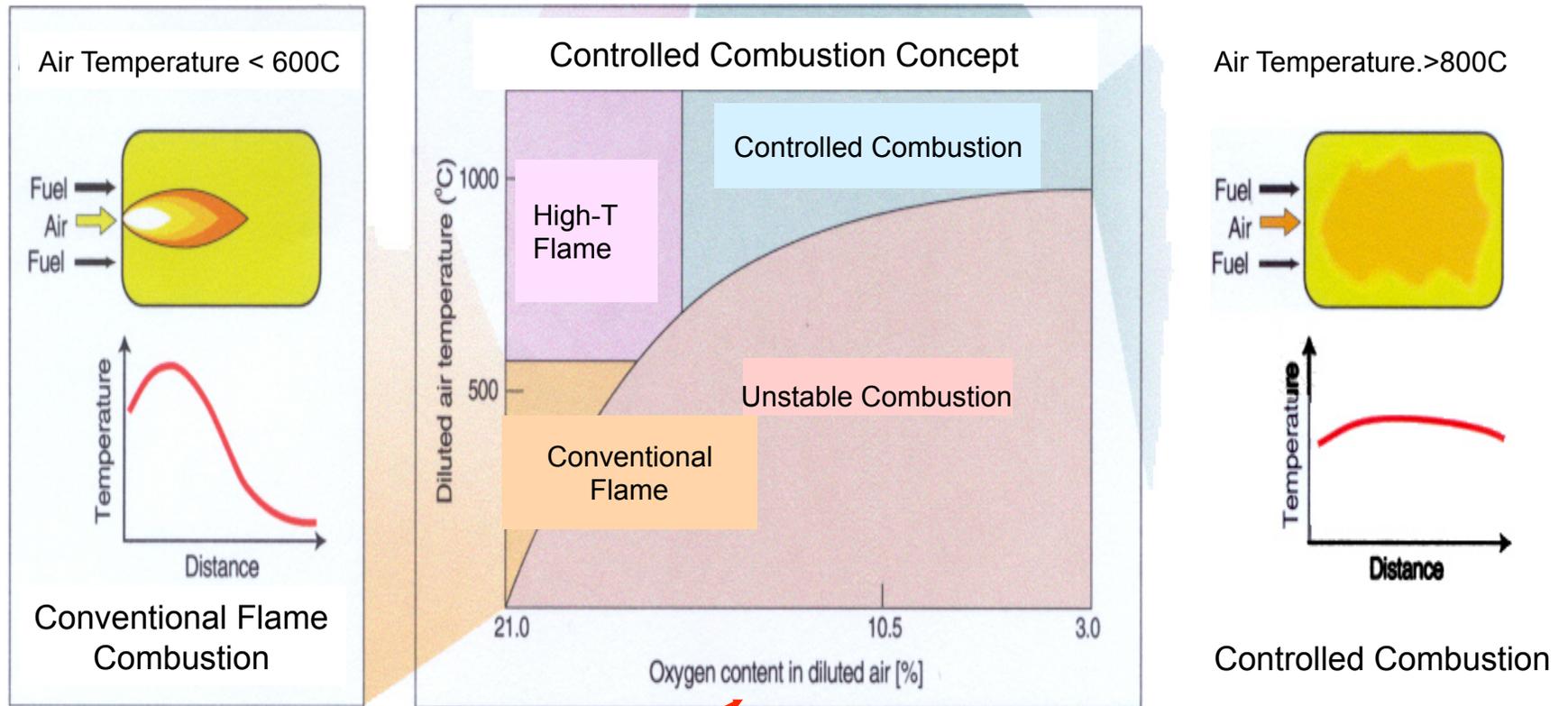


Biological Hydrogen Production: Complete Pathway in Each Cell



Controlled Combustion

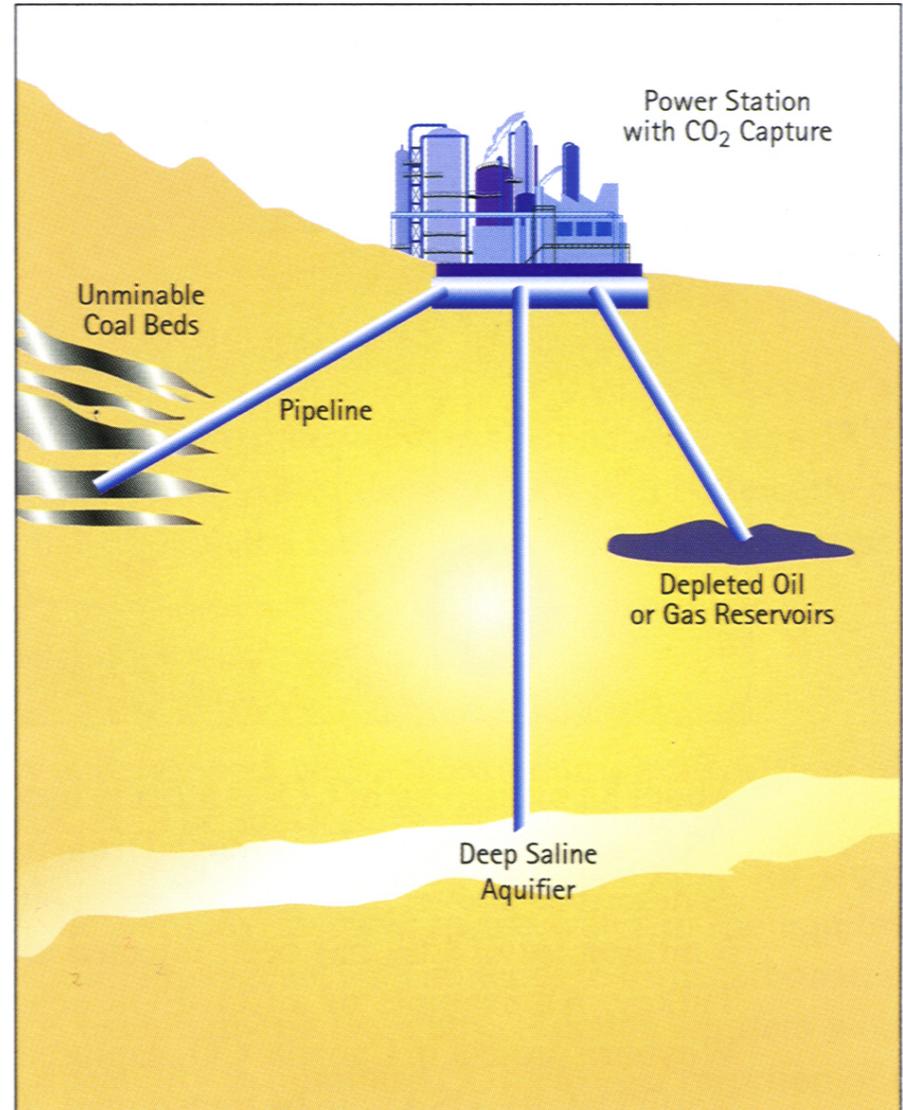
The Concept:



Dilution by combustion products, N_2 or CO_2

Geologic Storage of CO₂

- Use CO₂ to recover methane in coal beds.
- Dissolve CO₂ in deep aquifers that contain salt water.
- Inject CO₂ to recover oil and gas.
- Volumes are very large:
1 GtCO₂/yr = 25 million B/D.

