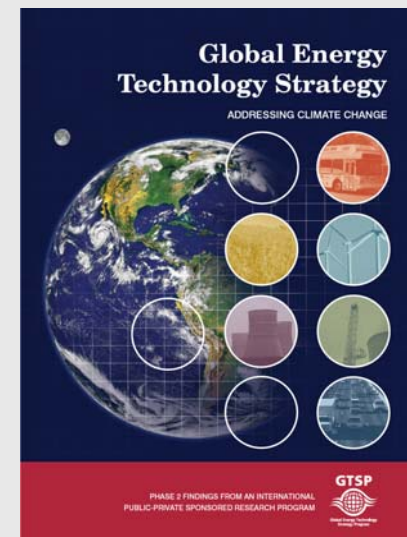


GTSP



Global Energy Technology
Strategy Program

Alternative Scenarios for Developing Countries



EPRI Global Climate Change Research Seminar

Westin Grand, Washington, DC

Jae Edmonds & Leon Clarke

May 21, 2008

Battelle



**Pacific Northwest
National Laboratory**

Operated by Battelle for the
U.S. Department of Energy

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- ▶ Thanks to Rich Richels for the original research insight.

Shaping the Global Debate:
Technology's Role in
Addressing Climate Change

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Global Energy Technology Strategy
ADDRESSING CLIMATE CHANGE

Initial Findings from
an International Public-Private Collaboration

Joint Global Change Research Institute

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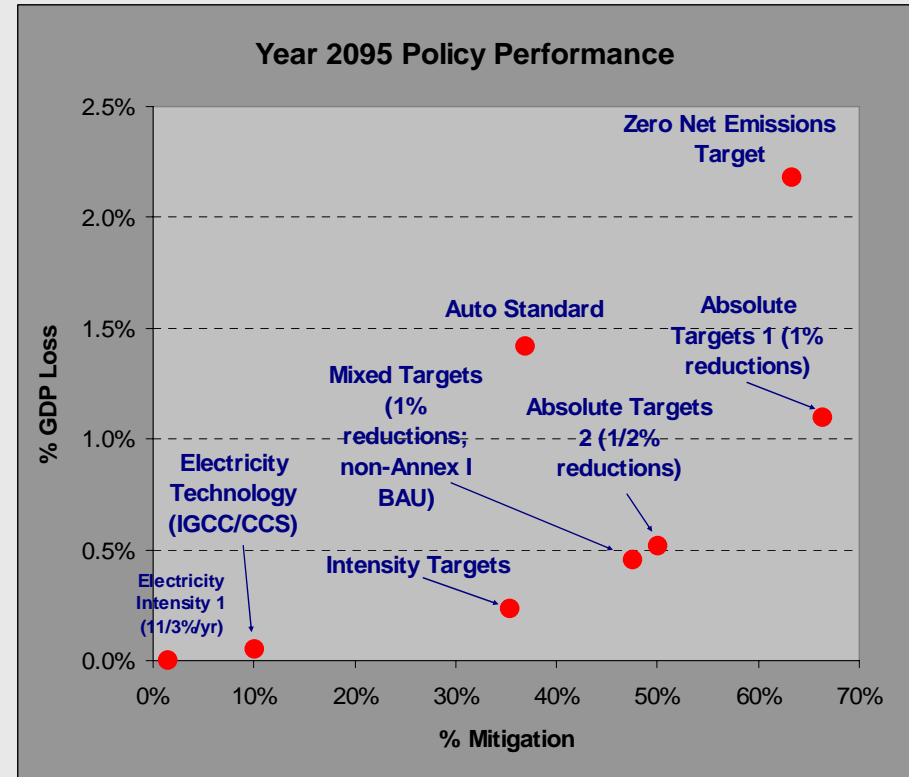
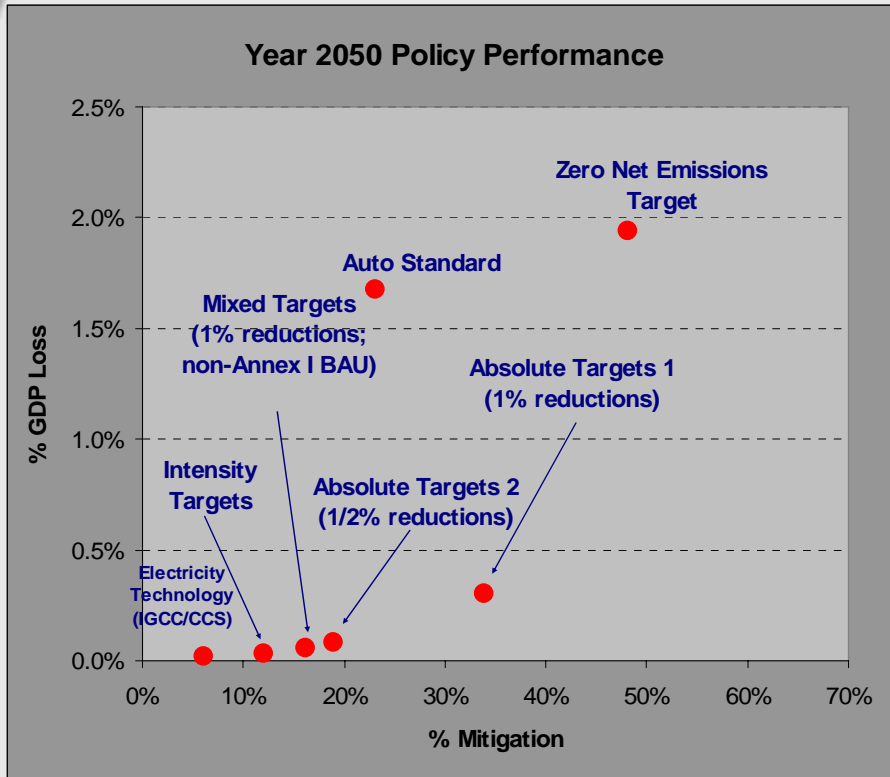


What Scenarios Should We be Considering?

- ▶ Many long-term, global scenarios have assumed efficient carbon regimes: all countries participate fully in mitigation from the outset.
- ▶ Reality is unlikely meet this ideal.
- ▶ Considering less coordinated and efficient future emissions mitigation regimes.
 - What policy structures are possible or likely?
 - What might these policy structures imply for the costs and burdens of stabilization?
 - What might they imply for strategic decisions such as technology development and deployment?

The Pocantico Process

A look at specific policy proposals.





Outline of this Research: Second-Best Paths to Stabilization

- ▶ Consider stabilization at four levels: 450 ppm, 550 ppm, 650 ppm, and 750 ppm.
- ▶ Consider four stabilization regimes:
 - Set 1: Idealized—perfect global where and when flexibility.
 - Set 2: Add graduated accession—some countries wait to participate.
 - Set 3: Add regionally differentiated regimes—participating countries face differentiated carbon prices.
 - Set 4: Add sectorally differentiated regimes—sectors face differentiated carbon prices.
- ▶ We will talk about the first three of these today.

