Modeling Post-2012 Climate Policy Scenarios

Interim Results

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SB 28 Side Event
Bonn, Germany
June 10, 2008

Objectives

- To visualize alternative forms of a "multi-track" climate framework integrating different types of mitigation commitments
- To assess their:
  - Environmental effectiveness: Produce near/medium-term effort consistent with 450-600 ppmv CO_2?
  - Economic efficiency: Relative to a idealized case of full global cap+trade
  - Fairness: Achieve a reasonable distribution of costs?
- Scenarios are illustrative – not "proposals"
  - Real value is in insights, not numbers

The Model

- ObjECTS-MiniCAM Model developed and run by Joint Global Change Research Institute, Battelle/UMD
- Partial equilibrium; Energy-Agriculture-Economy
  - Explicit energy technologies, regional specifications
    - End-use sectors: buildings, industry, transportation
    - Supply sectors: fossil-fuels, biomass (traditional and modern), electricity, hydrogen, synthetic fuels
  - Integrated agriculture and land use model
    - Will be incorporated for Phase II
  - CO_2 only
  - 13 Regions
  - Runs from 1990 to 2095 in 15-year time steps

Regions in the Model

- The regions:
  - Australia/New Zealand
  - Canada
  - Europe
  - Former Soviet Union
  - Japan
  - United States
  - Africa
  - China
  - India
  - Latin America
  - Middle East
  - South Korea
  - (Rest of) South & East Asia

Developing the Scenarios

- Policies in scenarios reflect:
  - What countries already doing (or discussing)
    - Specific domestic policies, specific sectors targeted
  - The world of commitment types
    - Being discussed in the UNFCCC and beyond
- Action/Commitment Types:
  - Targets
    - Economy wide targets (absolute, intensity, no-lose)
  - Policy-based commitments
    - National-level sectoral targets, efficiency standards
  - International sectoral agreements
    - Sector-specific targets or standards applied across regions
  - Funds for adaptation and technology

Differentiation within Scenarios

- Regional differentiation taking into account:
  - Regional emissions contexts
    - Fuel mix
    - Energy and GHG intensity and efficiency
  - Economic indicators
    - GDP, GDP/capita
    - Mitigation costs, cost as share of GDP
  - Emissions projections
    - Reference case
    - "Efficient" 450, 550, 650 ppmv stabilization scenarios
- Differentiation is illustrative, not formulaic

Graduation

- Graduation criteria are employed to illustrate the potential evolution of the framework over time
  - In most scenarios, developing regions graduate to absolute caps
- Criteria vary among scenarios:
  - All graduate in 2050
  - Graduate when per capita GDP reaches $5000/year but no later than 2050
  - Beginning in 2035, graduate when per capita GDP reaches $5000/year
  - No graduation (sectoral agreements)

Emissions Trading

- Mix of approaches:
  - Full trading (initially or over time)
  - No-lose crediting
  - Policy crediting
  - Intra-sectoral trading
  - Different combinations of the above

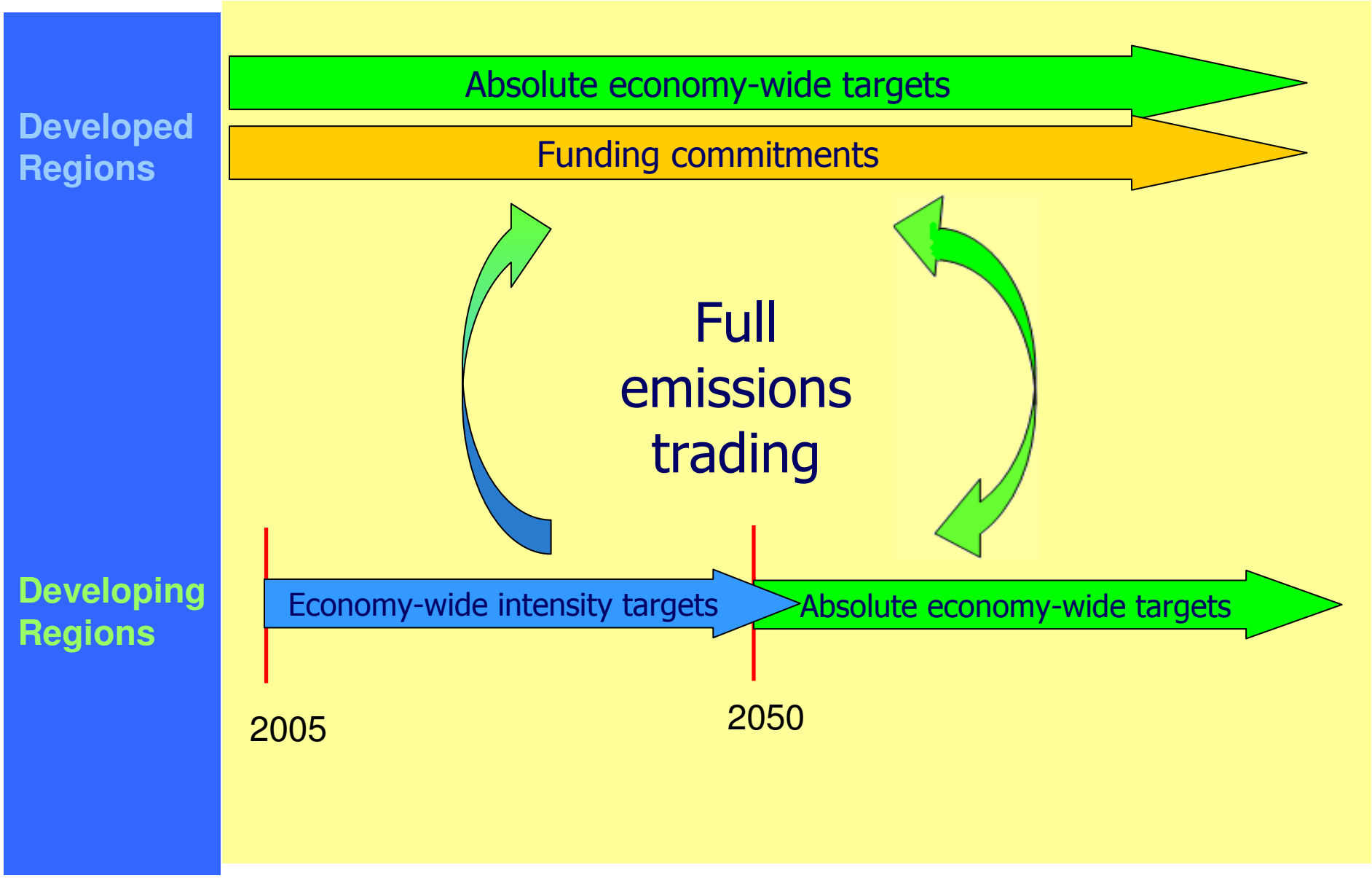
Land Use, Ag and Forestry

- Placeholders in scenarios for forestry policies
  - Battelle working to integrate land use component with energy model
  - Examining relationship between biofuels, food production, and land use emissions
- In this phase, land use emissions are represented in final concentrations only
  - Model impact on land use emissions, but have not yet included specific policies addressing land use emissions

Overview of Scenarios

- Baseline scenarios
  - Reference case: "business as usual" pathway
    - Based on CCSP MiniCAM Scenario (updated for 2008)
  - "Efficient" stabilization pathways to 450, 550, & 650 ppmv CO_2
- Six policy scenarios
  1. Mixed targets 1 (absolute and intensity)
  2. Mixed targets 2 (absolute and no-lose)
  3. Targets + policy-based commitments
  4. Parallel sectoral agreements
  5. Targets + sectoral agreements
  6. Targets + policy-based commitments + sectoral agreements

Scenario 1: Mixed Targets I



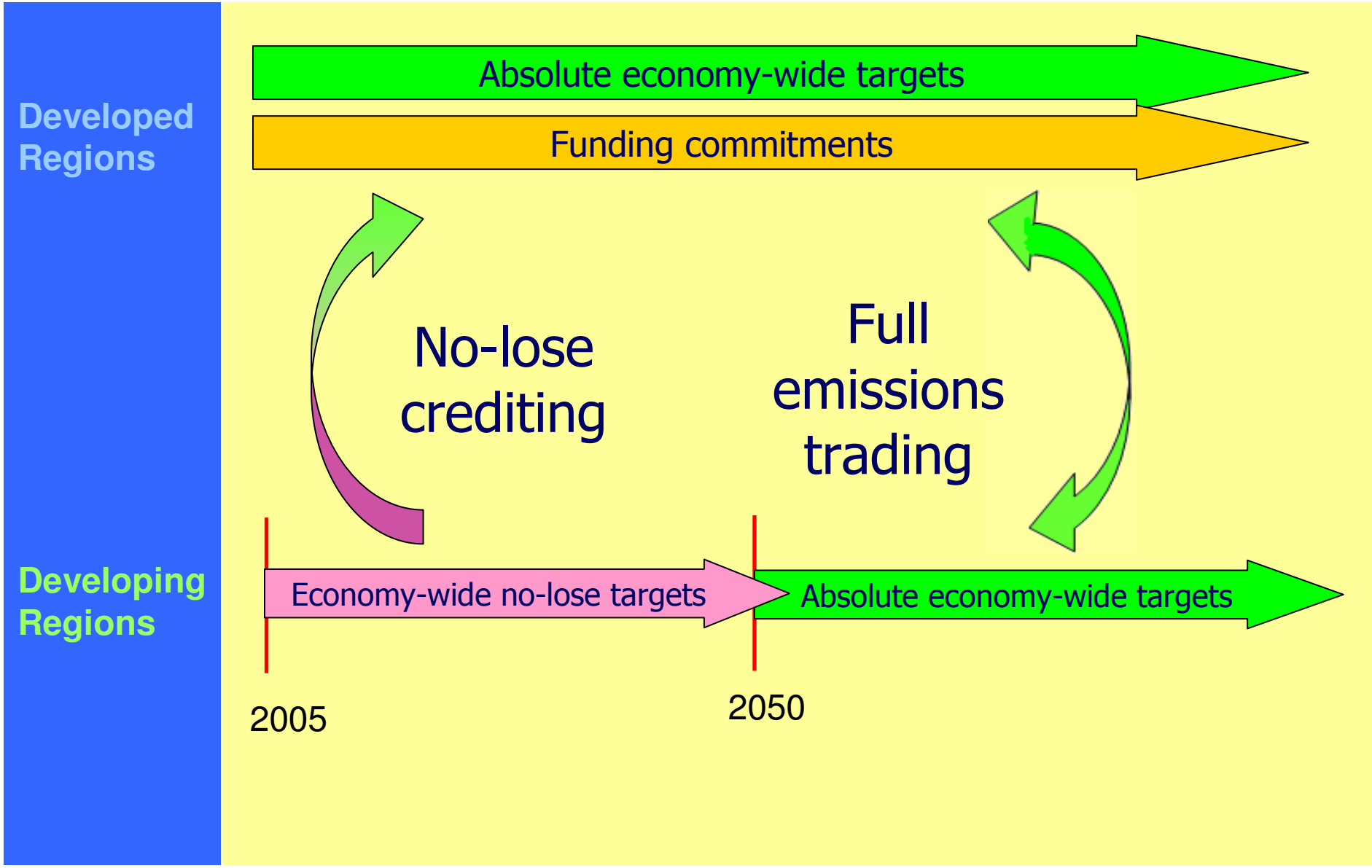
Scenario 1: Mixed Targets I

REGION	POLICIES	ALL PERIODS (2005 – 2095)
UNITED STATES, CANADA, EUROPE JAPANAUSTRALIA / NEW ZEALAND FORMER SOVIET UNION	Absolute target	For all periods: 15% reduction from previous period*
CHINA	Intensity target to 2050, then absolute target	50% reduction in GHG intensity from previous period from 2005-2020; 40% reduction in GHG intensity from previous period from 2020-2050 Beginning in 2050 → reduce absolute economy-wide emissions to 2050 levels, then 15% reduction in each subsequent period
LATIN AMERICA SOUTH/EAST ASIA		Period 1: 15% reduction in GHG intensity Periods 2 and 3: 20% reduction in GHG intensity Beginning in 2050 → reduce absolute economy-wide emissions to 2050 levels, then 7.5% reduction in each subsequent period
SOUTH KOREA MIDDLE EAST		30% reduction in GHG intensity from previous period, 2005-2050 Beginning in 2050 → reduce absolute economy-wide emissions to 2050 levels, then 15% reduction in each subsequent period
INDIA		Period 1: 20% reduction in GHG intensity Periods 2 and 3: 30% reduction in GHG intensity Beginning in 2050 → reduce absolute economy-wide emissions to 2050 levels, then 7.5% reduction in each subsequent period
AFRICA		Period 1: Maintain GHG intensity Periods 2 and 3: 10% reduction in GHG intensity Beginning in 2050 → reduce absolute economy-wide emissions to 2050 levels, then 7.5% reduction in each subsequent period
DEVELOPED COUNTRY REGIONS	Fund to support adaptation and technology deployment in developing regions	Developed regions contribute annually 0.5% of value of emission allowances