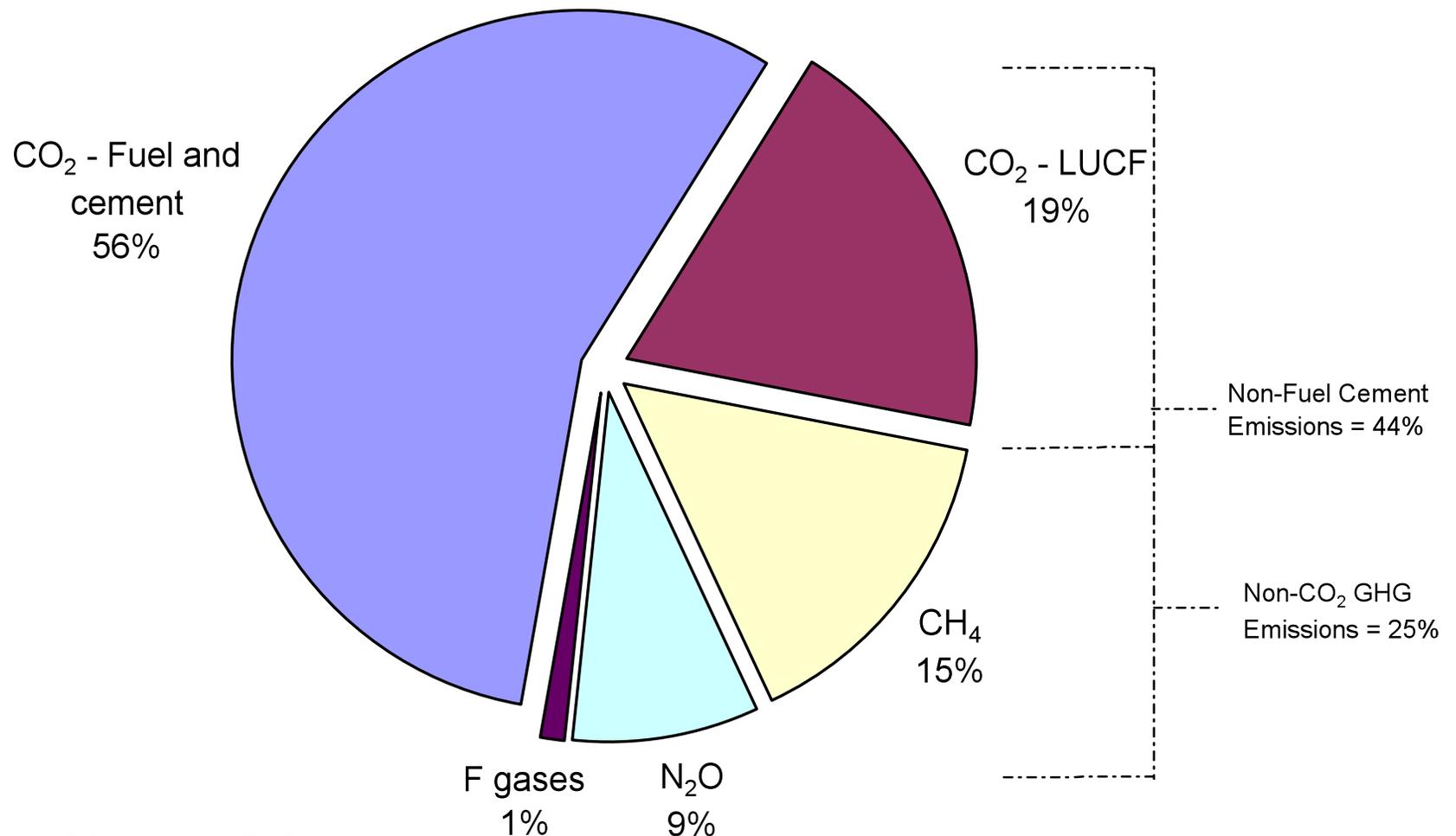


Four Kinds of Mitigation Policy Flexibilities