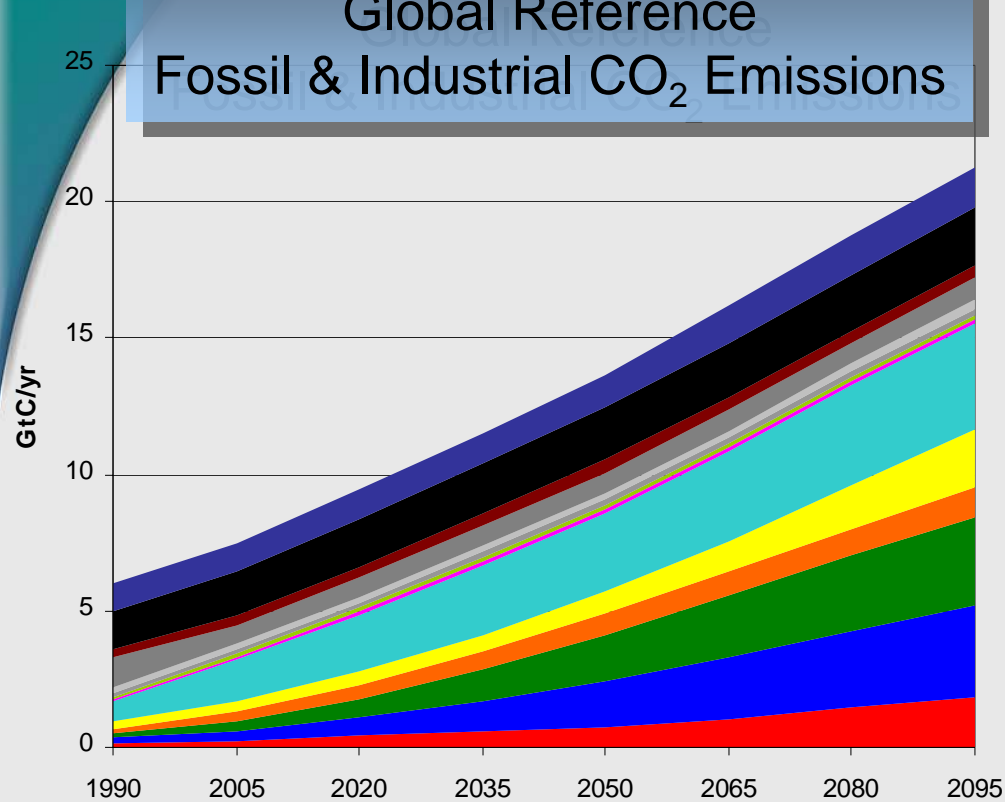


The Reference Scenario

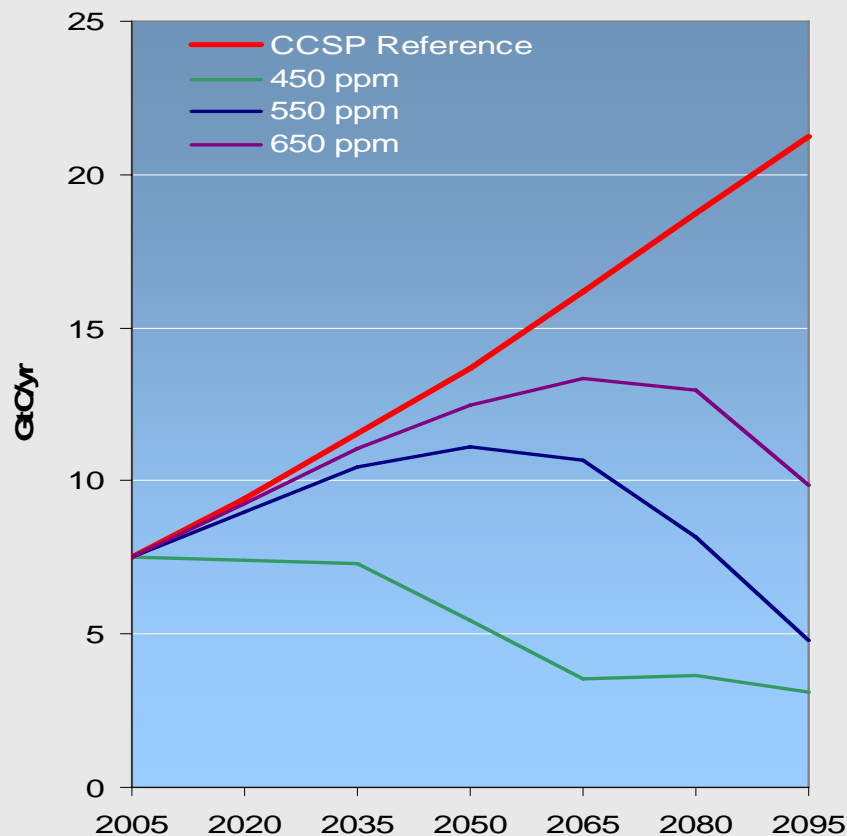


The GTSP Reference Scenario The Importance of Participation

Global Reference
Fossil & Industrial CO₂ Emissions



- Africa
- India
- Southeast Asia
- Middle East
- Latin America
- China
- Korea
- Australia_NZ
- Canada
- Eastern Europe
- Former Soviet Union
- Japan
- USA
- Western Europe



Global Emissions in
Reference & Stabilization



Stabilization Set 1 Full Participation



Scenario Set 1: Full Participation

▶ Stabilize CO₂ concentrations

- 450 ppm, 550 ppm, 650 ppm.
- Sectoral carbon prices—All EQUAL.
- Regional carbon prices—All EQUAL.
- Time path of carbon prices—Peck-Wan-Hotelling.

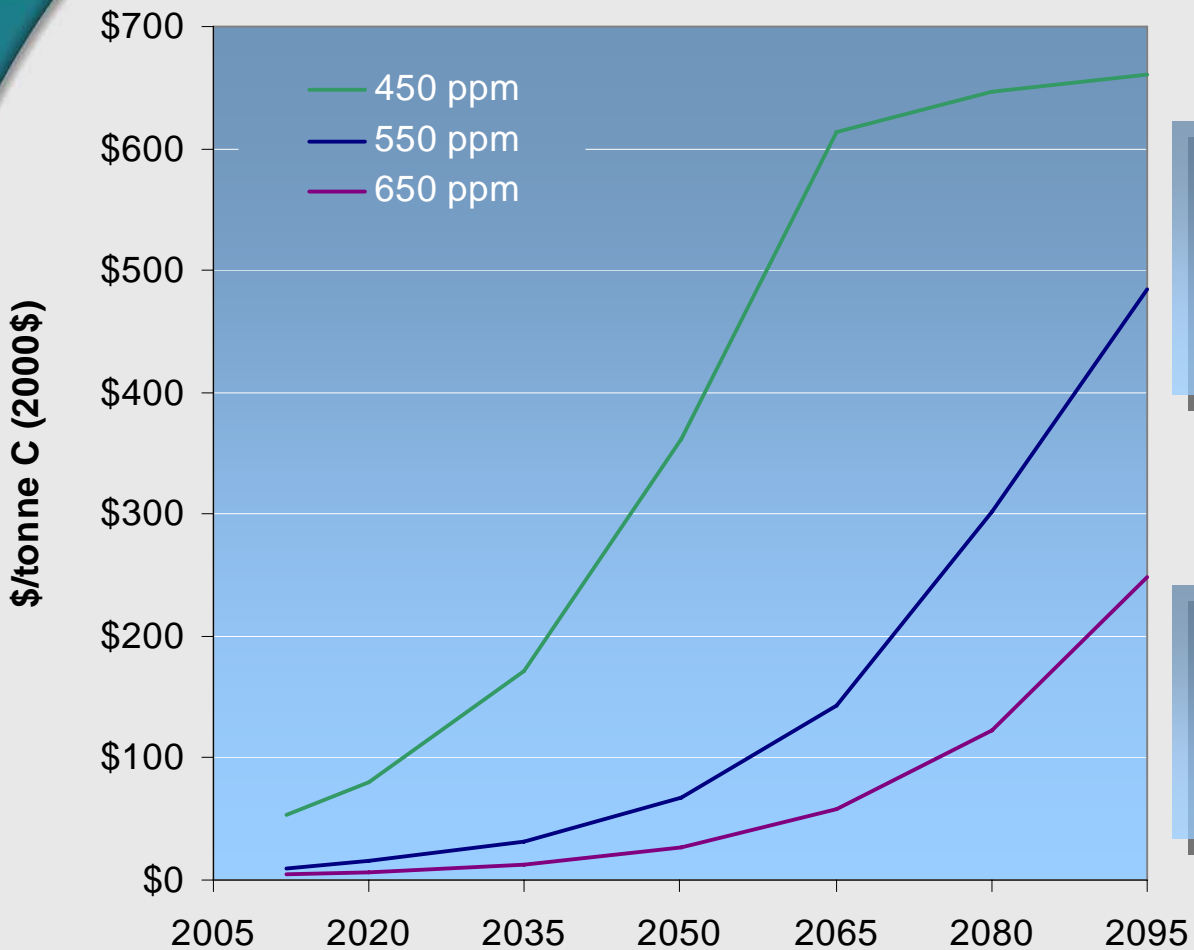
▶ Notes:

- We have chosen CO₂ rather than radiative forcing for simplicity. We have further simplified the analysis by assuming a fixed agriculture-land-use emissions path. Unmanaged ecosystem extent and composition is fixed.
- This case sets an economically efficient benchmark for comparison with other cases.



Scenario Set 1

The Global Carbon Price



The carbon price rises at roughly the rate of interest until stabilization is reached.