GRADUATION for developing regions: in 2050

*Former Soviet Union: In scenarios 1 and 2, reduce to 2005 level in period 1, then 15% reduction in subsequent periods; in scenarios 3, 4 and 6, 15% reduction in each period

Scenario 2: Mixed Targets II



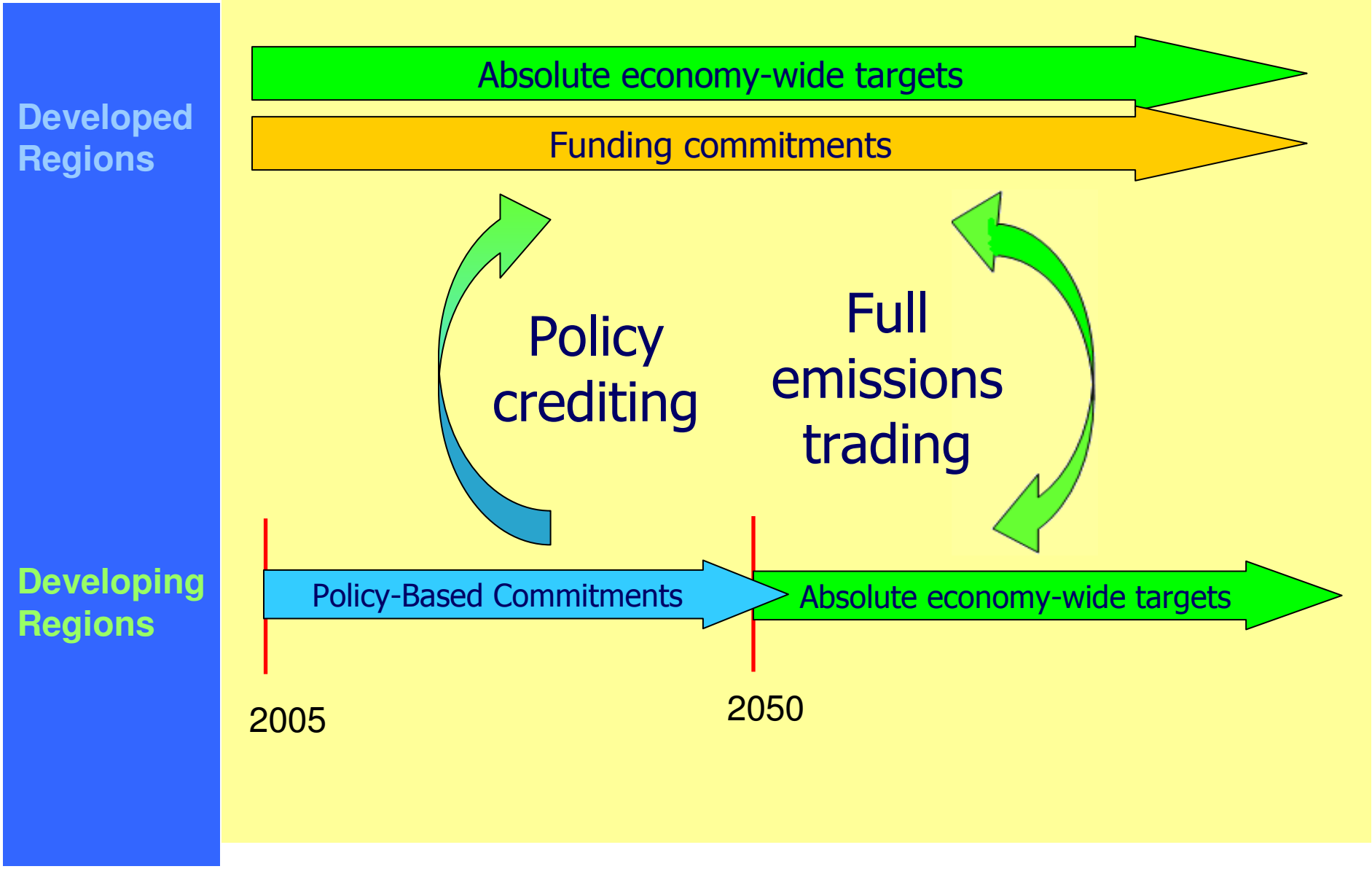
Scenario 2: Mixed Targets II

REGION	POLICIES	ALL PERIODS (2005-2095)
UNITED STATES CANADA EUROPE JAPAN AUSTRALIA/NEW ZEALAND FORMER SOVIET UNION	Absolute targets	Same as Scenario 1
CHINA SOUTH KOREA LATIN AMERICA AFRICA INDIA MIDDLE EAST SOUTH/EAST ASIA	No-lose targets*, graduating to absolute targets	Initially, no-lose targets set at 5% below BAU. Upon graduation → maintain absolute economy-wide emissions at level at which graduation occurs for that period, then 10% reduction in each subsequent period
DEVELOPED COUNTRY REGIONS	Fund to support adaptation and technology deployment in developing regions	Developed regions contribute annually 0.5% of value of emission allowances

GRADUATION for developing regions: When per capita GDP reaches $5000/year but no later than 2050

*No-lose target: A region receives tradable GHG credits for emission reductions that are greater than 5% percent below projected business-as-usual (BAU); growth above BAU is not restricted.

Scenario 3: Targets + Policies



Scenario 3: Targets + Policies

Developed Regions

Regions	Absolute targets	Adaptation/Technology Fund
United States, Canada, Europe, Japan, Australia/New Zealand, Former Soviet Union	Same as scenario 1	Contribute annually 0.5% value of emission allowances

Scenario 3: Targets + Policies

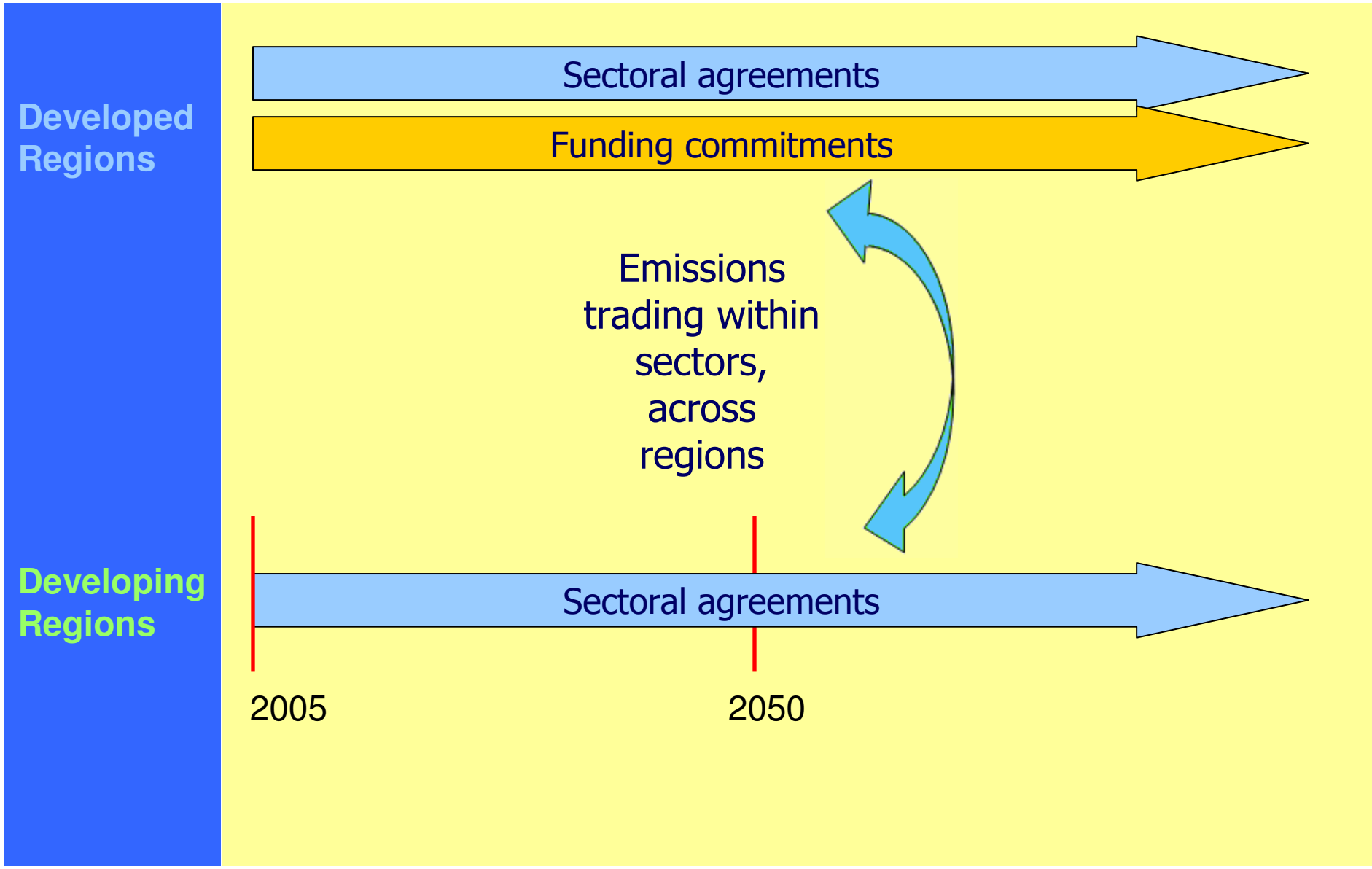
Developing Regions

Policies:	Fuel economy standard	Power sector CO2 intensity target	Biofuels target on liquid fuels	No-lose forestry target*	Policy-based crediting	ON GRADUATION: Absolute target
China	40 mpg in period 1, then 10% improvement in each period	30% reduction from previous period	5% in period 1, increasing by 2.5% per period	None	Developing regions received tradable GHG credits for reductions below BAU (for 50% of reductions in period 1; 40% in period 2; 30% on period 3; and 20% in subsequent periods)	Stabilize at level at which graduation occurs, then 15% reduction in subsequent periods
Korea				None		
Latin America		None		For each period: 15% reduction in forestry emissions from BAU		Stabilize at level at which graduation occurs, then 7.5% reduction in subsequent periods
Middle East	None	30% reduction from previous period	None	None		Stabilize at level at which graduation occurs, then 15% reduction in subsequent periods
India	40 mpg in period 1, then 10% improvement in each period		5% in period 1, increasing by 2.5% per period	None		Stabilize at level at which graduation occurs, then 7.5% reduction in subsequent periods
S/E Asia	None	None	None	For each period: 15% reduction in forestry emissions below BAU		
Africa	None	30% reduction from previous period	None	None		

GRADUATION for developing regions: Starting in 2035, when per capita GDP reaches $5000/year