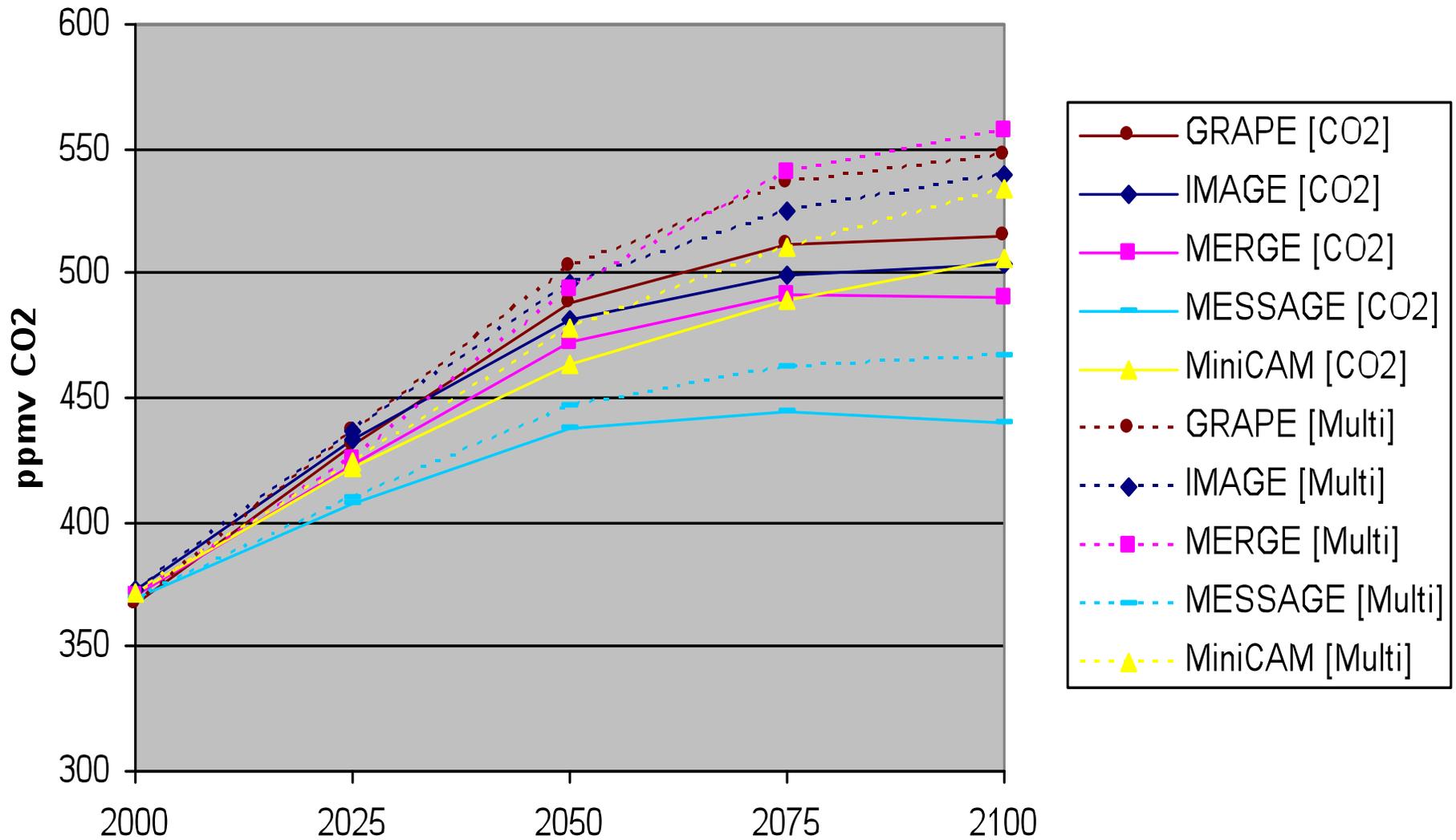
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Why Multi-gas Mitigation?