Today's price depends on tomorrow's technology

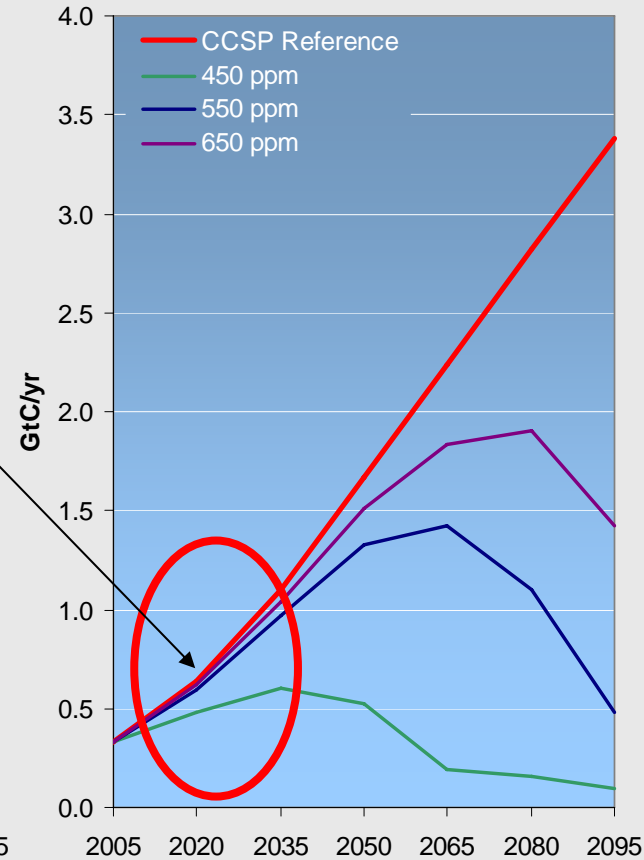
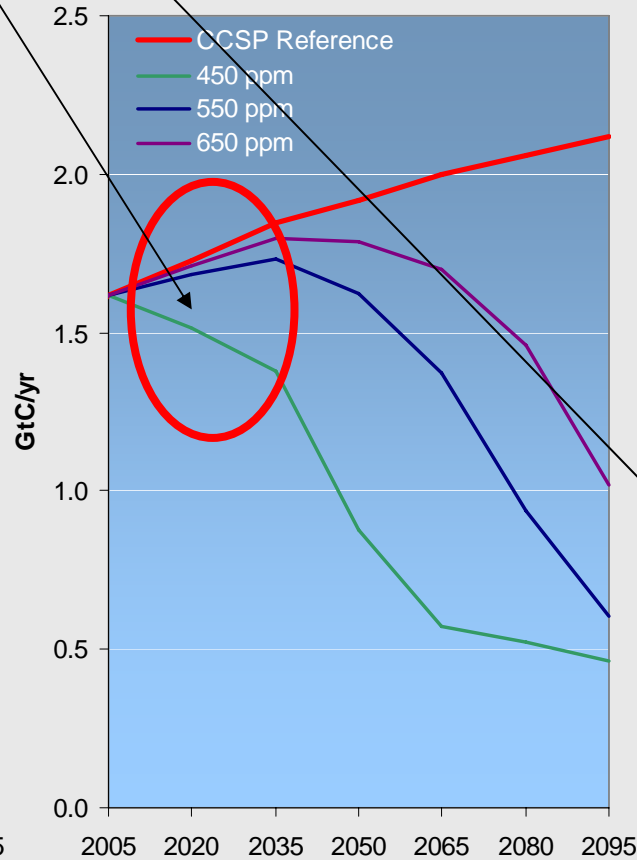
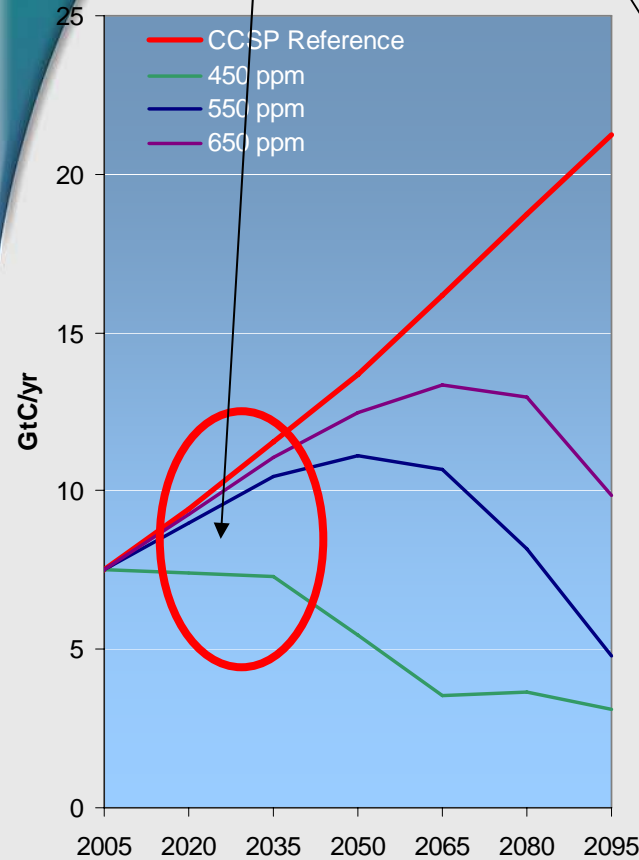
450 ppm has fundamentally different near-term implications than 550 ppm and above

Scenario Set I Industrial CO₂ Emissions

Global

USA

India





Stabilization Set 2 Graduated Accession



Stabilization Scenario Set 2

Graduated Accession

▶ Stabilize CO₂ concentrations

- 450 ppm, 550 ppm, 650 ppm.
- Sectoral carbon prices—All EQUAL.
- Regional carbon prices—All EQUAL.
- Time path of carbon prices—Peck-Wan-Hotelling.
- Staggered accession based on per capita income.
 - Alternative accession cases—first group enters: 2020, 2035, 2050

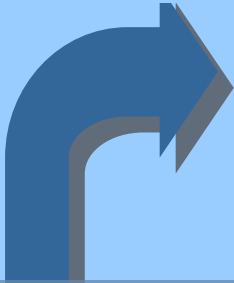
Countries come in at
the global market price
of carbon

▶ Notes:

- We assume that all Annex 1 nations participate in an international protocol by 2012 and that others join at different times based on per capita income. Non-Annex 1 participation is keyed to China's entry date.

Order of Regional Participation (1st NA1 Group Enters 2020-2035)

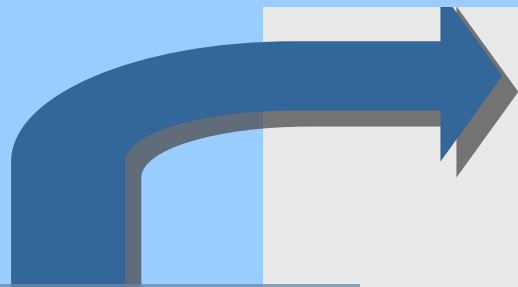
2005-2020	2020-2035	2035-2050	2050-2065	2065-2080	2080-2095
USA	USA	USA	USA	USA	USA
Australia & NZ	Australia & NZ	Australia & NZ	Australia & NZ	Australia & NZ	Australia & NZ
Canada	Canada	Canada	Canada	Canada	Canada
W. Europe	W. Europe	W. Europe	W. Europe	W. Europe	W. Europe
E. Europe	E. Europe	E. Europe	E. Europe	E. Europe	E. Europe
Japan	Japan	Japan	Japan	Japan	Japan
FSU	FSU	FSU	FSU	FSU	FSU
	Korea	Korea	Korea	Korea	Korea
	China	China	China	China	China
	Latin America	Latin America	Latin America	Latin America	Latin America
	Mideast	Mideast	Mideast	Mideast	Mideast
		Other SE Asia	Other SE Asia	Other SE Asia	Other SE Asia
		India	India	India	India
			Africa	Africa	Africa



**NA1 1st Group
 Enters 2020-2035**

Order of Regional Participation (1st NA1 Group Enters 2035-2050)

2005-2020	2020-2035	2035-2050	2050-2065	2065-2080	2080-2095
USA	USA	USA	USA	USA	USA
Australia & NZ	Australia & NZ	Australia & NZ	Australia & NZ	Australia & NZ	Australia & NZ
Canada	Canada	Canada	Canada	Canada	Canada
W. Europe	W. Europe	W. Europe	W. Europe	W. Europe	W. Europe
E. Europe	E. Europe	E. Europe	E. Europe	E. Europe	E. Europe
Japan	Japan	Japan	Japan	Japan	Japan
FSU	FSU	FSU	FSU	FSU	FSU
		Korea	Korea	Korea	Korea
		China	China	China	China
		Latin America	Latin America	Latin America	Latin America
		Mideast	Mideast	Mideast	Mideast
			Other SE Asia	Other SE Asia	Other SE Asia
			India	India	India
				Africa	Africa



**NA1 1st Group
Enters 2035-2050**

Order of Regional Participation (1st NA1 Group Enters 2050-2065)

2005-2020	2020-2035	2035-2050	2050-2065	2065-2080	2080-2095
USA	USA	USA	USA	USA	USA
Australia & NZ	Australia & NZ	Australia & NZ	Australia & NZ	Australia & NZ	Australia & NZ
Canada	Canada	Canada	Canada	Canada	Canada
W. Europe	W. Europe	W. Europe	W. Europe	W. Europe	W. Europe
E. Europe	E. Europe	E. Europe	E. Europe	E. Europe	E. Europe
Japan	Japan	Japan	Japan	Japan	Japan
FSU	FSU	FSU	FSU	FSU	FSU
			Korea	Korea	Korea
			China	China	China
			Latin America	Latin America	Latin America
			Mideast	Mideast	Mideast
				Other SE Asia	Other SE Asia
				India	India
					Africa

NA1 1st Group
Enters 2050-2065

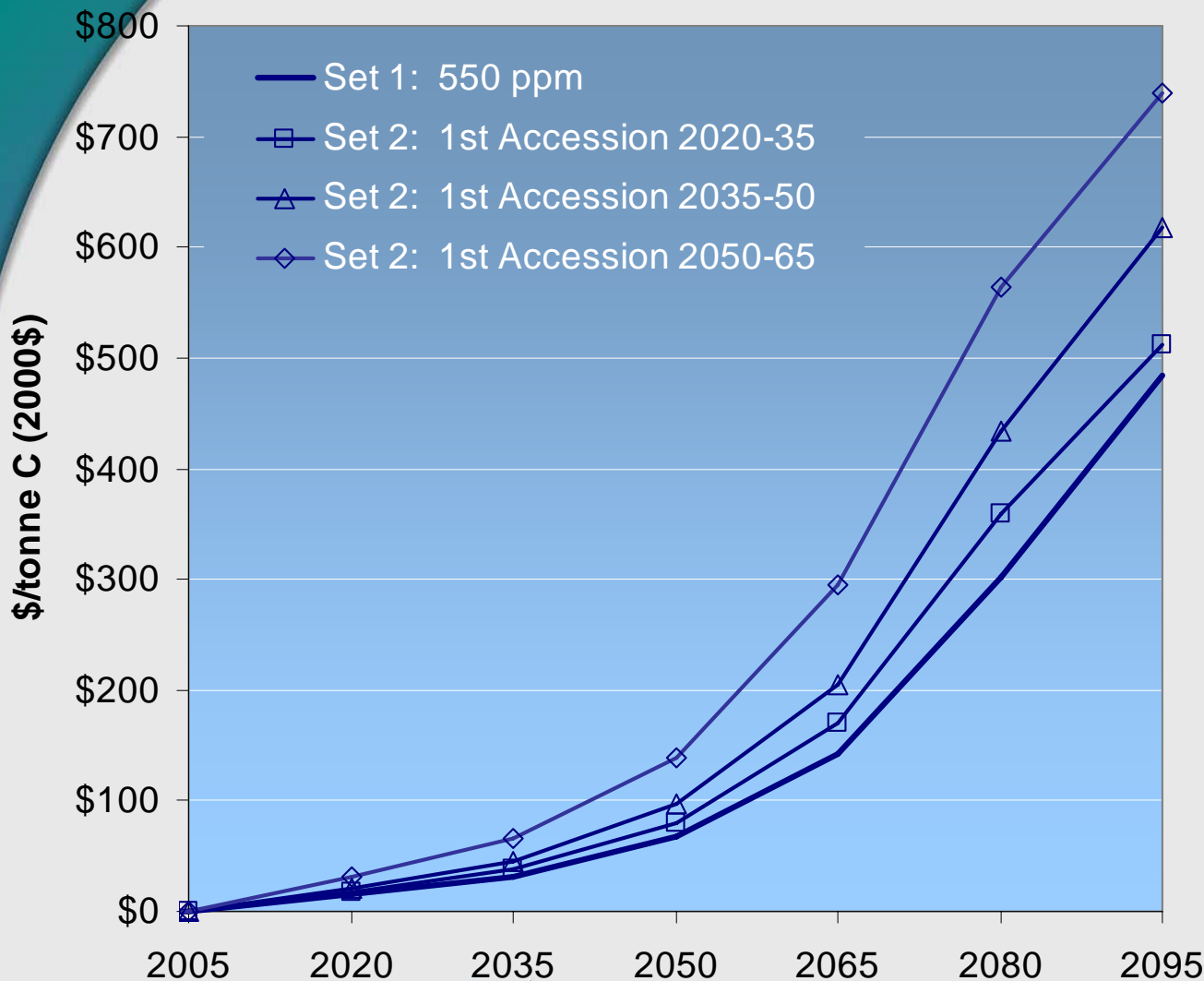
Note that India
comes in one period
after China



