The MIT Emissions Prediction and Policy Analysis (EPPA) Model

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MIT Joint Program on the Science and Policy of Global Change

*EPPA has been developed at MIT over a number of years with contributions from many. Much credit for the current version goes to Mustafa Babiker.

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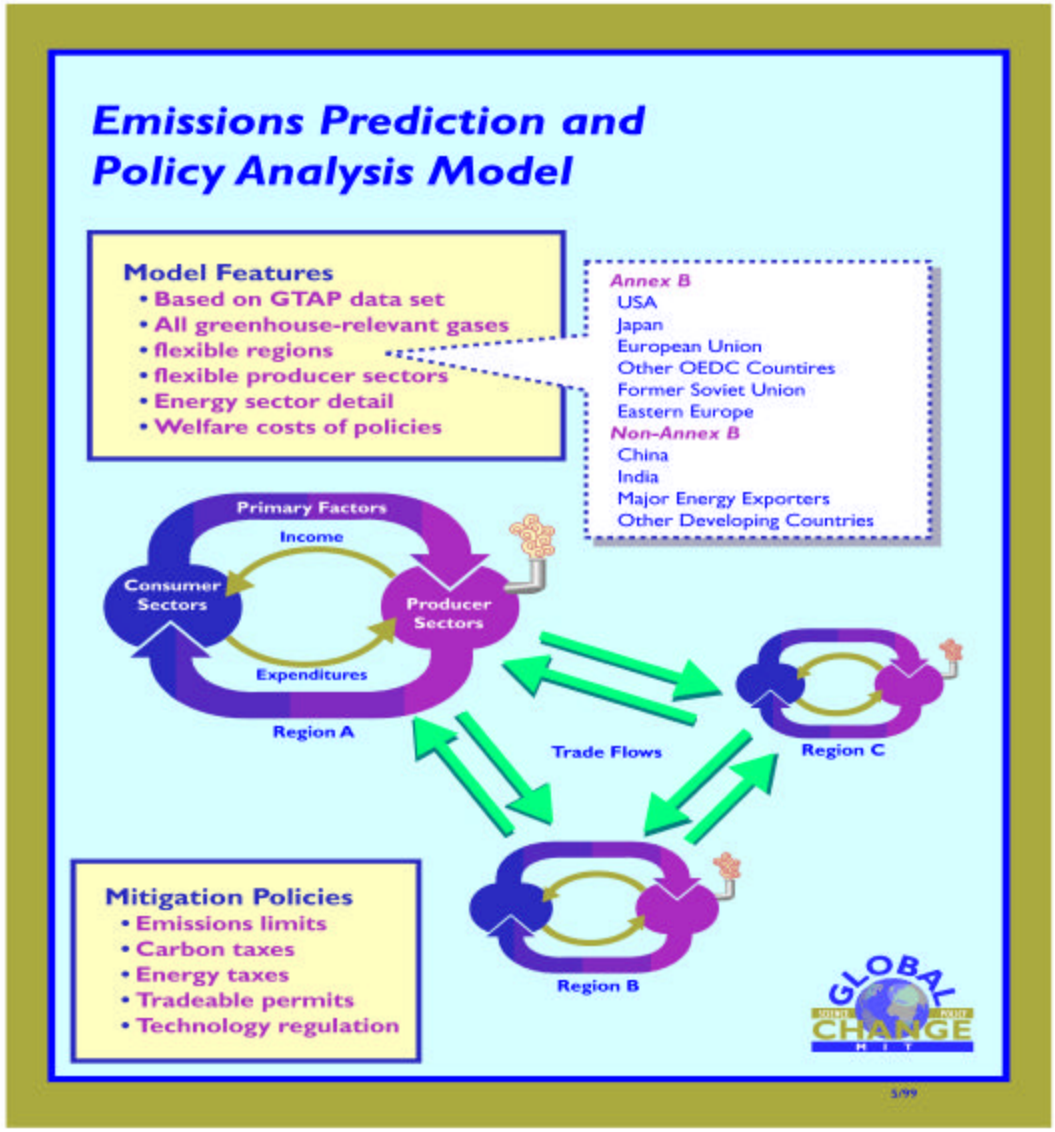
Beijing, China