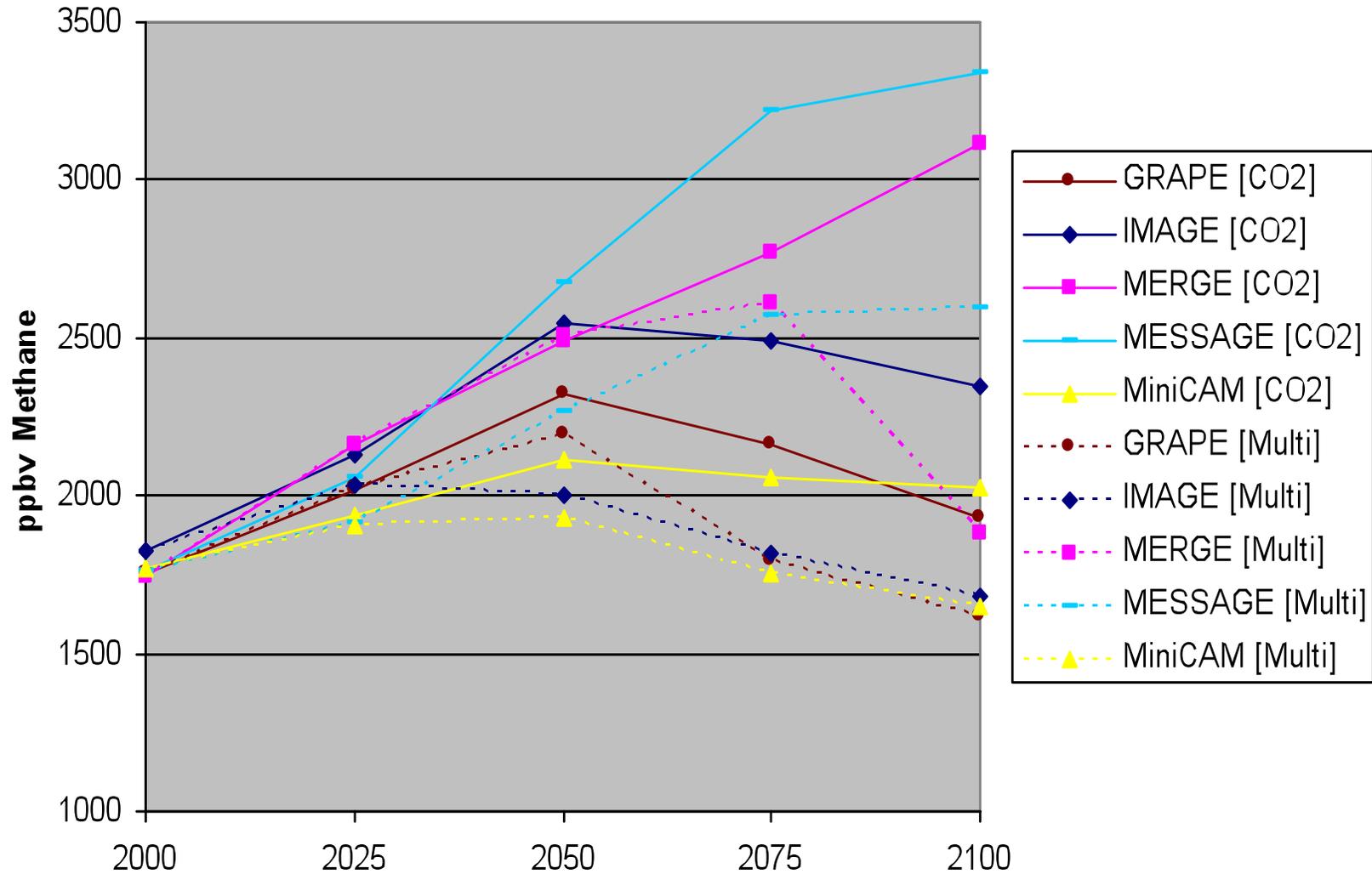
2000 Global Net Emissions of CO₂, CH₄, N₂O, F gases, and LUCF (Total 10,863 MMTCE)