*Will be modeled in Phase II

Scenario 4: Parallel Sectoral Agreements



Scenario 4: Parallel Sectoral Agreements

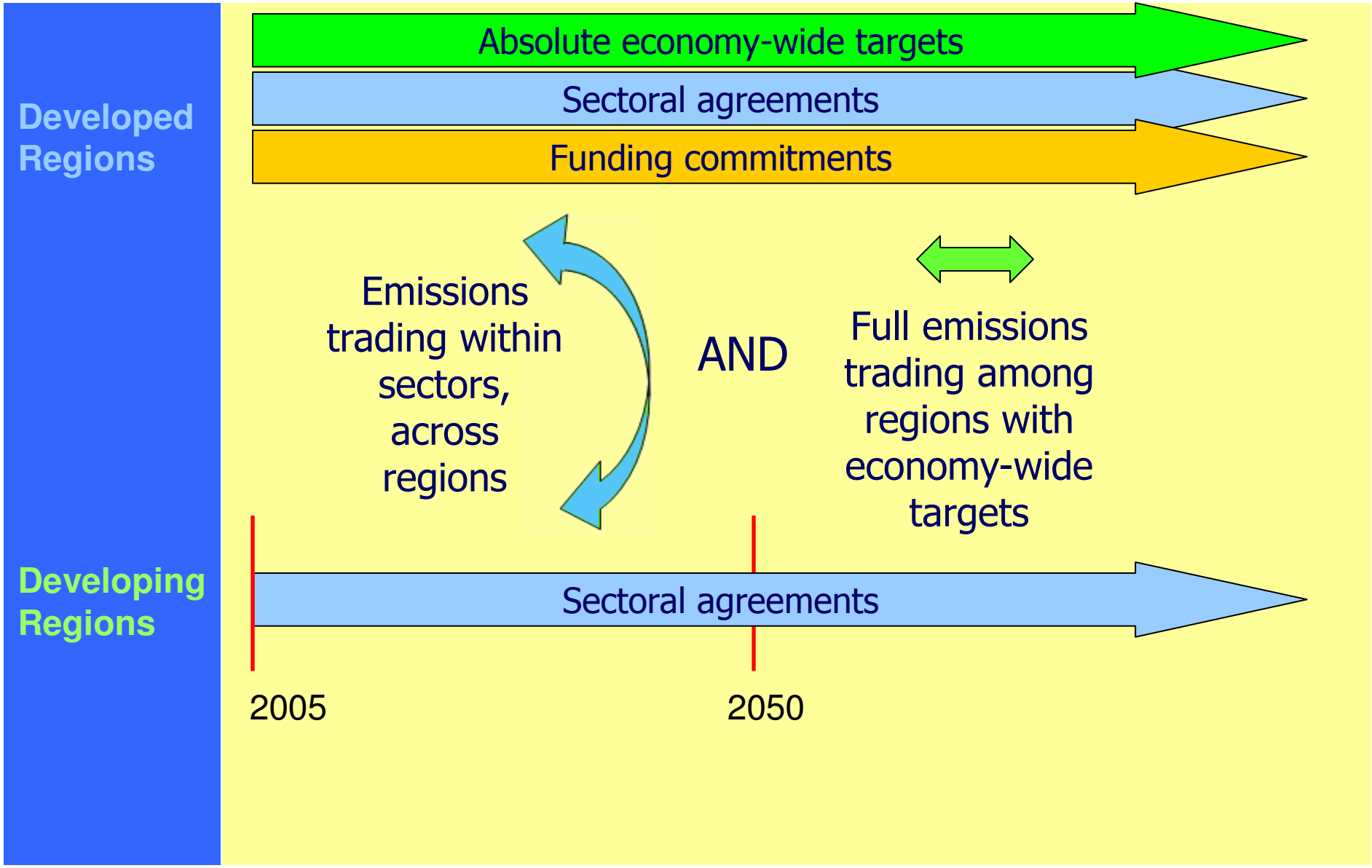
ELECTRICITY SECTOR		
POLICIES	**REGIONS**	**ALL PERIODS (2005-2095)**
CO_2 intensity targets (CO_2 per KWh)	CANADA EUROPE	In each period, 10% intensity reduction from previous period
	JAPAN LATIN AMERICA	In each period, 15% intensity reduction from previous period
	MIDDLE EAST	In each period, 20% intensity reduction from previous period
	UNITED STATES SOUTH KOREA FORMER SOVIET UNION	In each period, 25% intensity reduction from previous period
	CHINA INDIA AFRICA AUSTRALIA/NEW ZEALAND SOUTH/EAST ASIA	In each period, 30% intensity reduction from previous period
End-use efficiency standards on buildings	ALL REGIONS	Building end-use efficiency improvement of 5% per period
Fund to help deploy CCS in developing regions	UNITED STATES CANADA EUROPE JAPAN AUSTRALIA/NEW ZEALAND FORMER SOVIET UNION	Developed regions contribute $0.0006 per KWh of electricity generated annually. Fund covers the incremental cost of CCS in developing regions (makes new CCS cost the same as new conventional). 100% of incremental cost covered in 2020, 75% in 2035, 50% in 2050.

Scenario 4: Parallel Sectoral Agreements

TRANSPORT SECTOR		
POLICIES	**REGIONS**	**ALL PERIODS (2005-2095)**
Fuel economy standard for passenger cars and trucks	ALL	For each period: 20% increase in average fuel economy
Biofuels target for liquid fuels	ALL	5% of liquid fuels must be biofuels in period 1; 10% in period 2; 15% in period 3; 25% in period 4; 40% in period 5; 50% in period 6
INDUSTRY SECTOR		
POLICIES	**REGIONS**	**ALL PERIODS (2005-2095)**
Absolute target	ALL	No constraint for period 1; stabilize at 2020 levels in period 2; decrease 10% per period in subsequent periods
FORESTRY SECTOR*		
POLICIES	**REGIONS**	**ALL PERIODS (2005-2095)**
No-lose target	Latin America, S/E Asia	For each period: 15% reduction in forestry emissions below BAU

*Will be modeled in Phase II

Scenario 5: Targets and Sectoral Agreements

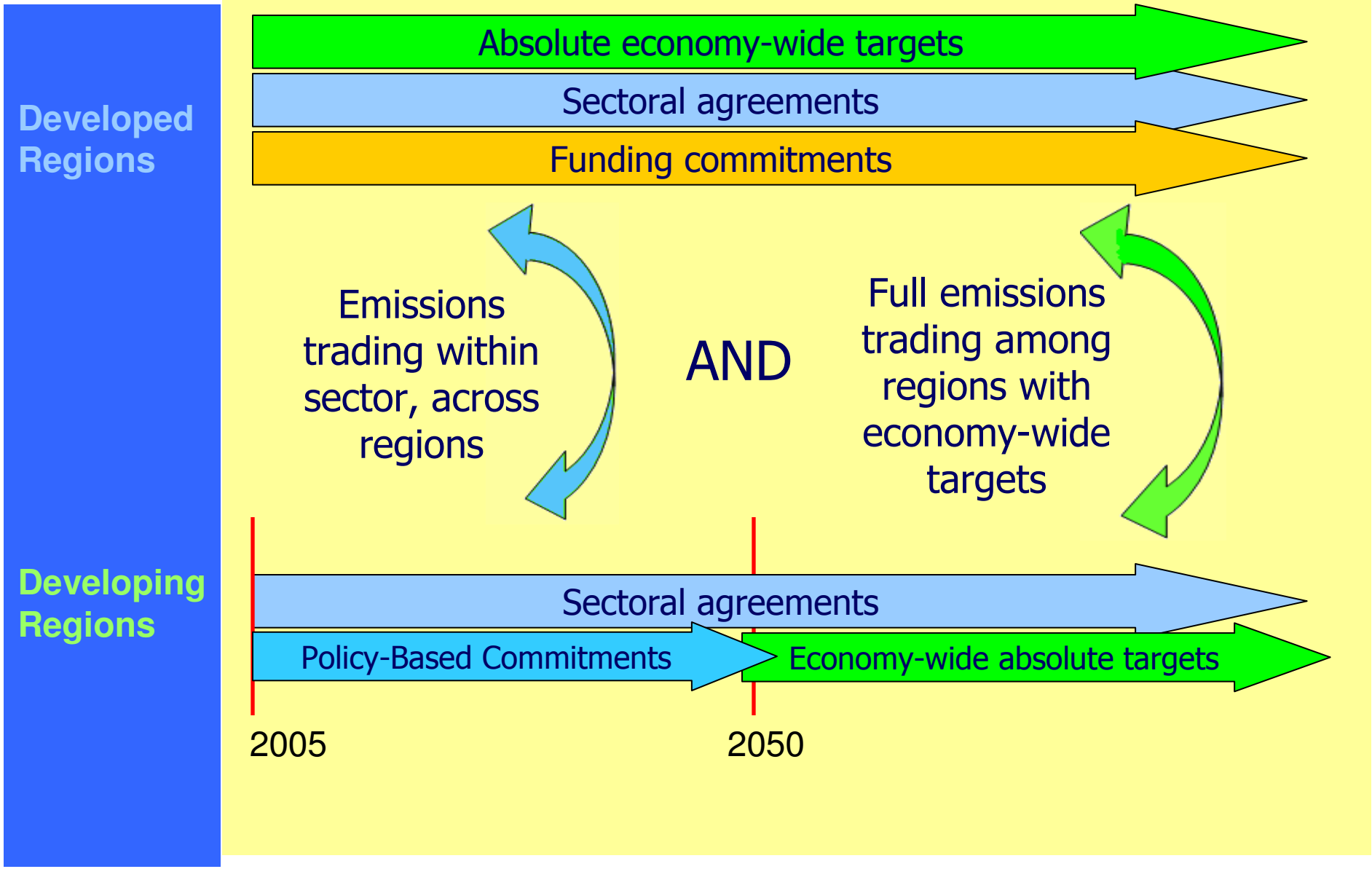


Scenario 5: Targets and Sectoral Agreements

REGIONS	POLICIES	ALL PERIODS (2005-2095)
UNITED STATES, CANADA, EUROPE, JAPAN, AUSTRALIA/NEW ZEALAND, FORMER SOVIET UNION	Absolute targets	Same as Scenario 1
ALL REGIONS	ELECTRICITY: •Low-carbon portfolio standard •CCS assistance	•30% of electricity generation from renewables, nuclear, and fossils with CCS in period 1; increasing 10% each period to 80% in period 6 •CCS fund same as scenario 4
ALL REGIONS	TRANSPORT: •Fuel economy standard •Biofuels target for liquid fuels	Same as Scenario 4
ALL REGIONS	INDUSTRY: •Absolute targets	Same as scenario 4
LATIN AMERICA; SOUTH/EAST ASIA	FORESTRY:* •No-lose targets	Same as scenario 4
DEVELOPED COUNTRY REGIONS	Fund to support adaptation in developing regions	Developed regions contribute annually 0.25% of value of emission allowances

*Will be modeled in Phase II

Scenario 6: Targets + Policies + Sectoral



Scenario 6: Targets + Policies + Sectoral

ALL REGIONS

Sectoral Agreement in Transport	
All regions	Fuel economy standard and biofuels target (same as scenario 4)

DEVELOPED REGIONS

Regions	Absolute targets	Fund
United States, Canada, Europe, Japan, Australia/New Zealand, Former Soviet Union	Same as scenario 1	Contribute annually 0.5% value of emission allowances

Scenario 6: Targets + Policies + Sectoral

DEVELOPING REGIONS

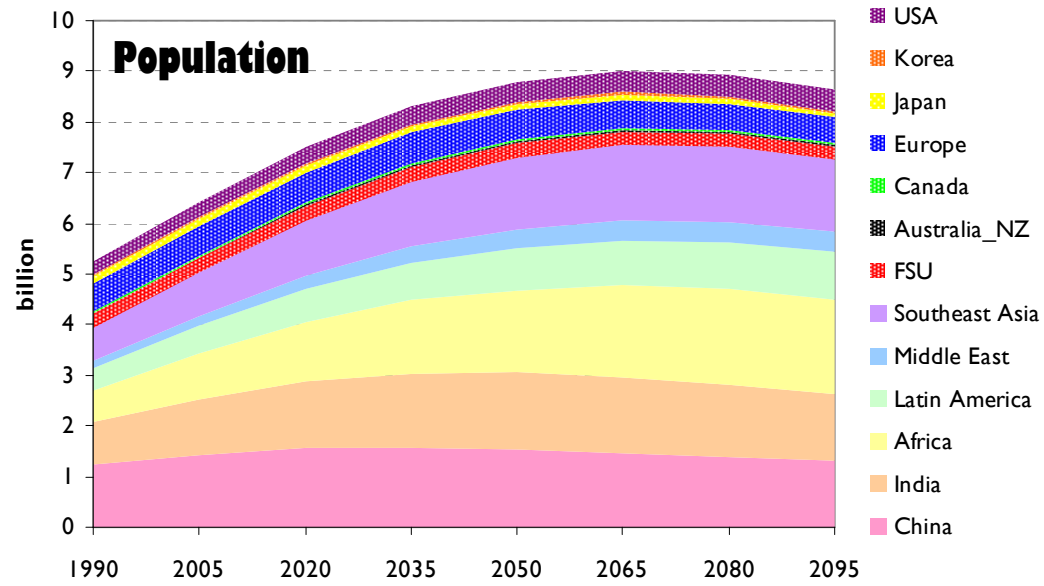
	Power sector CO2 intensity target	No-lose forestry target*	ON GRADUATION: Absolute target
China	30% reduction from previous period	None	Stabilize at level at which graduation occurs, then 15% reduction in subsequent periods
Korea		None	
Latin America	None	For each period: 15% reduction in forestry emissions from BAU	Stabilize at level at which graduation occurs, then 7.5% reduction in subsequent periods
Middle East	30% reduction from previous period	None	Stabilize at level at which graduation occurs, then 15% reduction in subsequent periods
India		None	Stabilize at level at which graduation occurs, then 7.5% reduction in subsequent periods
S/E Asia	None	For each period: 15% reduction in forestry emissions below BAU	
Africa	30% reduction in CO2 per KWh per period until graduation	None	

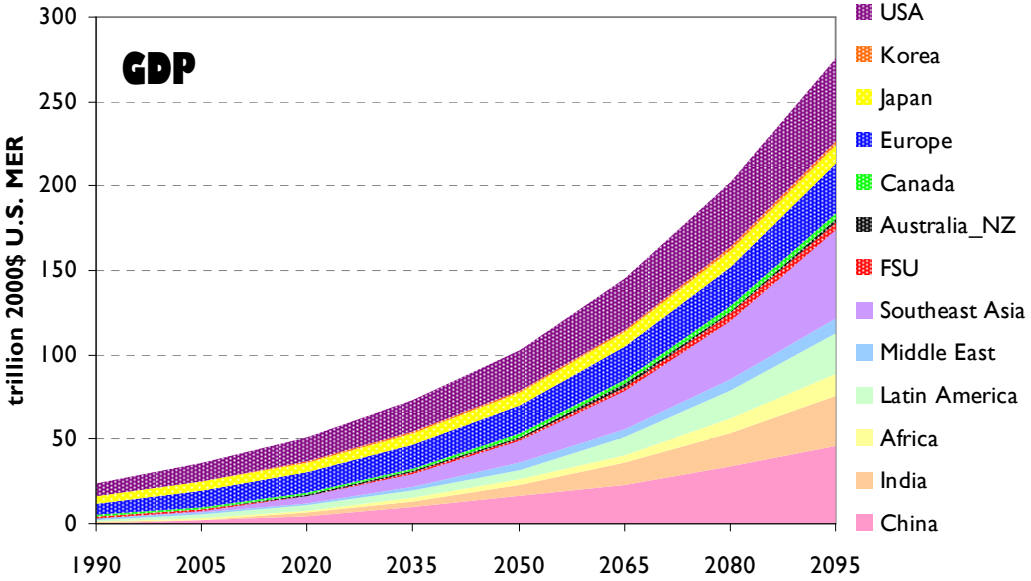
GRADUATION for developing regions: Same as Scenario 2 (when GDP per capita reaches $5000/year but no later than 2050)

*Will be modeled in Phase II.