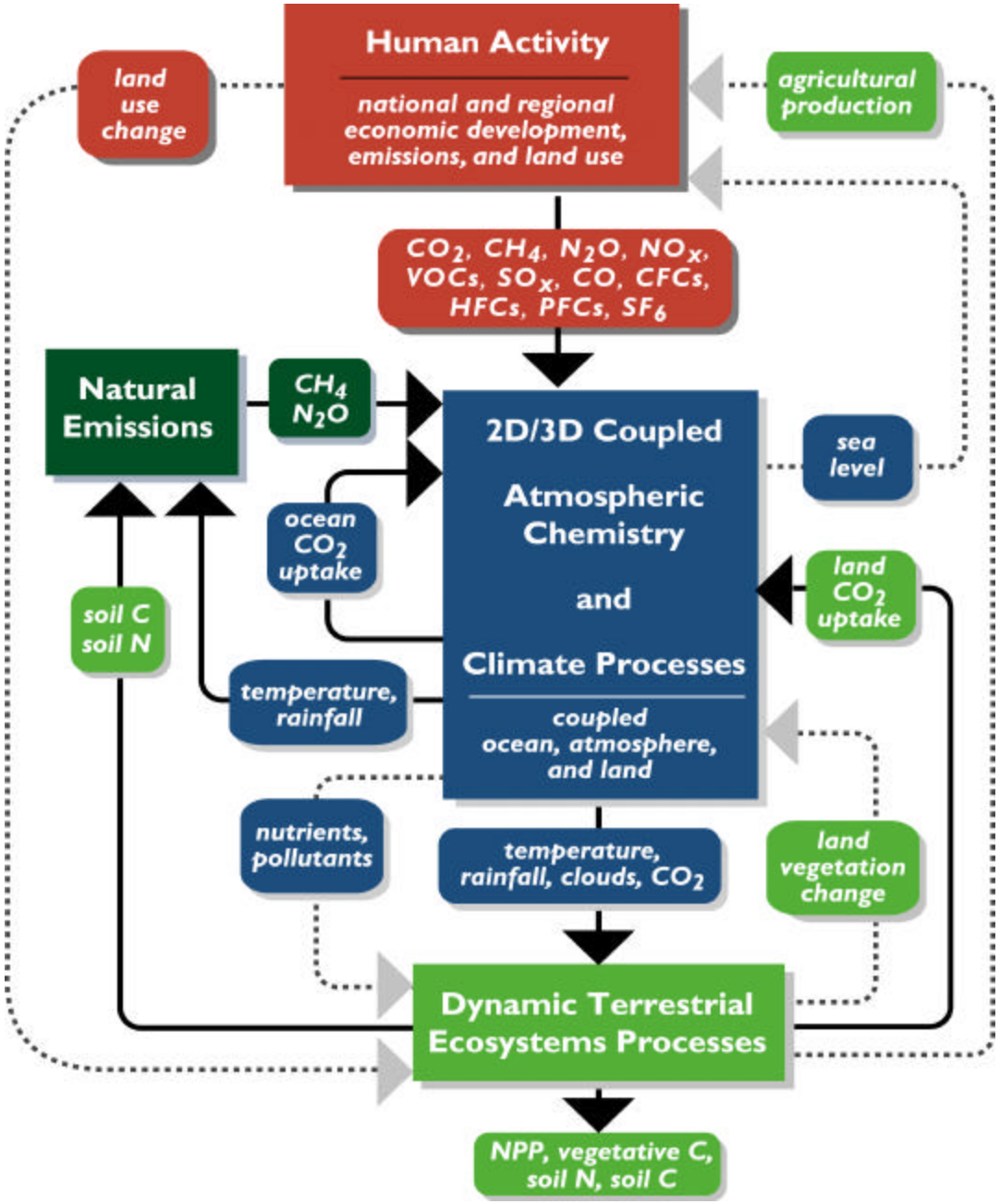
23-25 May 2001

Outline

- EPPA Structure
- Variations on EPPA and Reference Projections
- Some Results With Methane Abatement



EPPA is a Computable General Equilibrium model of the world economy



EPPA is Part of the MIT Integrated Global Systems Model (IGSM)

EPPA Features

- Recursive Dynamic Computable General Equilibrium Model
- Explicit Resource Stocks Subject to Depletion
- CES Family Production and Consumption Functions
- Armington Trade in Goods
- Technical Change/Technology Penetration
- Solved Using MPSG
- GTAP/IEA 4.0 data provides ability to disaggregate and is regularly updated.