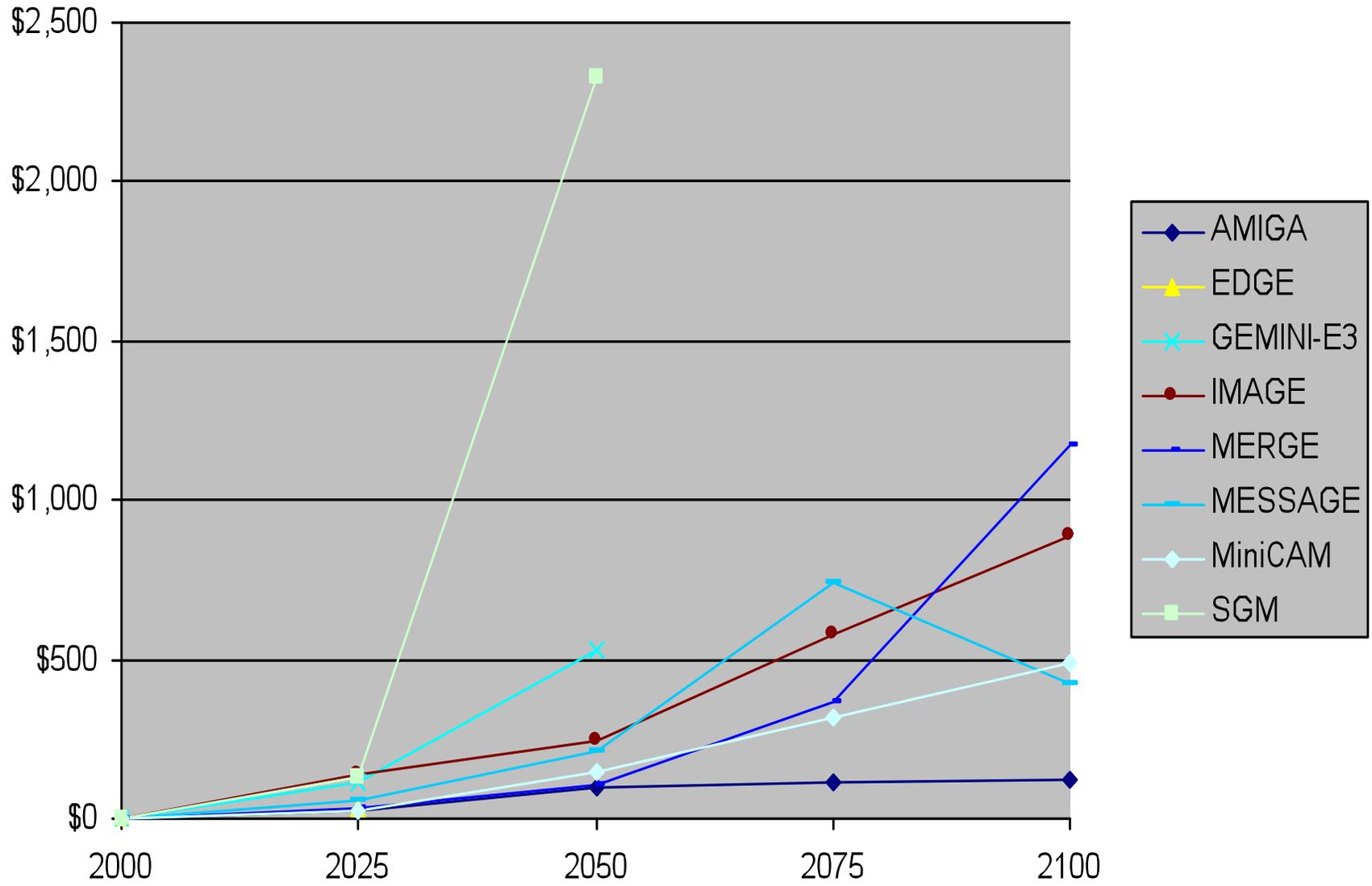
Atmospheric CO2 Concentration in Two Policy Scenarios: Stabilization With CO2 Only and Multi-Gases



Atmospheric Methane Concentration in Two Policy Scenarios: Stabilization With CO2 Only and Multi-Gases



Carbon Permit Price (\$USD 2000/tC) in CO2-Only Scenario



Carbon Permit Price (\$USD 2000/tC) in Multigas Scenario