Introduction to Modeling Results

The Reference Case: Growing Economies





The reference scenario envisions a growing global economy with an evolution in the distribution of economic activity.

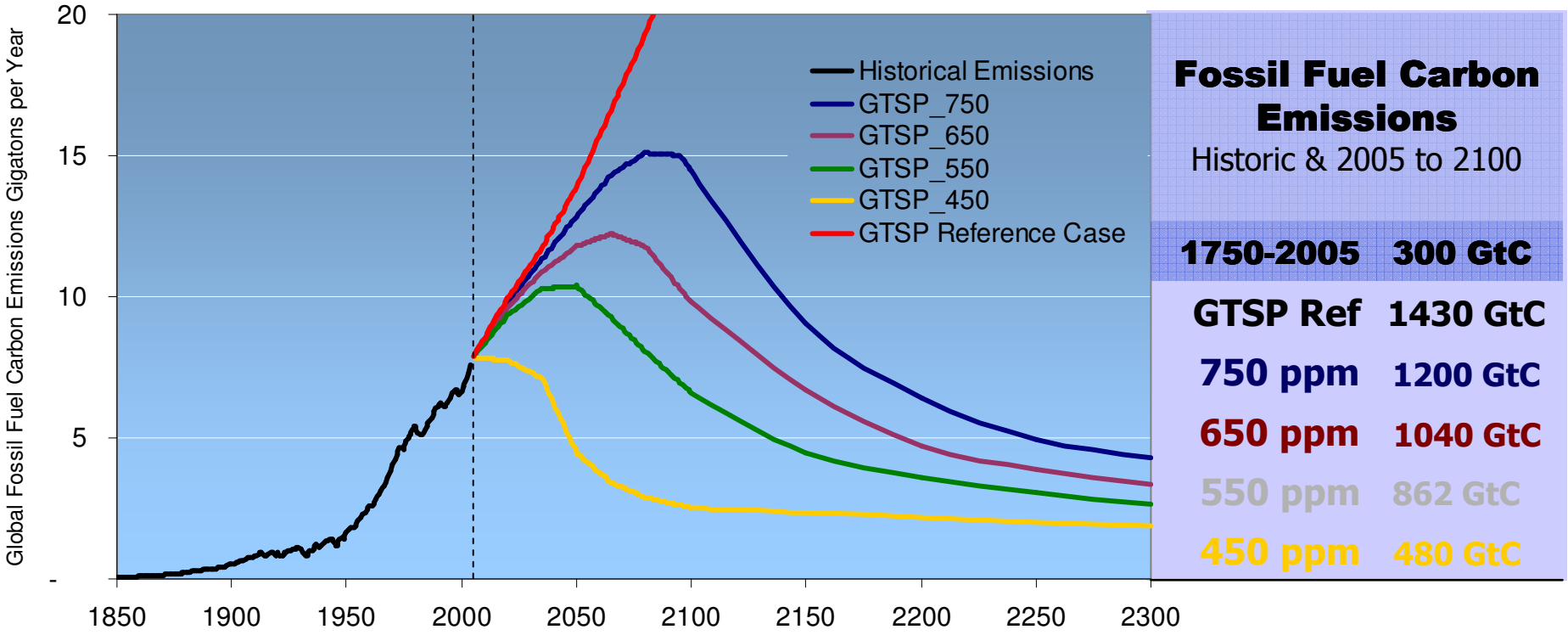
Overview of Technology Assumptions

- Abundant fossil resources
  - An eventual decline in conventional crude production accompanied by a gradual increase in production from unconventional sources
- Nuclear competitive with fossil electricity sources
- CCS available at reasonable cost with no limits on deployment in most regions
- Wind competitive in the near-term, solar later; limits on wind supply, and backup requirements for solar and wind on the grid
- Roughly 1% annual improvement in end use efficiency globally

Technology assumptions from: L. Clarke, J. Lurz, M. Wise, J. Edmonds, S. Kim, H. Pitcher, S. Smith, 2007. Model Documentation for the MiniCAM CCSP Stabilization Scenarios: CCSP Product 2.1a, Technical Report PNNL-16735, Pacific Northwest National Laboratory.

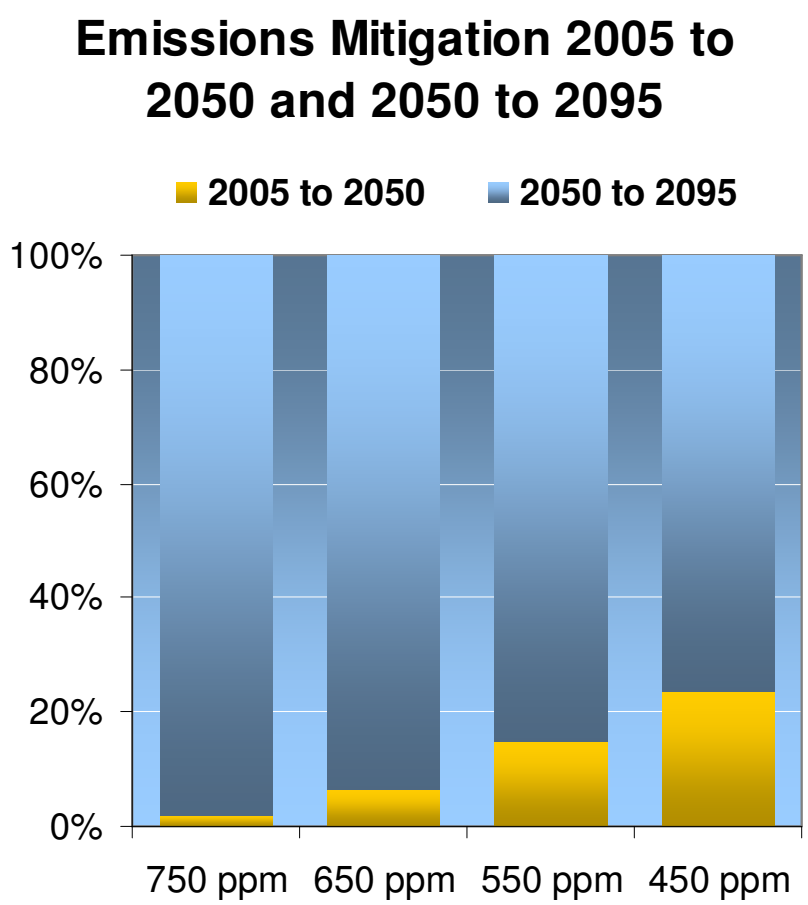
Available at http://www.globalchange.umd.edu/

Mitigation: A Long-Term Strategic Challenge



- Stabilizing CO_2 **concentrations** at any level means that **global** CO_2 emissions must peak and then decline forever.

Mitigation in 2005-2050 is Just the Start



- The bulk of emissions reductions will need to take place beyond 2050.
- The tighter the concentration, the greater emissions reductions in the near-term.
- Ultimately, achieving large-scale future reductions will require that all countries and sectors participate in mitigation.
- These scenarios explore differing policy architectures on a transition toward a comprehensive long-term policy regime.

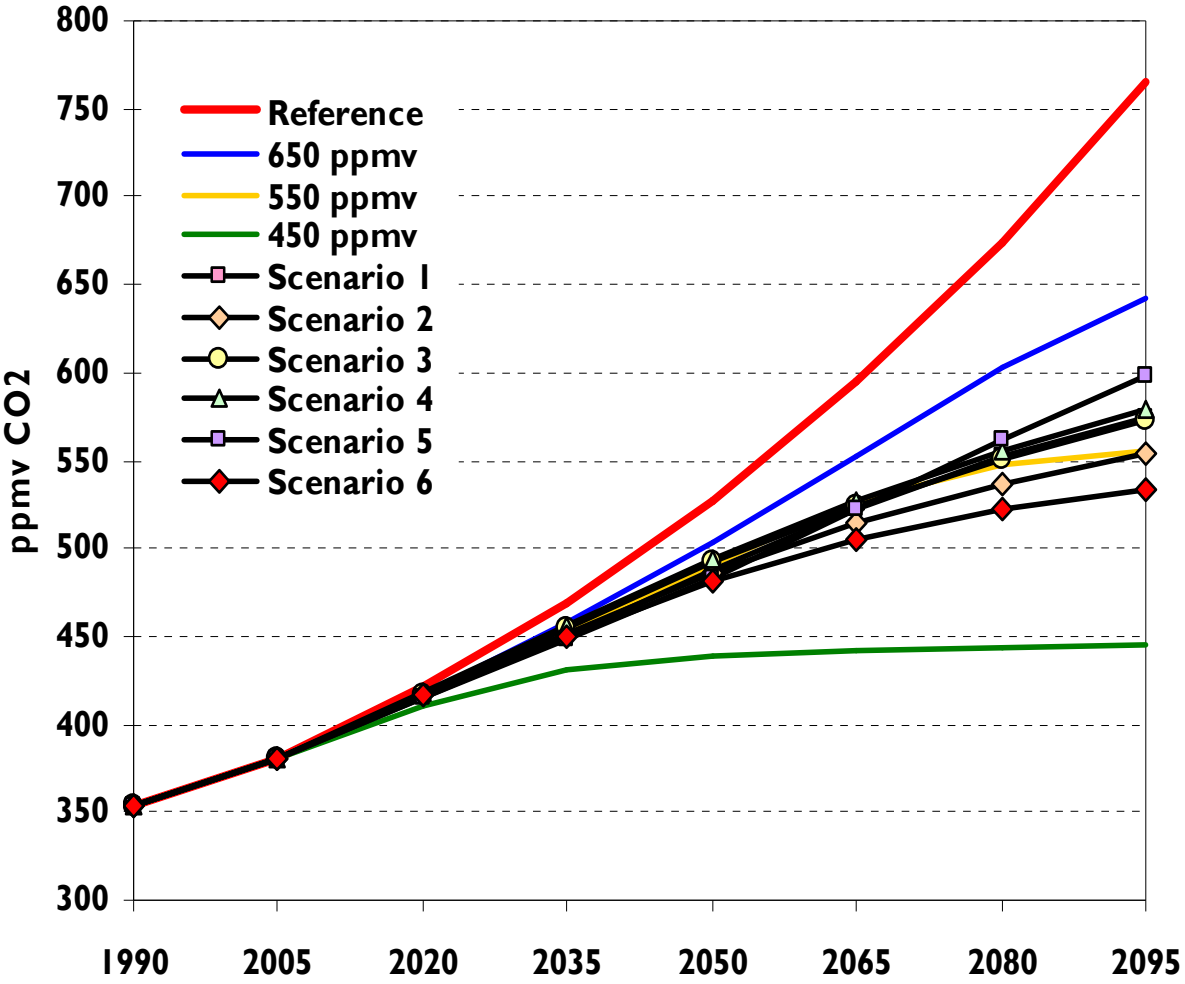
From Edmonds, J., Wise, M., Dooley, J., Kim, S., Smith, S., Runci, P., Clarke, L., Malone, E., and Stokes, G., 2007, *Global Energy Technology Strategy, Addressing Climate Change: Phase 2 Findings from an International Public-Private Sponsored Research Program*, Battelle Memorial Institute.