Scenario Set 2, 550 ppm



Scenario Set 2, 550 ppm Global Carbon Price



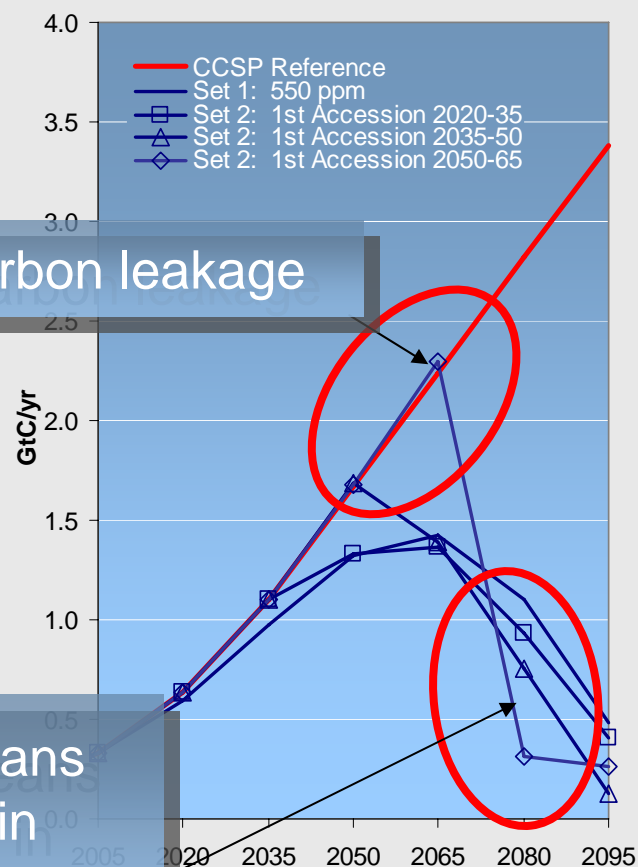
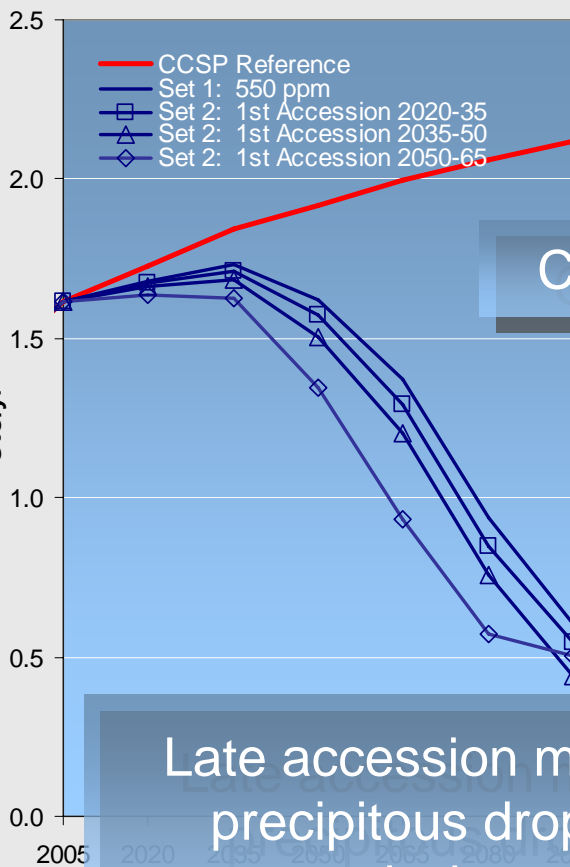
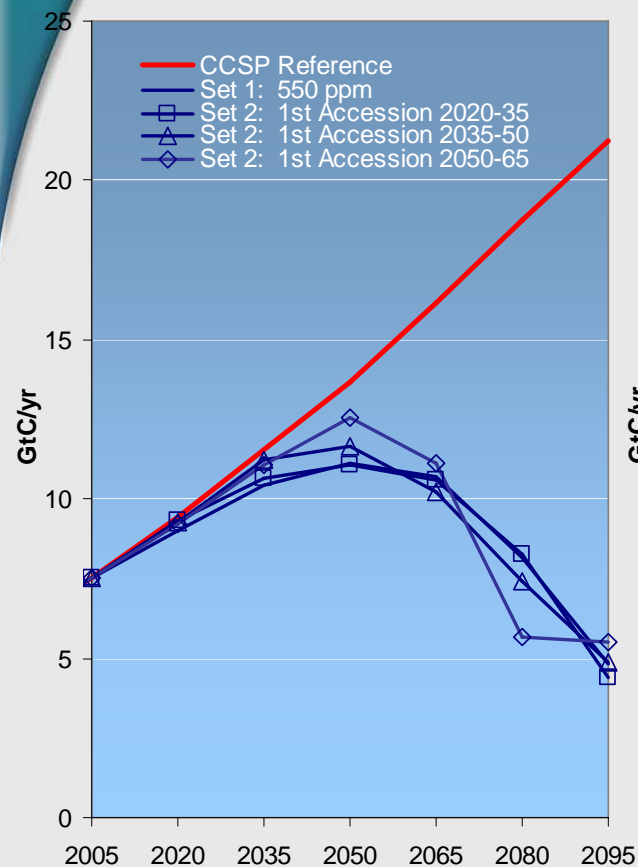
Effect on carbon prices is not extreme in the 550 scenario

Scenario Set 2, 550 ppm Fossil & Industrial CO₂ Emissions

Global

USA

India



Carbon leakage

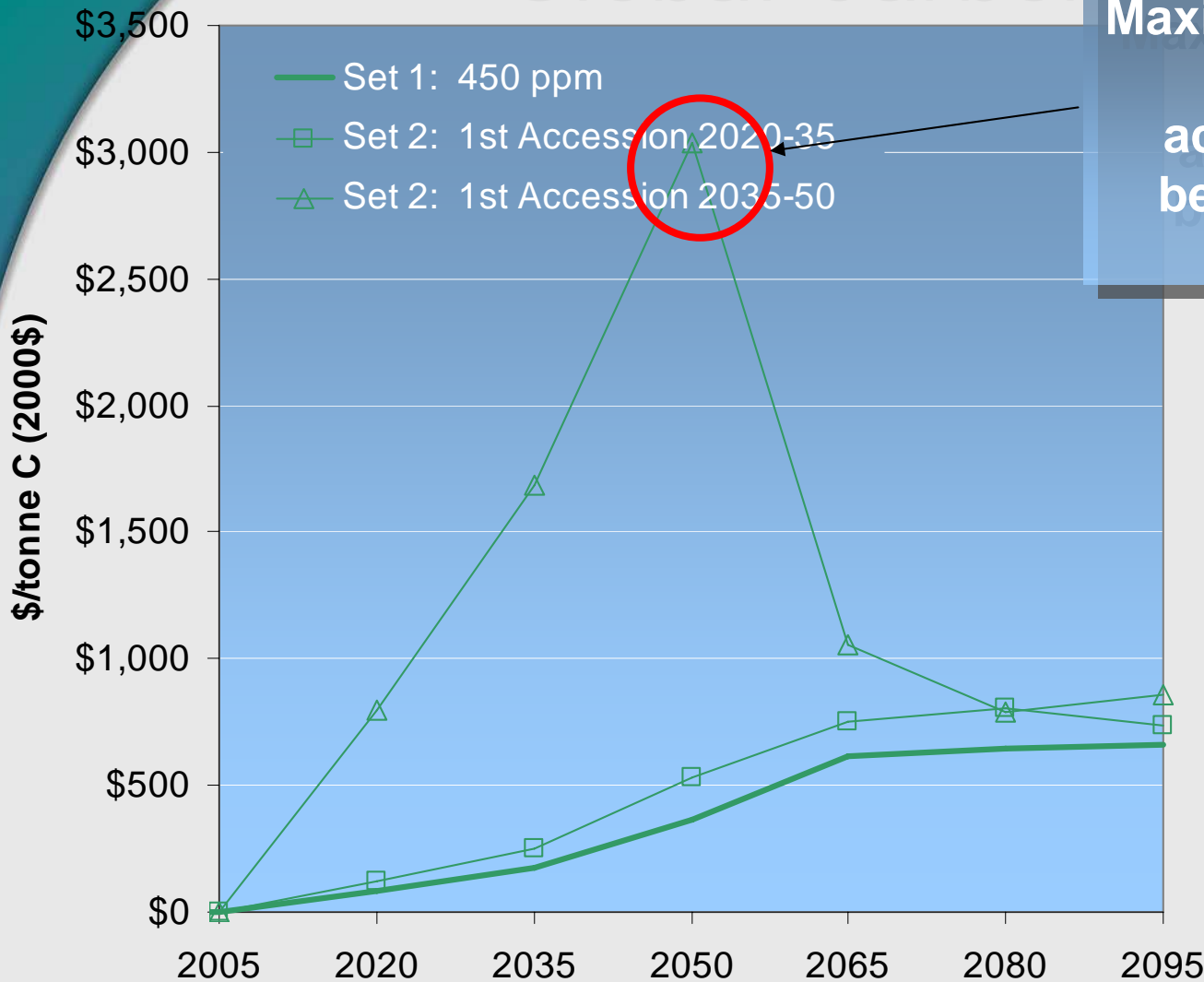
Late accession means precipitous drop in emissions



Scenario Set 2, 450 ppm



Scenario Set 2, 450 ppm Global Carbon Price



Maximum price just as Non-annex 1 accession begins between 2035 and 2050

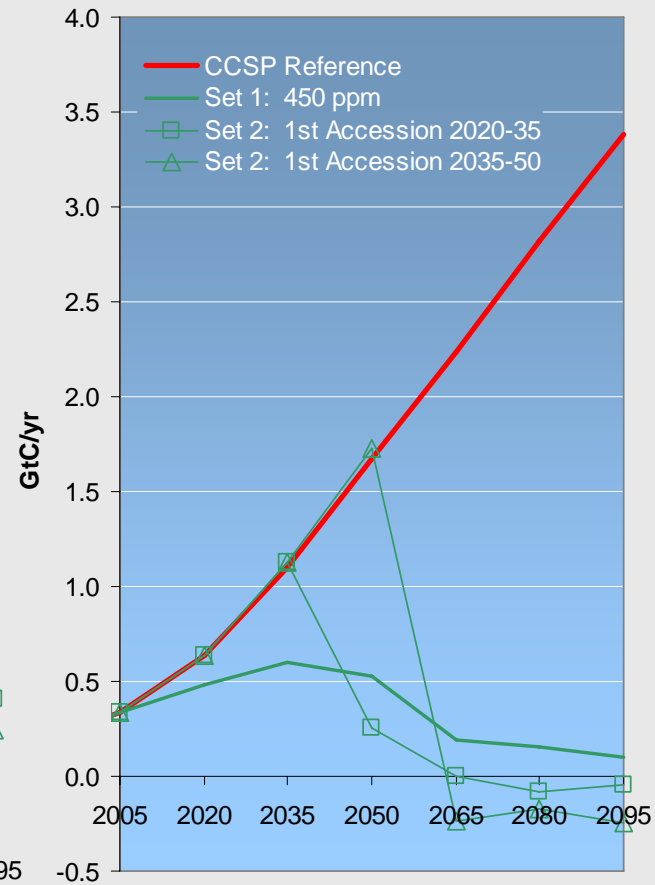
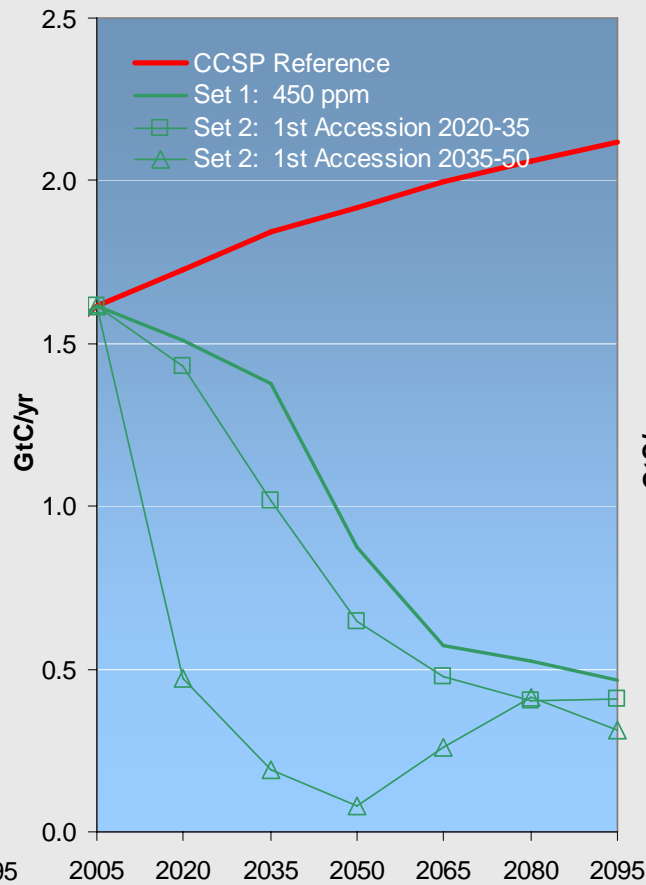
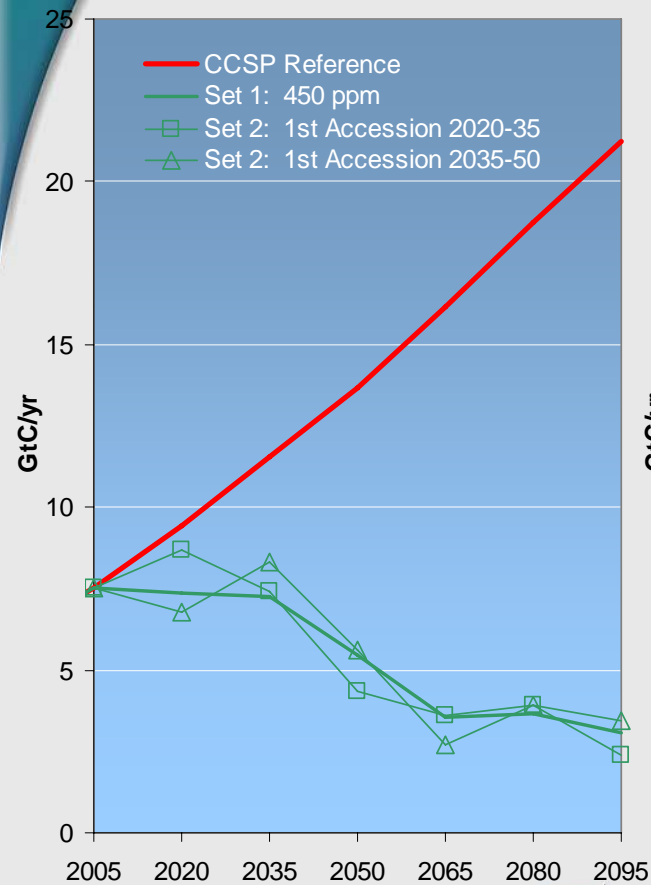
Set 2 1st Accession beginning in 2050 is infeasible!

Scenario Set 2, 450 ppm Fossil & Industrial CO₂ Emissions

Global

USA

India



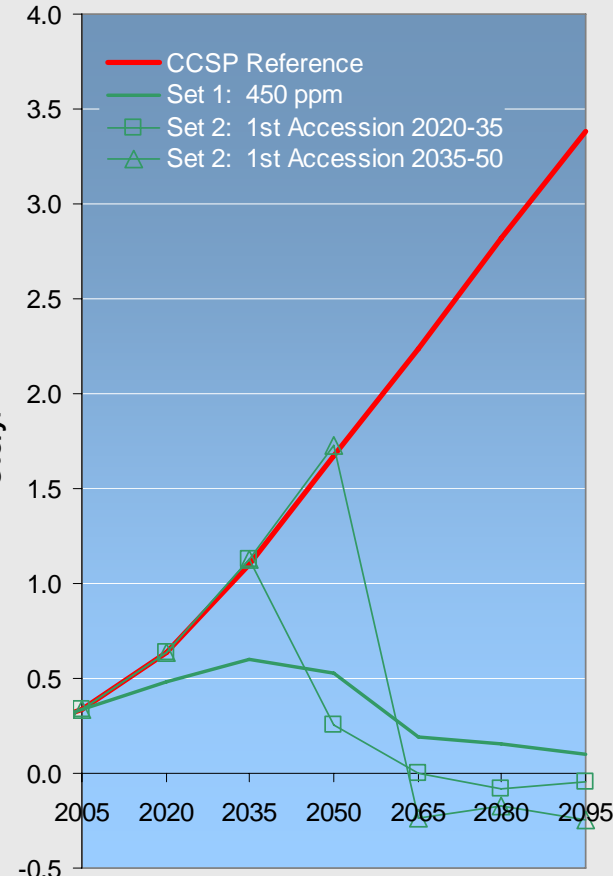
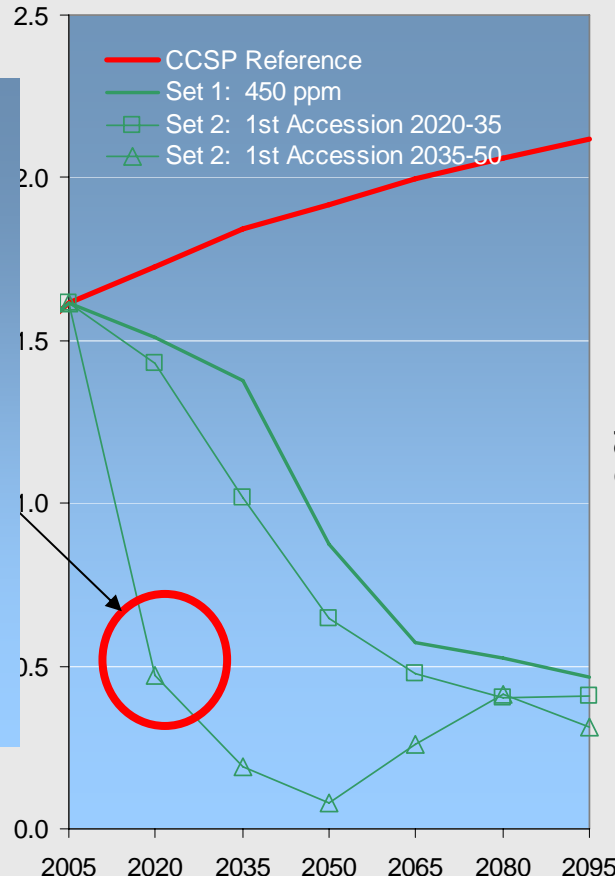
Scenario Set 2, 450 ppm Fossil & Industrial CO₂ Emissions