Overview of Results

To Keep in Mind in Interpreting the Results

- In each scenario, important to distinguish between broad *architecture* and *stringency* of assumed policies
  - Architecture: the mix of instruments (e.g., economy-wide caps)
  - Stringency: the numbers (e.g., the specific cap levels)
- *Equity* and *efficiency* (cost-effectiveness) interact but are not the same
  - It is feasible to have equitable distributions of costs that are not cost-effective and vice versa
- It is important to distinguish between costs with and without trading
- This analysis does not address the economic benefits of avoided climate impacts

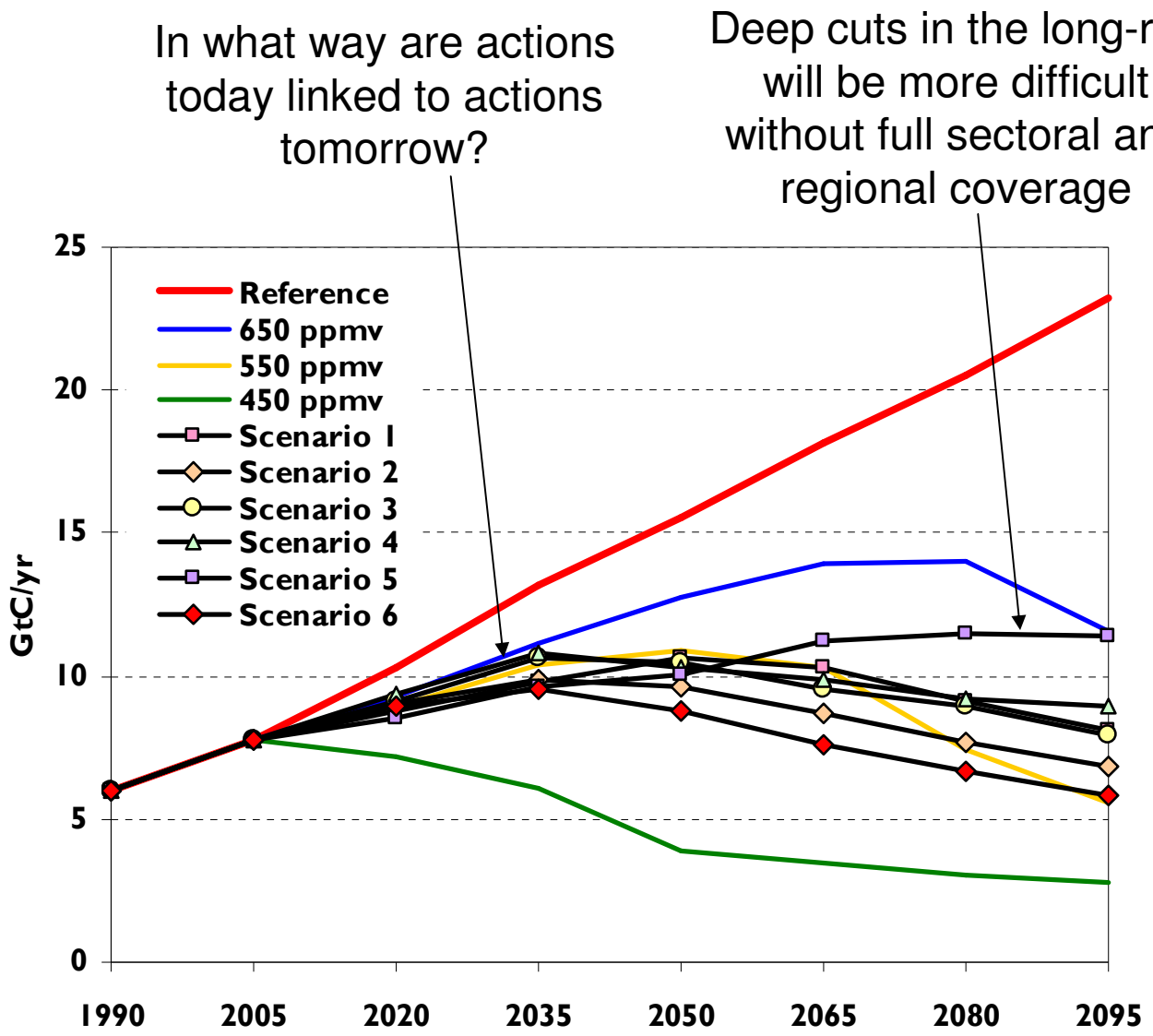
CO_2 Concentrations through 2095



The scenarios generally lead to concentrations in the range of 550 ppmv.

All architectures in this study could be used for deeper reductions and lower concentration levels than achieved here.

Annual CO_2 Emissions through 2095

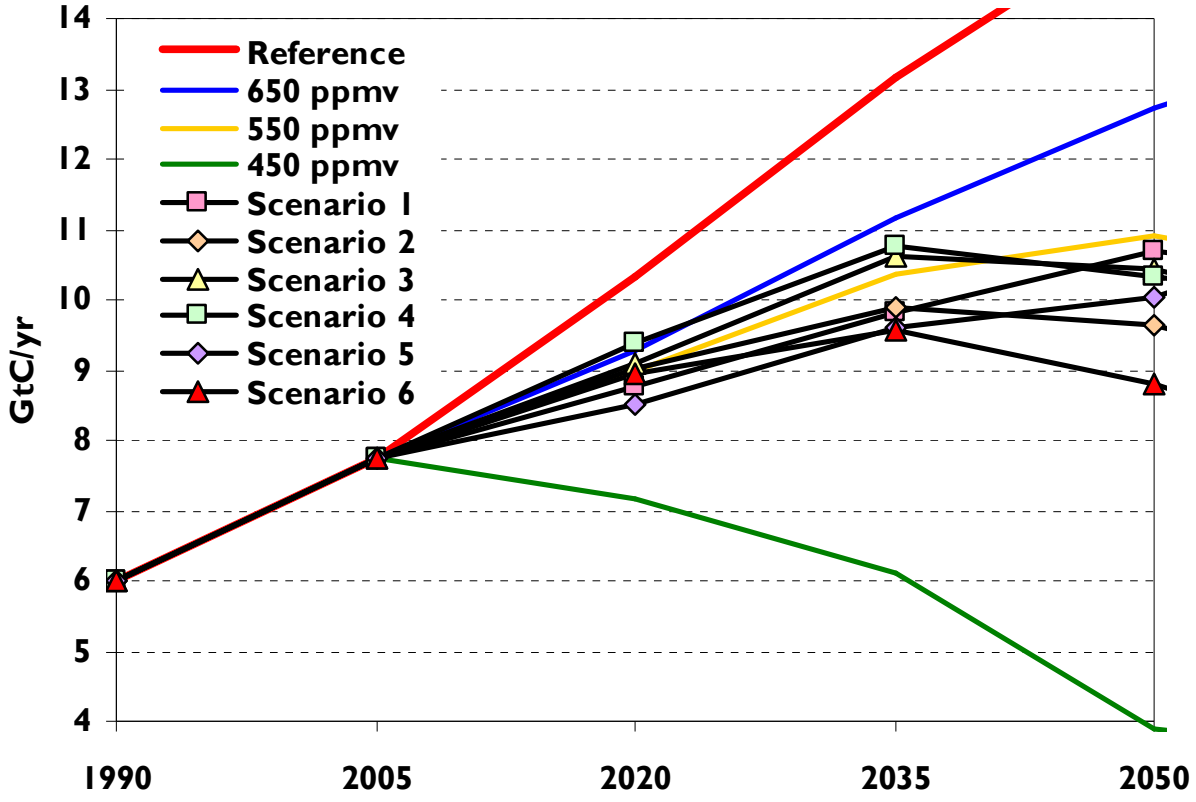


The scenarios differ in their near-term and long-term emissions pathways.

None of the near-term pathways precludes deeper cuts in the long-term.

What long-term momentum derives from near-term actions?

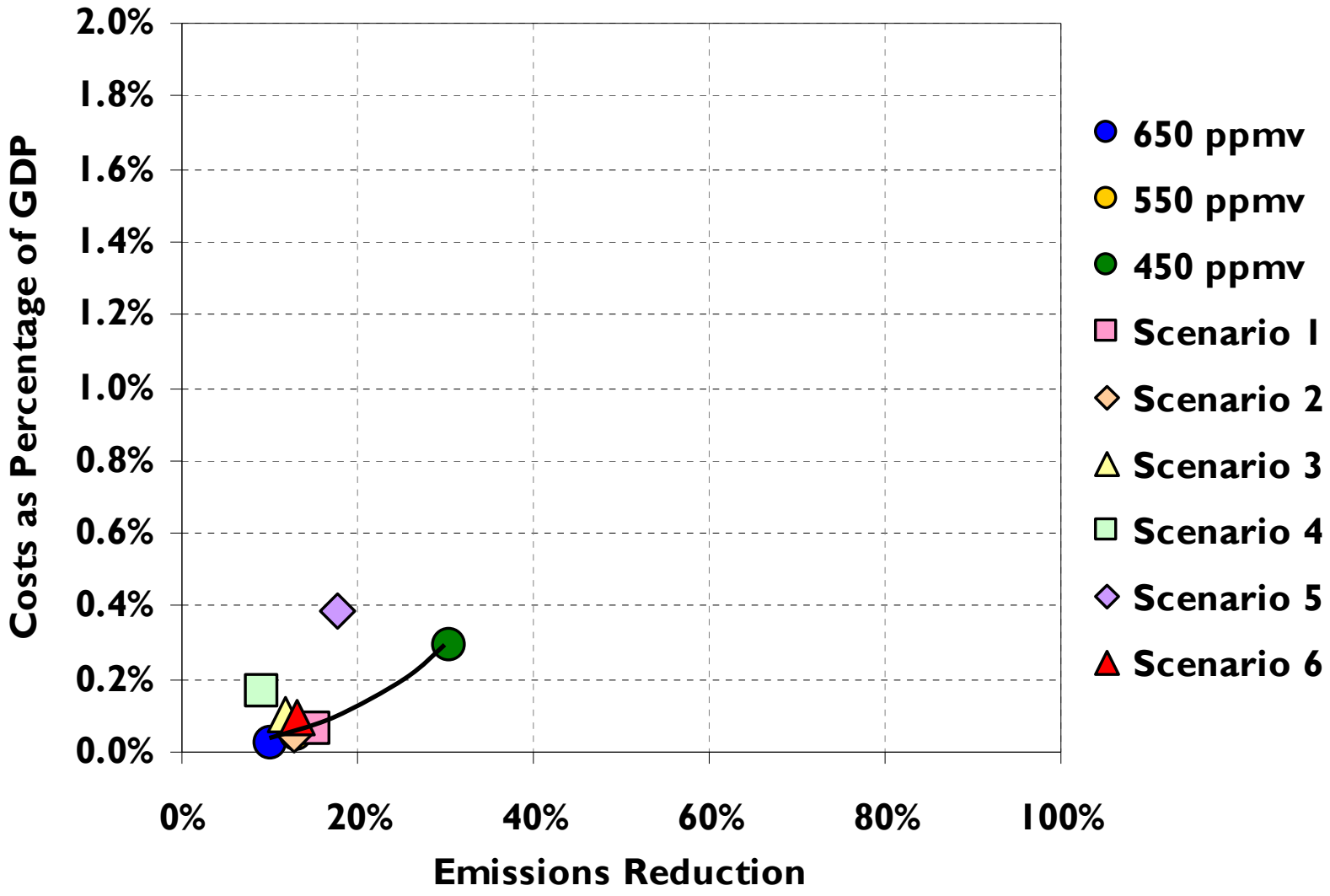
Annual CO_2 Emissions through 2050



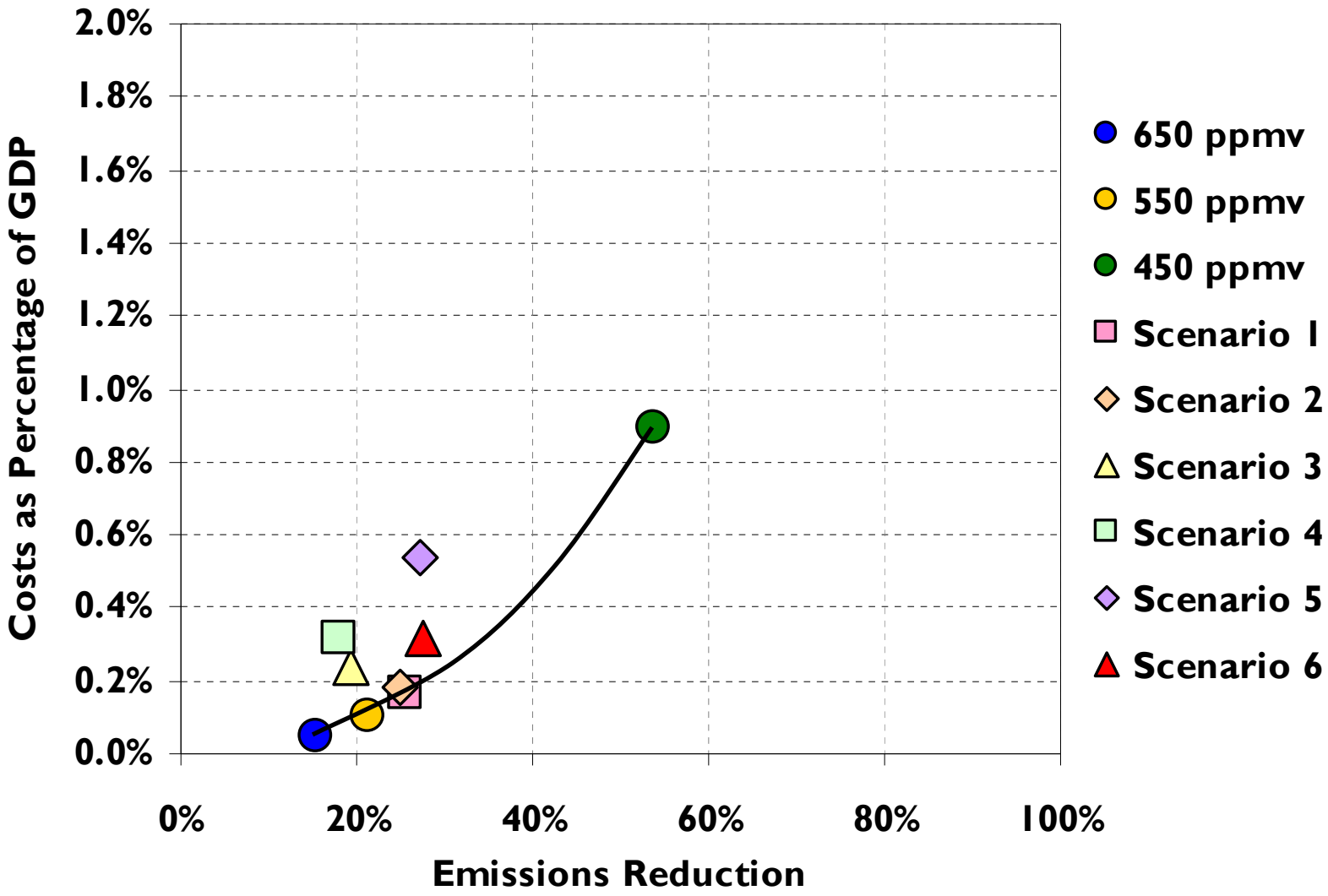
The emissions pathways cluster around idealized 550 ppmv emissions pathway.

The same architectures with differing levels of stringency could produce substantially larger reductions.