Global

USA

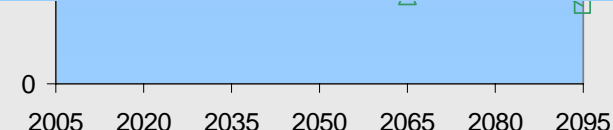
India

25
— CCSP Reference



Two periods of delay mean 2/3 reduction in US emissions by 2020.

Accession delay past 2050 is totally infeasible for 450 ppm.

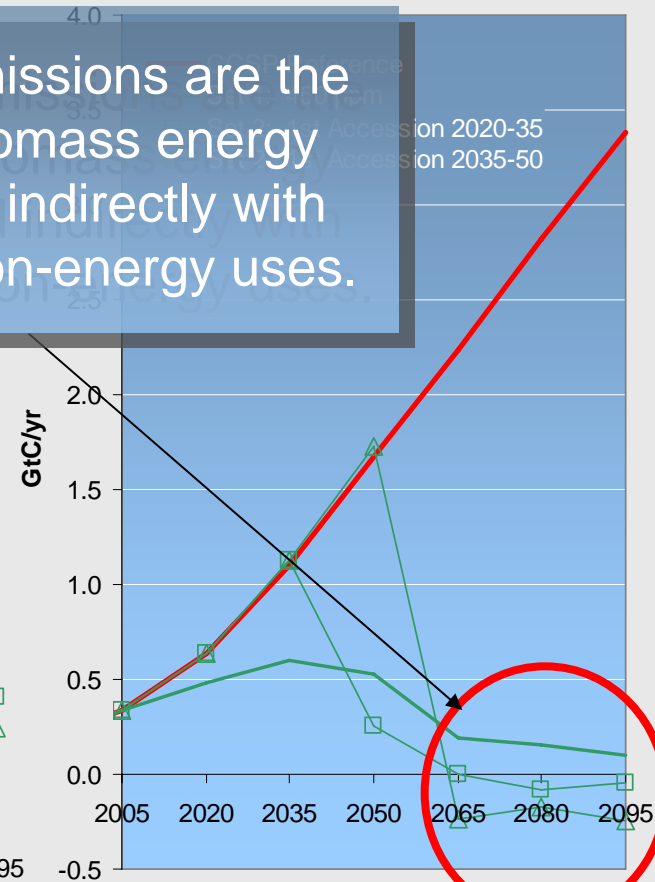
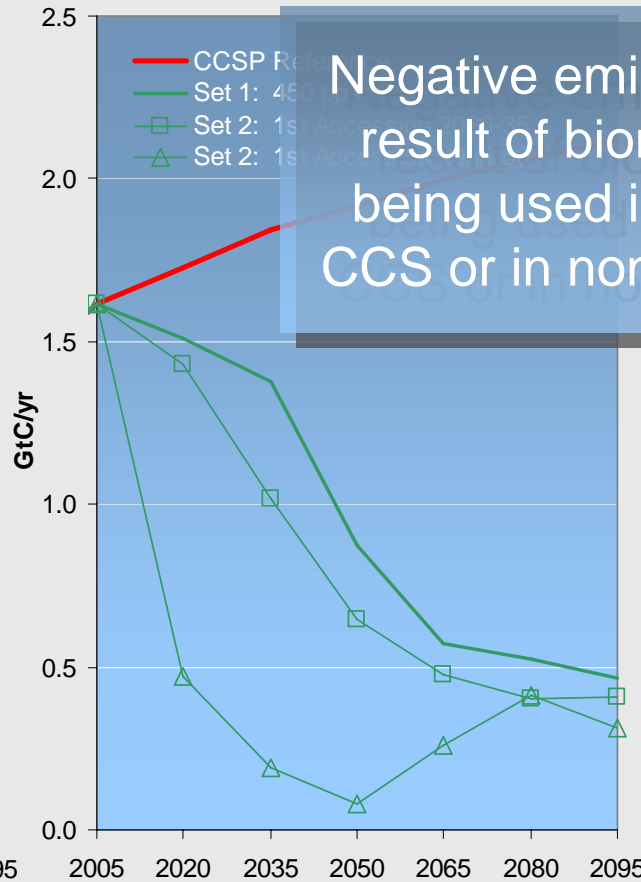
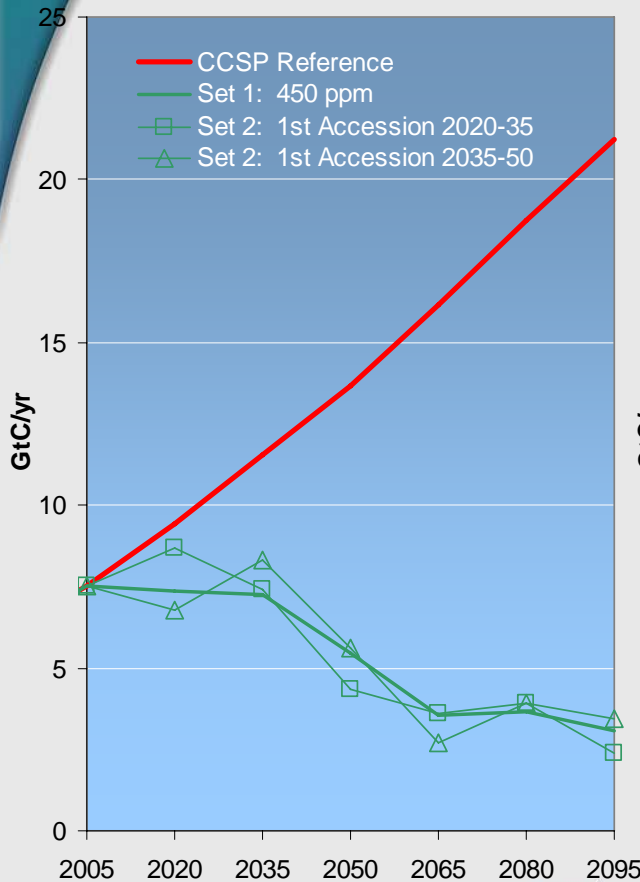


Scenario Set 2, 450 ppm Fossil & Industrial CO₂ Emissions

Global

USA

India

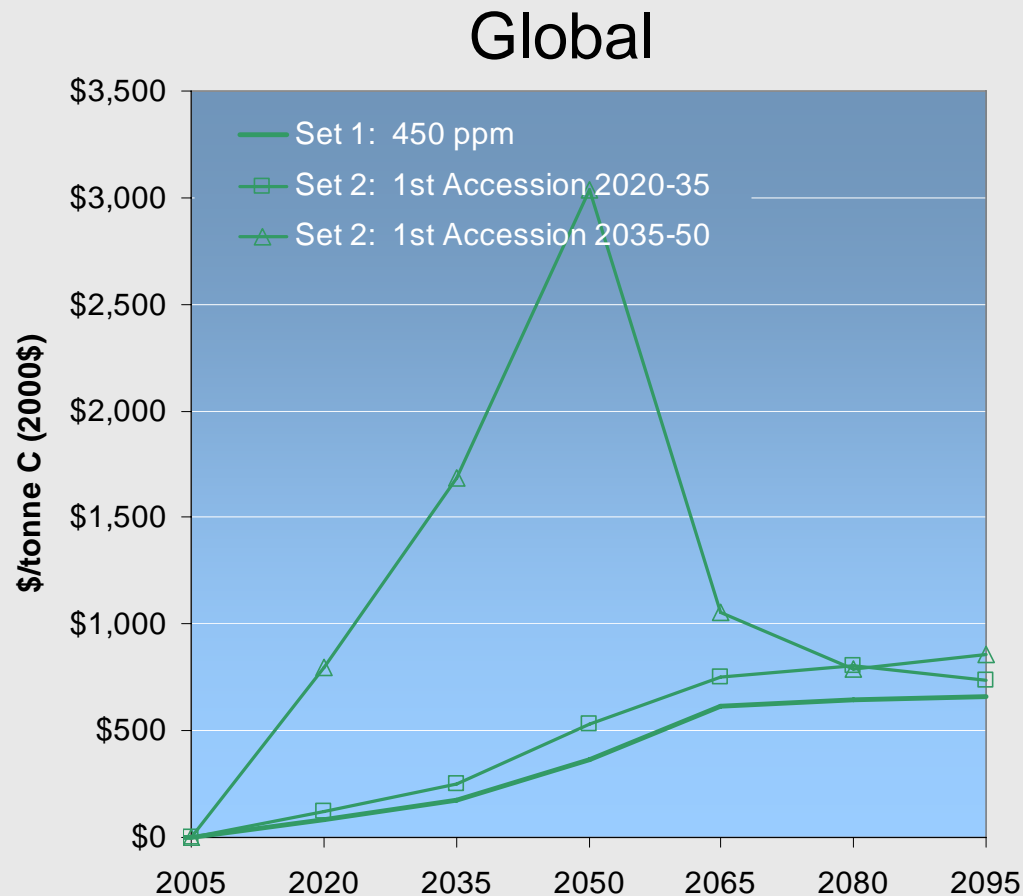


Negative emissions are the result of biomass energy being used indirectly with CCS or in non-energy uses.



Carbon Prices in the Annex 1 and Non-Annex 1

- ▶ Graduated accession or differentiated regimes means different prices in different regions.
 - What does this imply for technology choice?
- ▶ Annex 1 faces carbon prices of over \$1000/tonne C with no abatement in non-Annex 1 countries.





Stabilization Set 3 Graduated Accession + Differentiated Prices

Stabilization Scenario Set 3 Graduated Accession + Differentiated Prices

- ▶ Stabilize CO₂ concentrations
 - 450 ppm, 550 ppm, 650 ppm.
 - Sectoral carbon prices—All EQUAL.
 - Regional carbon prices—each region separate.
 - Time path of carbon prices
 - Annex 1 follows Peck-Wan-Hotelling.
 - Other regions carbon price proportional to relative per capita income.
 - Staggered accession based on per capita income.
 - Alternative accession cases—first group enters: 2020, 2035, 2050.

Difference
with Set 2

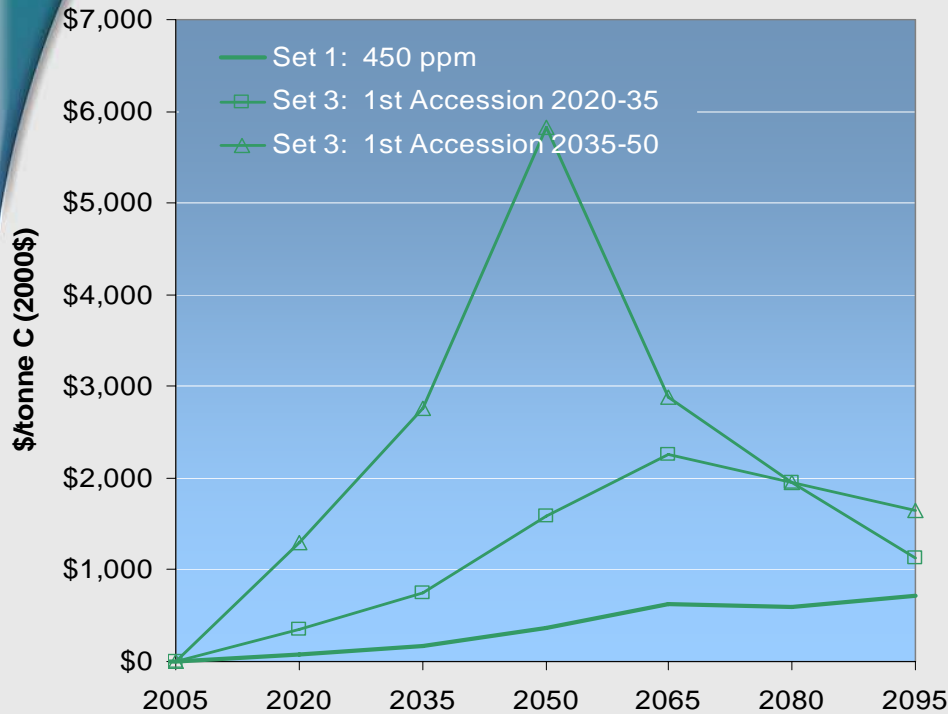


Scenario Set 3, 450 ppm

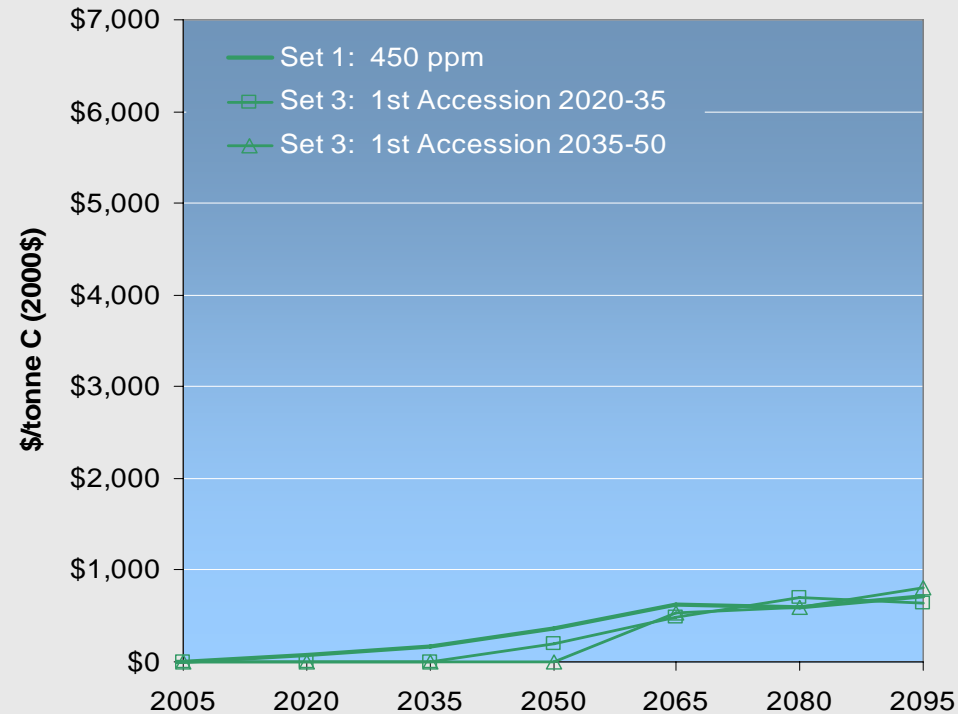
Highly differentiated pricing between Annex I and non-Annex I

Scenario Set 3, 450 ppm Carbon Prices by Region

USA



India

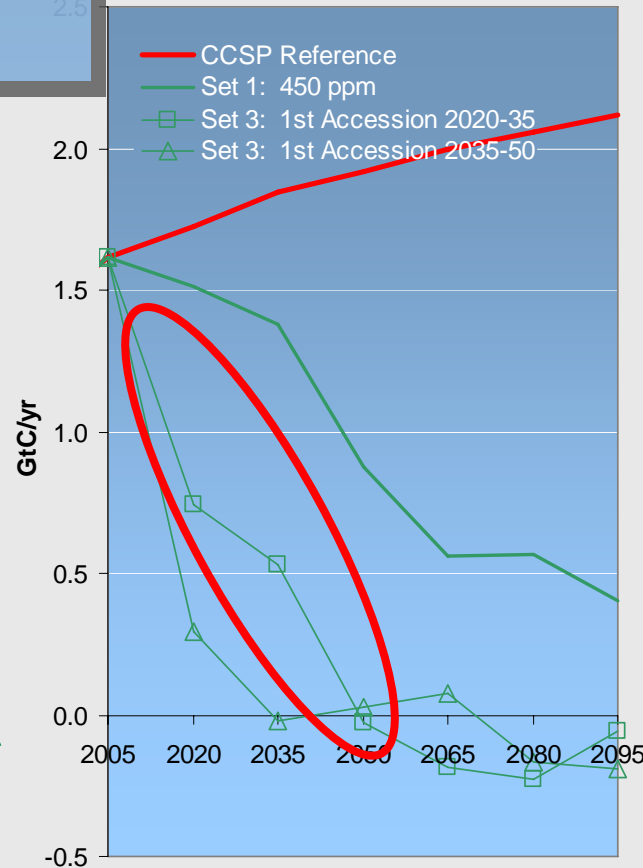


Set 3 1st Accession 2050-65 is infeasible!