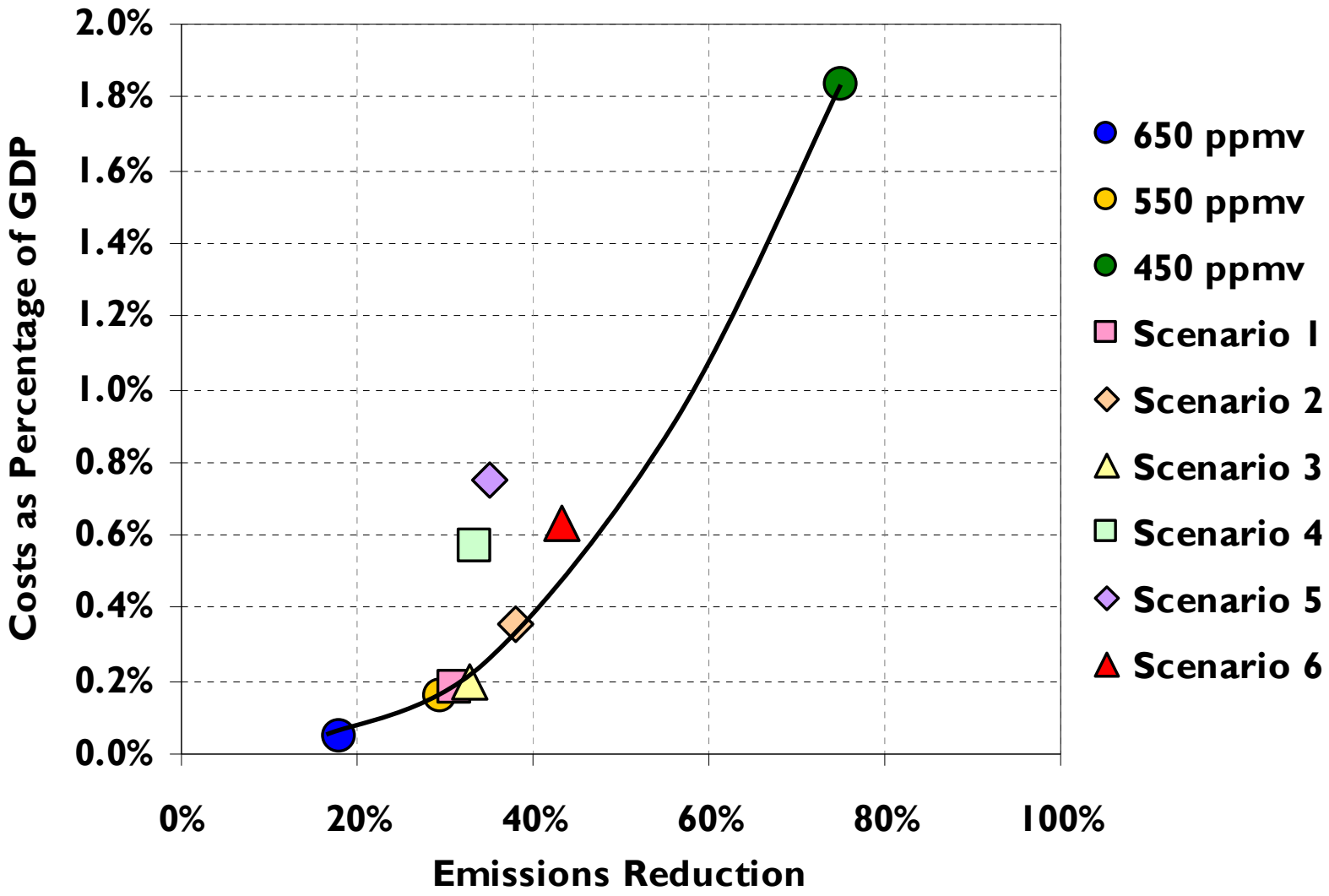
Global Emissions and Costs: 2020



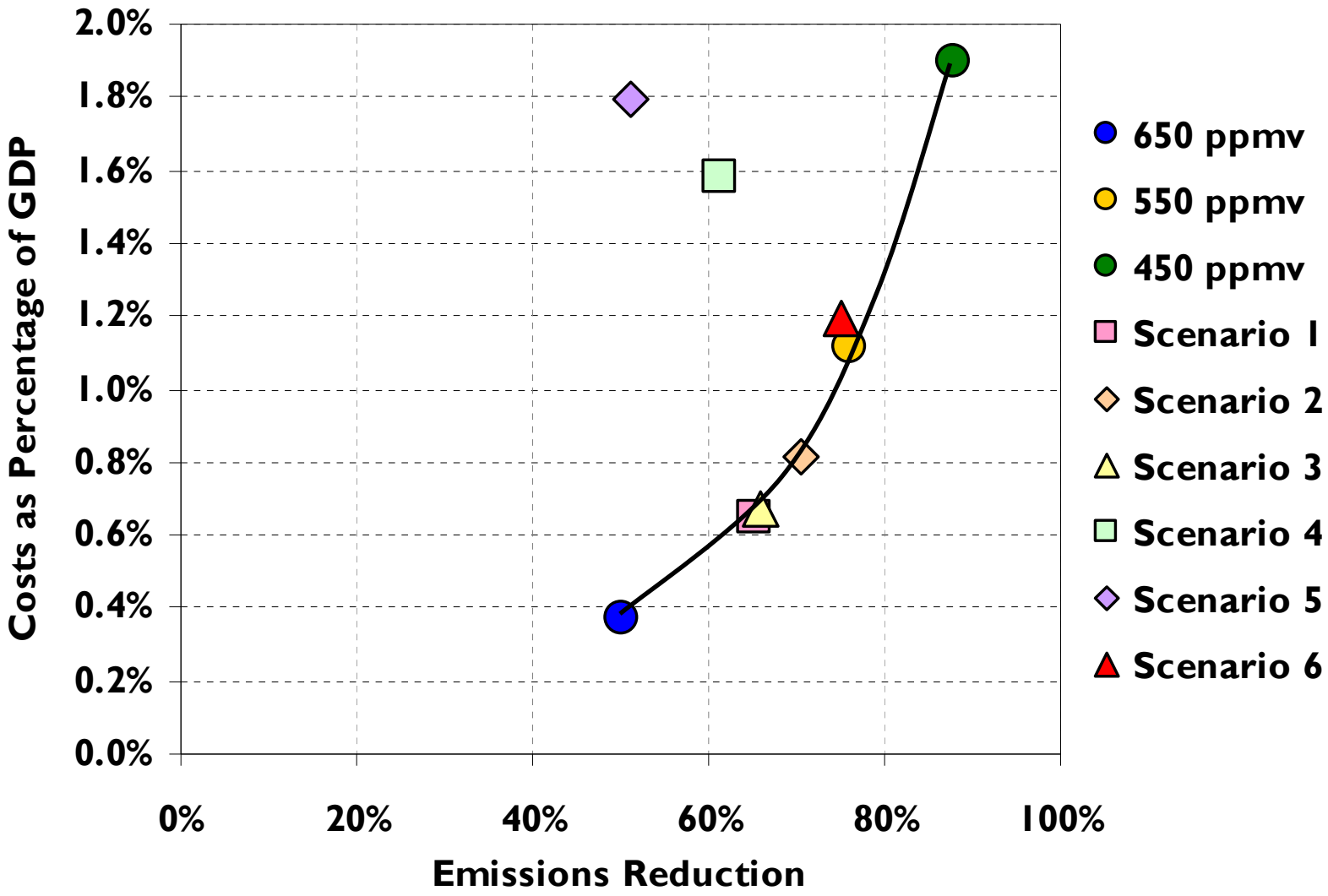
Global Emissions and Costs: 2035



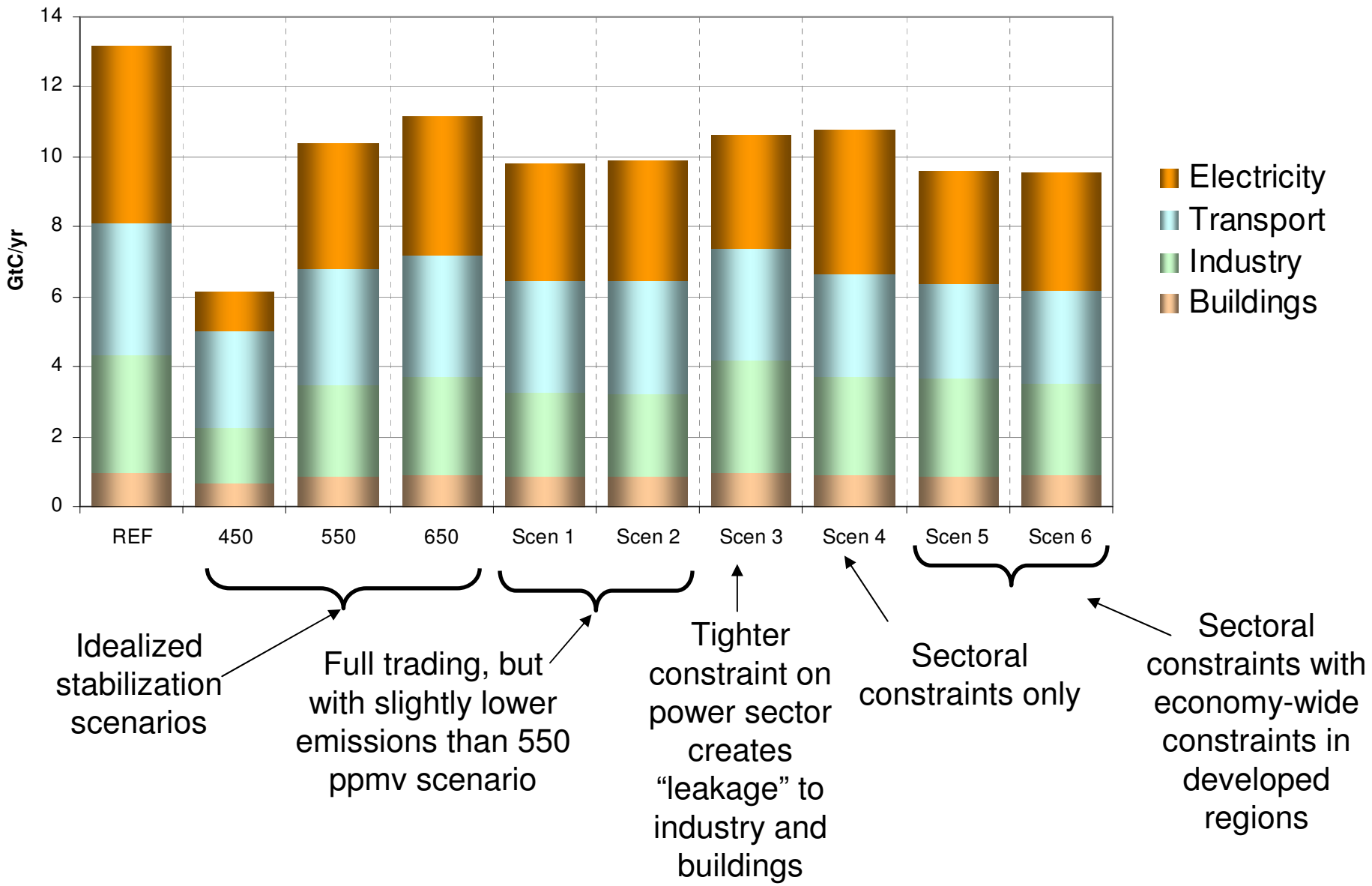
Global Emissions and Costs: 2050



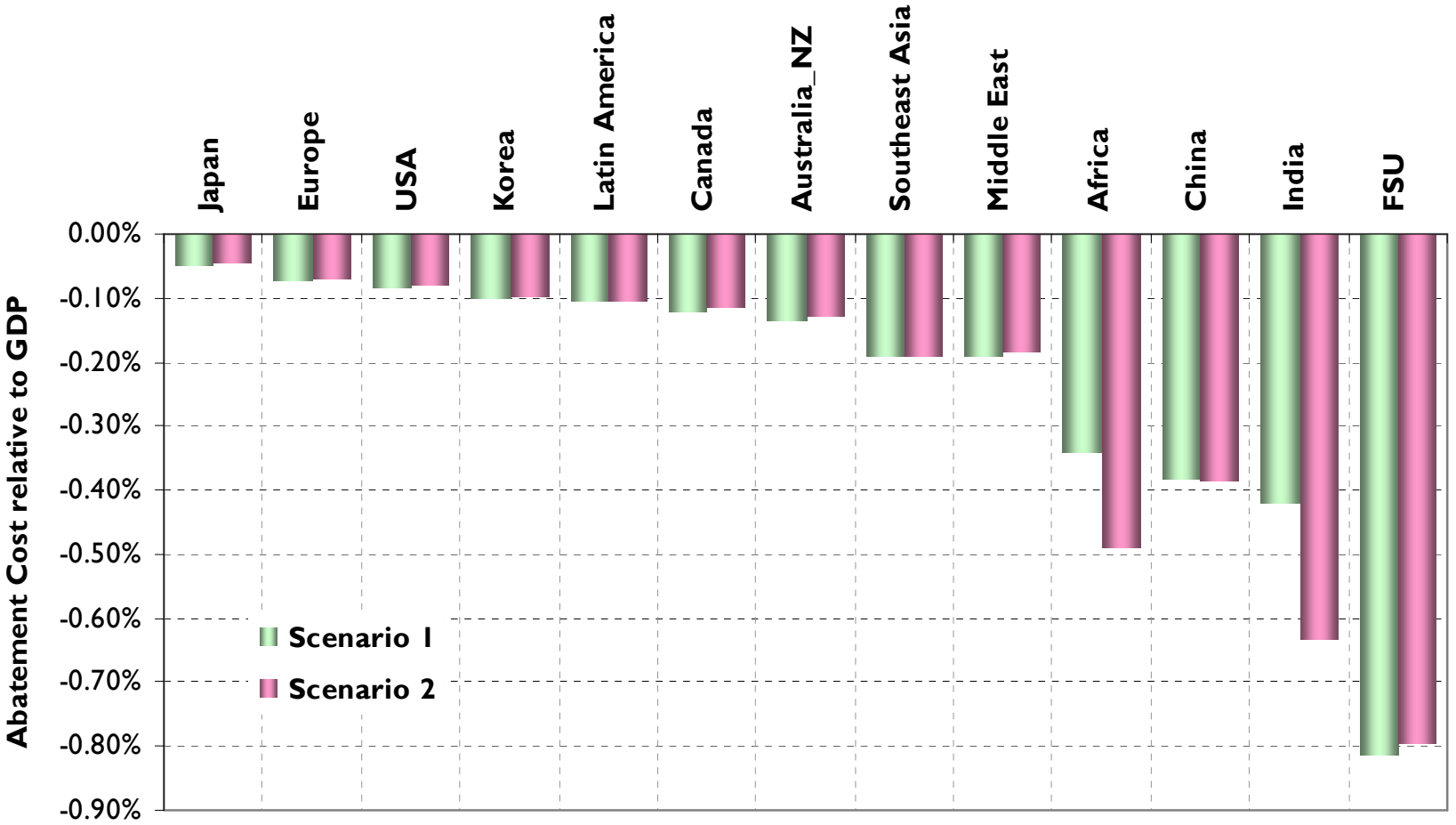
Global Emissions and Costs: 2095



Sectoral Emissions: 2035



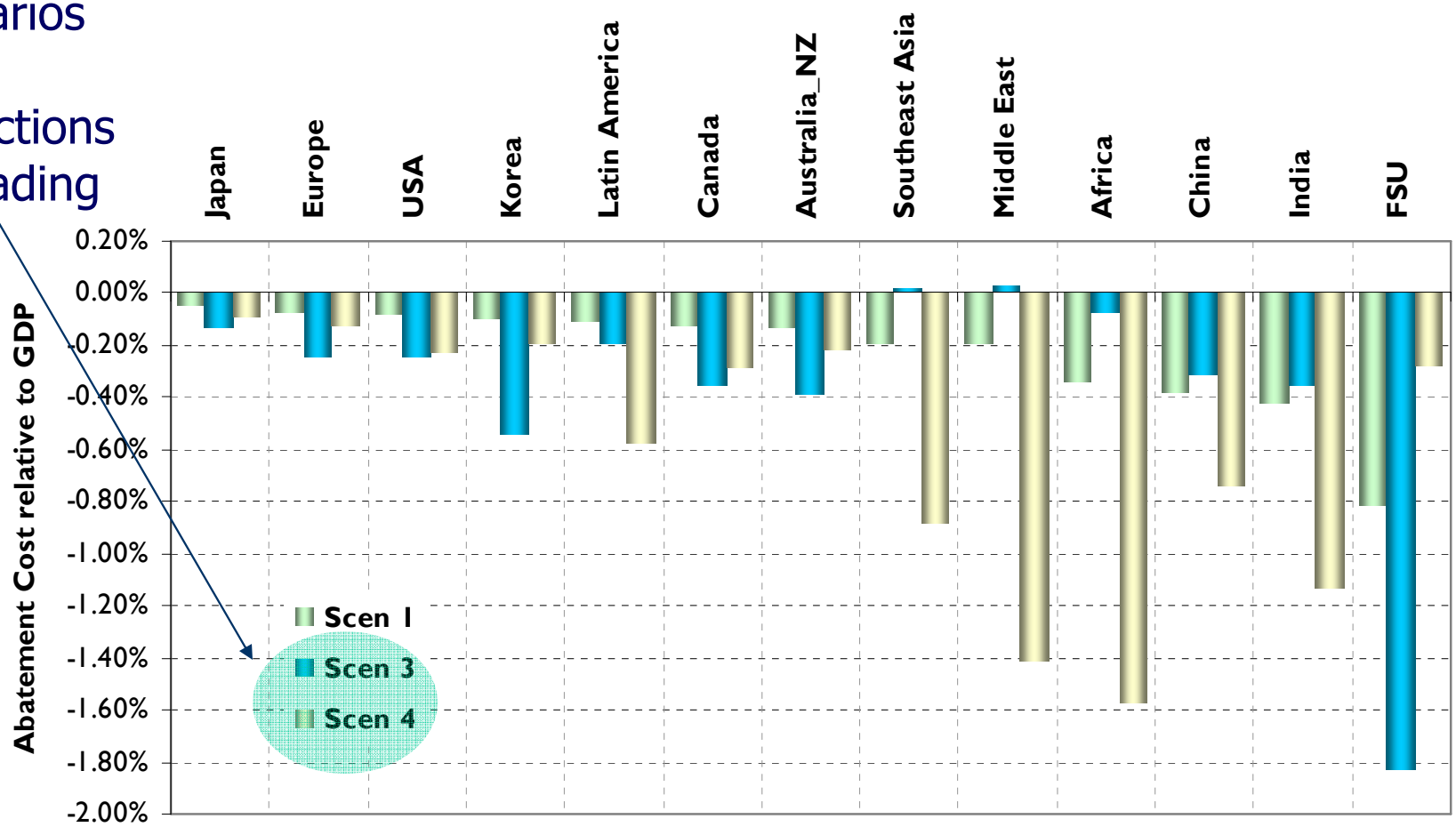
Abatement by Region: 2035



With trading, emissions reductions are completed where they are least costly.