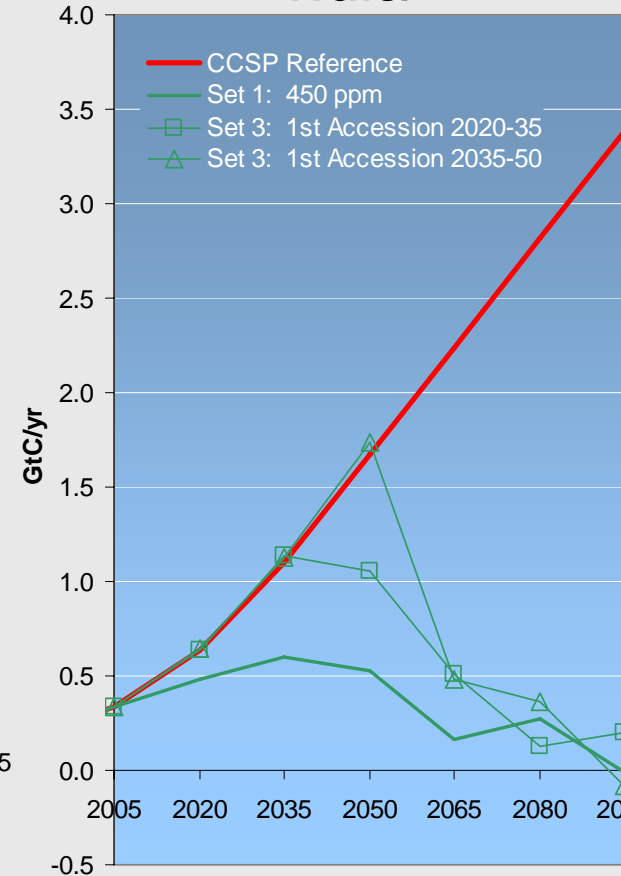
There is little difference in the Set 3 global emissions path from Set 1, however USA emissions must be much lower with ANY delay in non-Annex 1 accession.

Scenario Set 3, 450 ppm Industrial CO₂ Emissions

USA



India



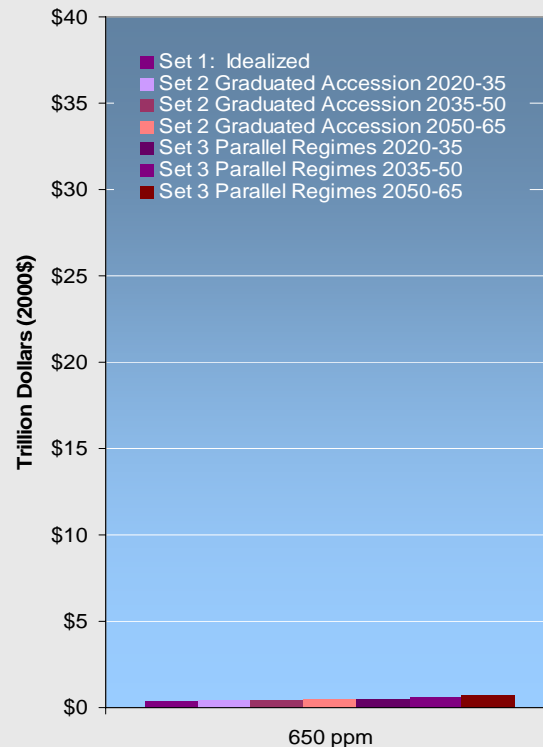
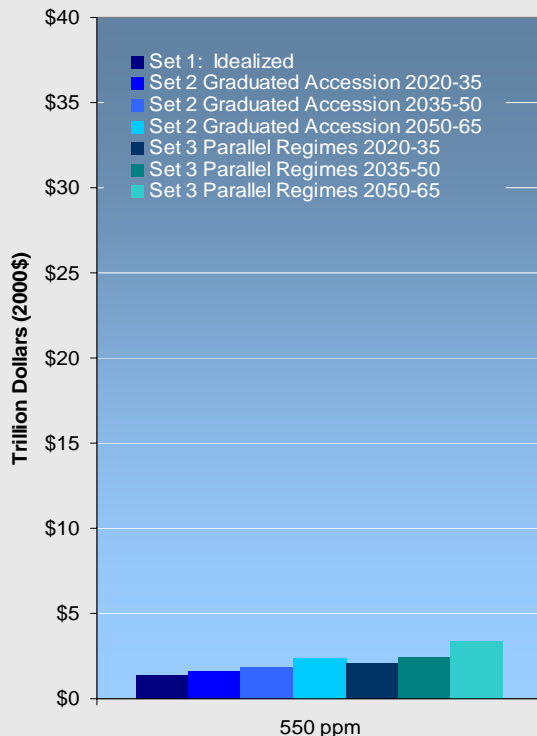
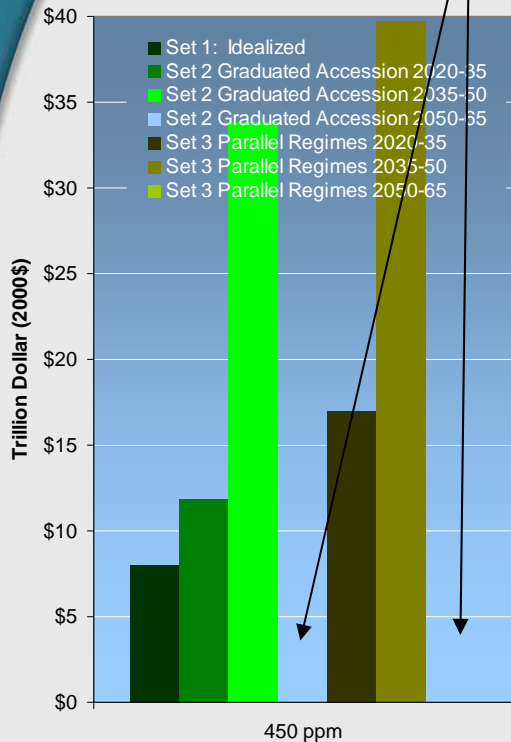


The Costs of Stabilization



Inefficient Participation and the Total Costs of Stabilization

Post 2050 non-Annex 1 accession not possible under the reference assumptions

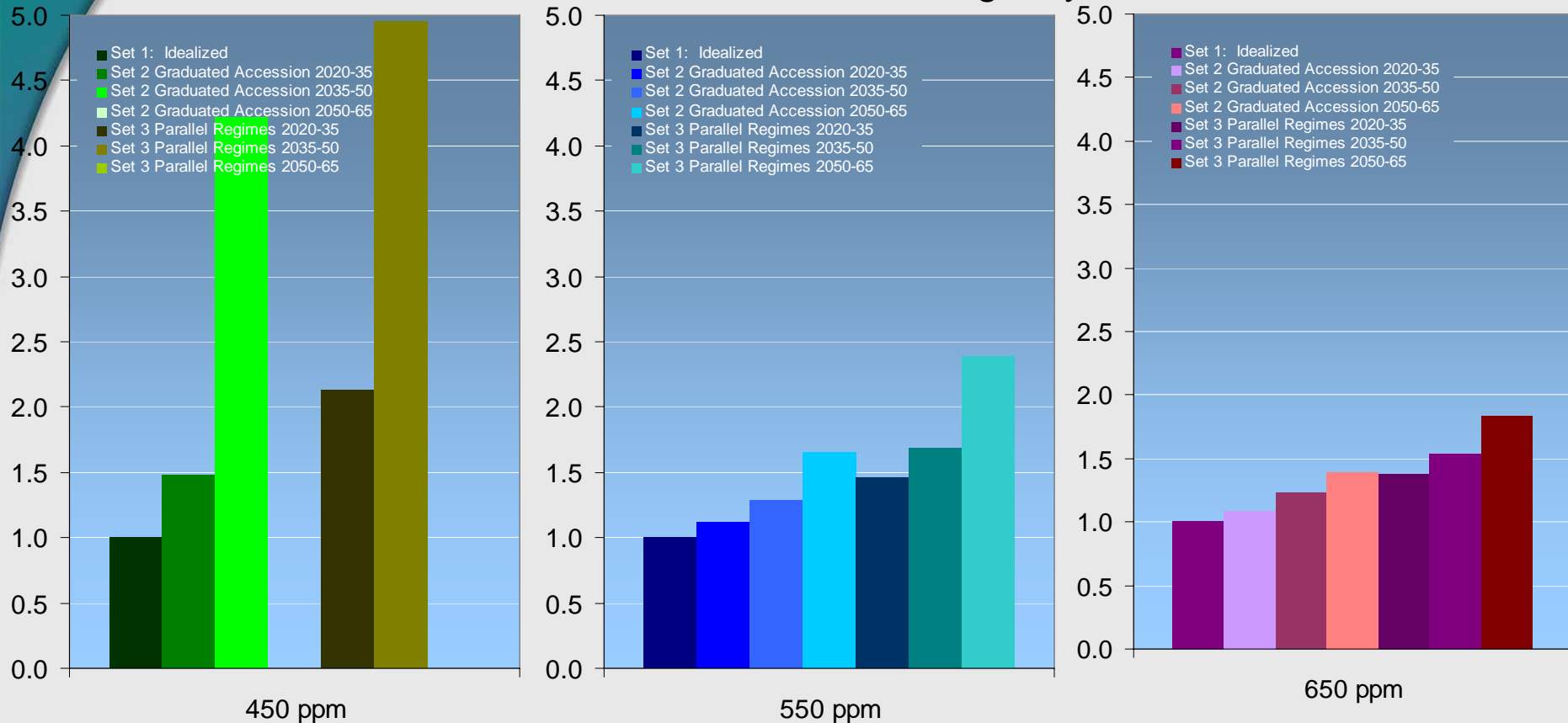


The dominant determinant of cost is the stabilization level.



Inefficient Participation and the Total Costs of Stabilization

The relative effect on cost increases as the stringency of the limitation rises.



All costs normalized to the idealized cost at the concentration.



Final Observations

- ▶ “Second best” is just that, second best.
- ▶ Near-term prices of carbon depend on expectations about the future—among other things—the international emissions mitigation architecture and long-term stabilization goal.
 - Inefficiencies matter more for 450 ppm stabilization.
- ▶ Prices could vary regionally.



END