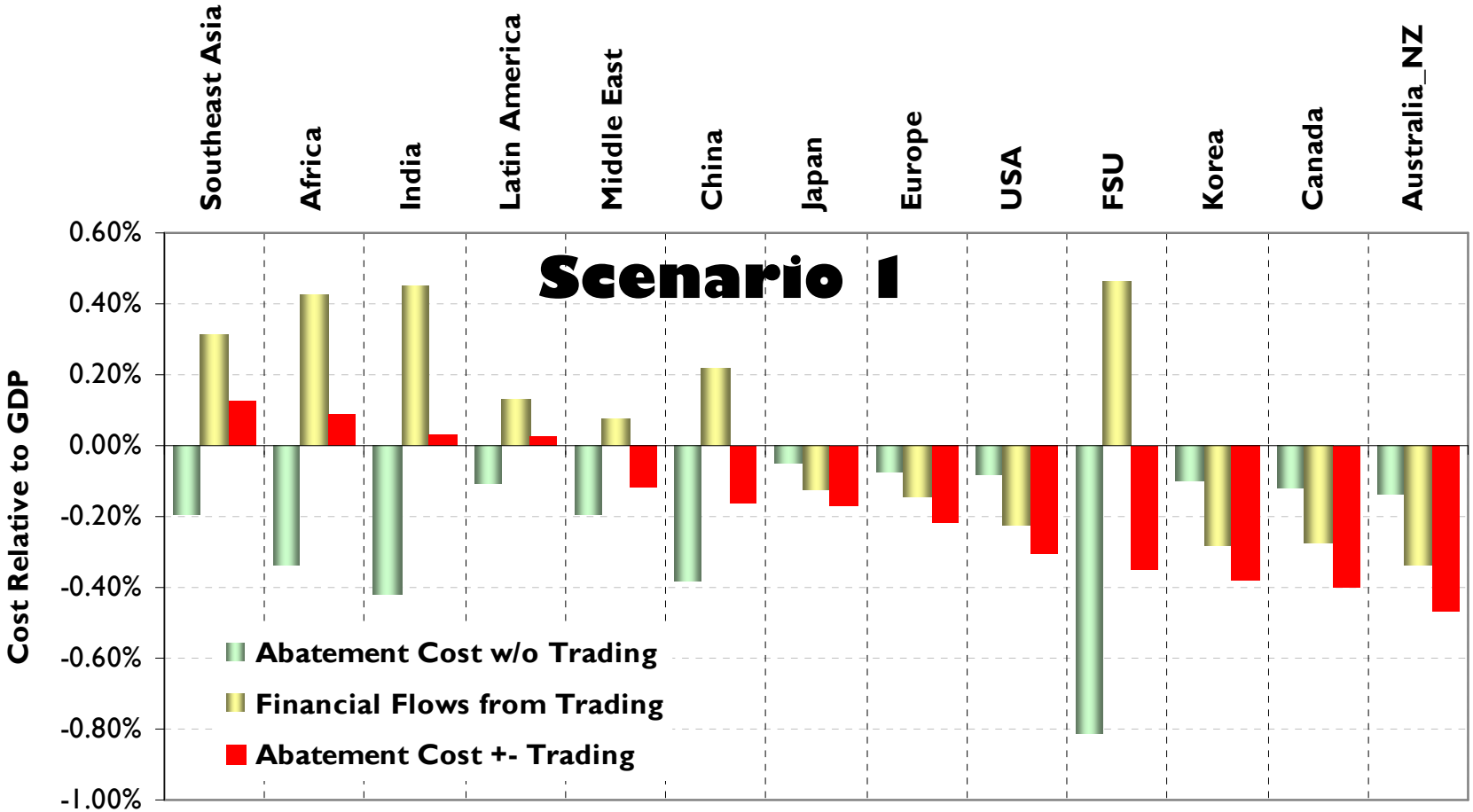
Abatement by Region: 2035

Scenarios with restrictions on trading



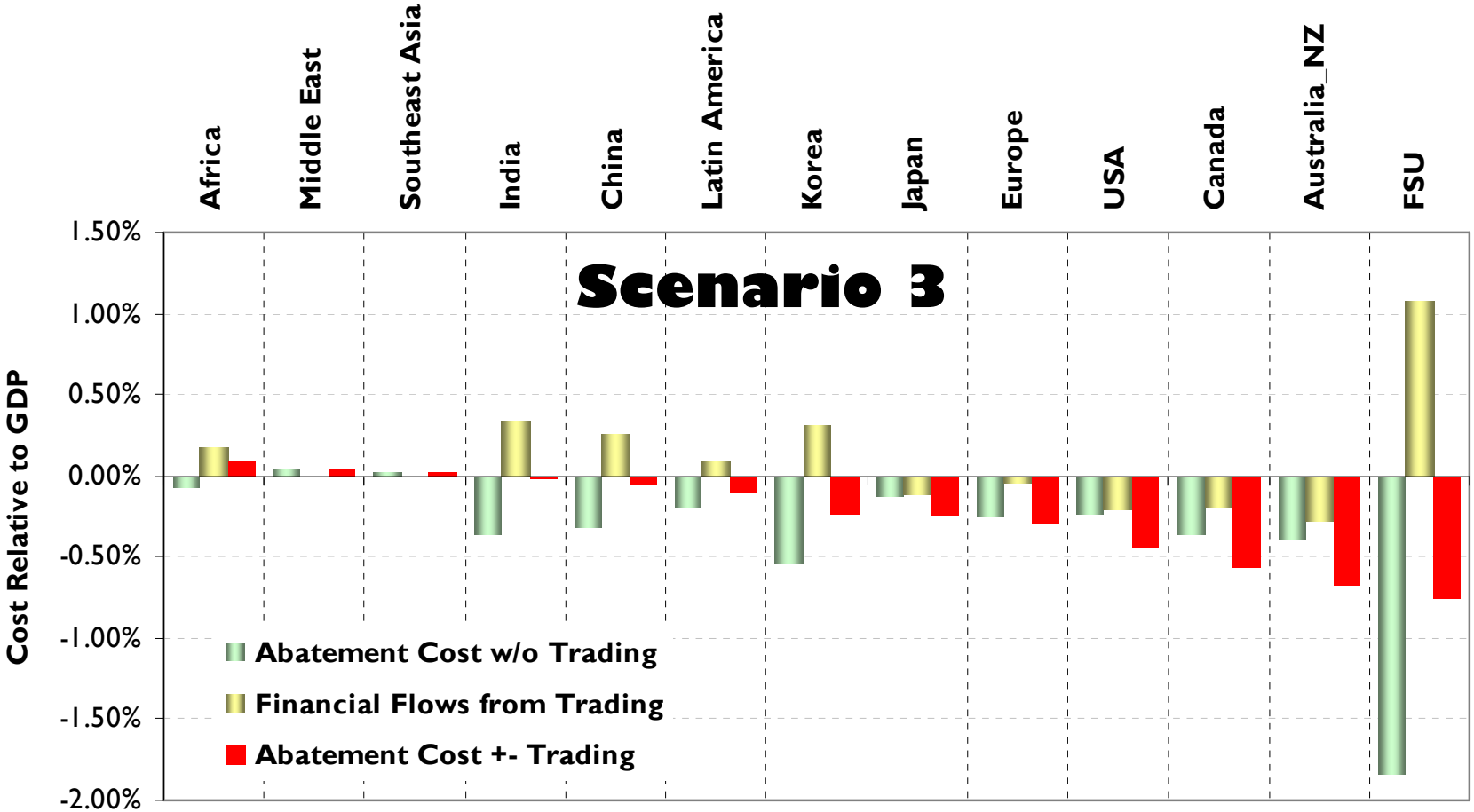
Policy approaches or sectoral approaches can lead to a different distribution of emissions reductions.

Regional Cost Distribution: 2035



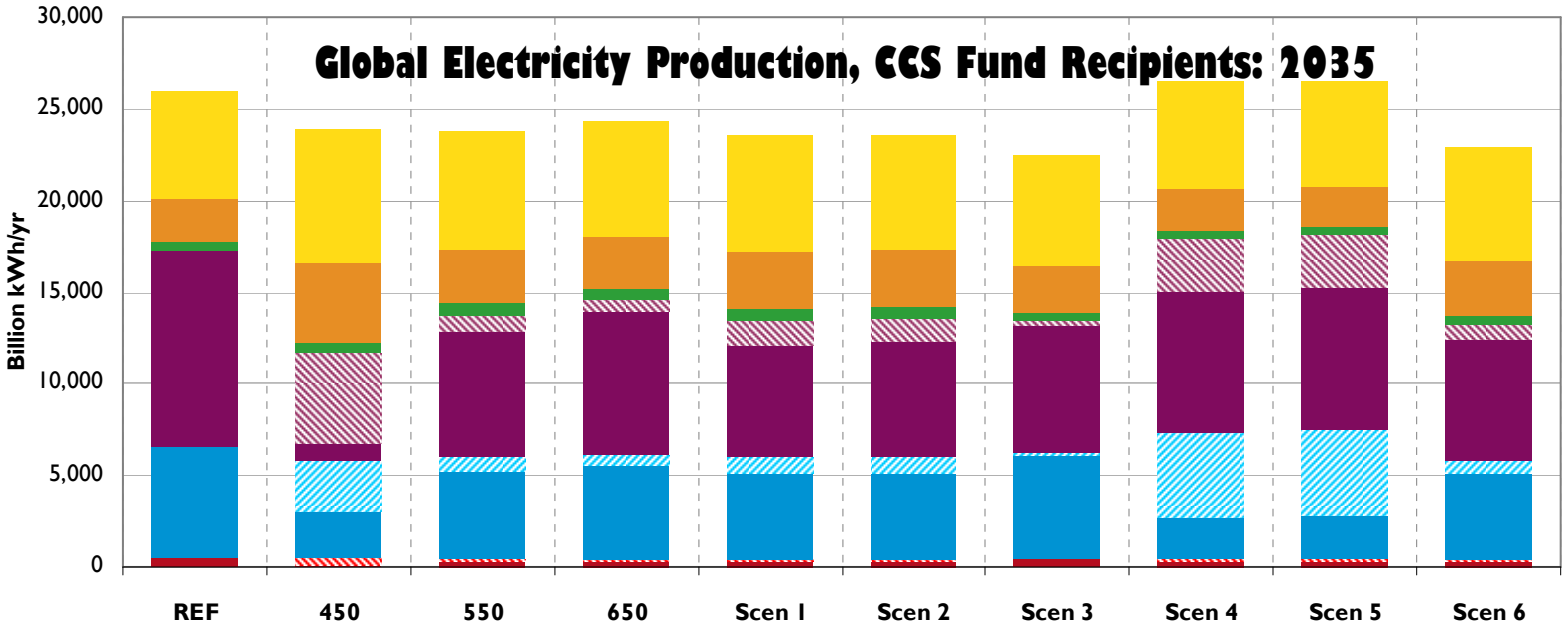
Trading redistributes costs.

Regional Cost Distribution: 2035



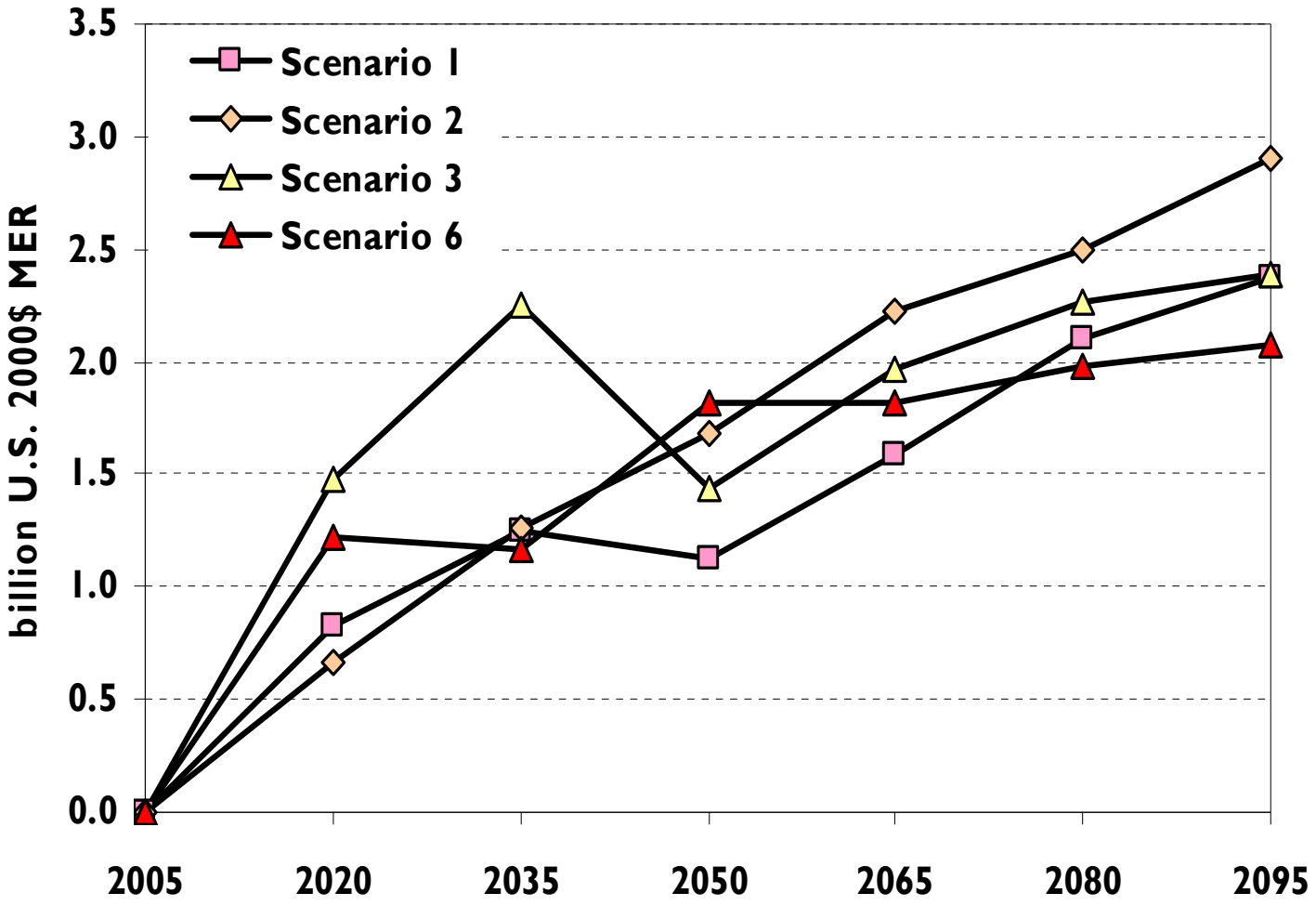
Cost redistribution also feasible with policy-based commitments and partial trading.

CCS Deployment Fund



CCS fund increases CCS fund in recipient nations; lowers cost of electricity, reducing impact on total demand

Adaptation/Technology Funds



Developed regions contribute 0.5% of emissions allowances annually

Summary

- Ultimately, all sectors and regions must participate in emissions mitigation to achieve stabilization
- These scenarios have explored near- and mid-term policy architectures in the context of long-term stabilization
- A range of architectures could lead to emissions reductions in the near- and mid-term that are consistent with long-term stabilization at levels between 450 and 600 ppmv CO2
- The greater the overlap and intersections between policy approaches, the more difficult to predict the outcome
- Deviations from full trading will reduce the absolute economic efficiency of any architecture; the degree of deviation depends on the mechanisms included in the architecture for trading
- A variety of trading mechanisms can be used to redistribute costs among regions

Concluding Thoughts

- Effectiveness
  - A range of policy mixes can produce a near/medium-term effort consistent with long-term stabilization
- Fairness
  - A range of policy mixes can produce a reasonable distribution of cost
- Efficiency
  - A transition to full global trading and coverage is key to economic efficiency in the long term
  - In the nearer term, can we tolerate some trade-off of efficiency to achieve the broad participation needed to put countries on track toward the long-term objective?

For More Information

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