EPPA Model Dimensions: Standard Version

Production sectors

Non-Energy

1. AGRIC Agriculture
2. ENERINT Energy-intensive industries
3. OTHERIND Other industries and services

Energy

4. OIL Crude oil including Tar Sands
5. GAS Natural gas
6. REFOIL Refined oil
7. COAL Coal
8. ELEC Conventional
9. ELEC Nuclear

Future Energy Supply

10. Shale oil Producing OIL equivalent
11. Coal Gas Producing GAS equivalent
12. Renewable Carbon-free electric

Primary Factors

1. Labor
2. Capital
3. Fixed factor resources for coal, oil, gas, shale oil, and agriculture

Countries and regions

Annex B

USA United States
JPN Japan
EEC Europe
OOE Other OECD
FSU Former Soviet Union
EET Central European Associates

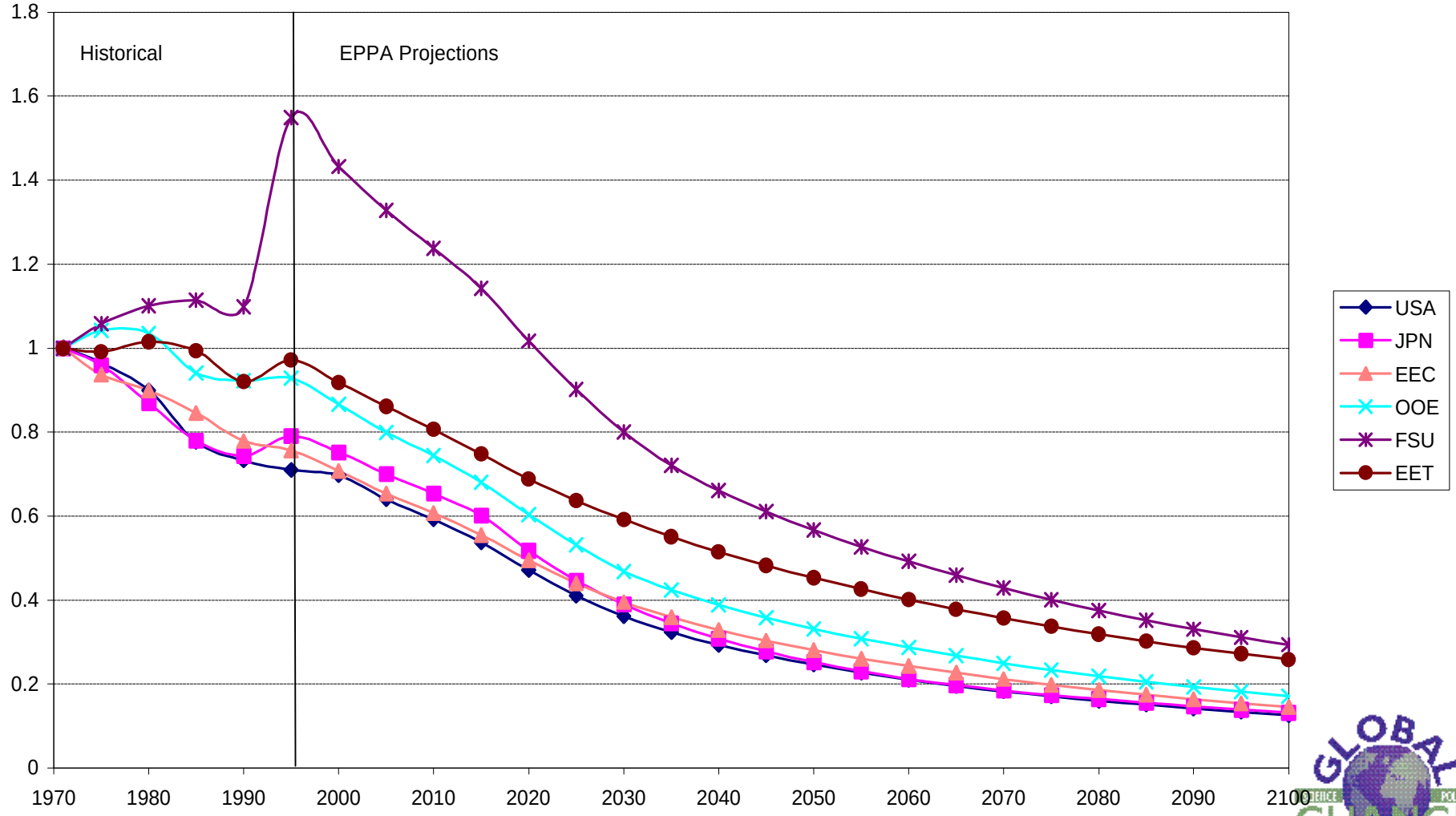
Non-Annex B

CHN China
IND India
EEX Energy Exporters
BRA Brazil
DAE Dynamic Asian Economies
ROW Rest of the World[e]

EPPA: Other Versions

- Full Dynamic Version ~30 hours solution time
- Developing Country Disaggregation (19 developing + 6 developed countries/regions)
- EU-Transportation Disaggregation (10 EU + 5 developed+ 6 developing countries/regions with commerical and household transportation sectors)
- OECD With Distortionary Labor, Capital, Consumption, and Energy Taxes
- Endogenous GHG Costs

Developed Countries Energy Intensity of GDP, 1970-2100 (1970=1.0)



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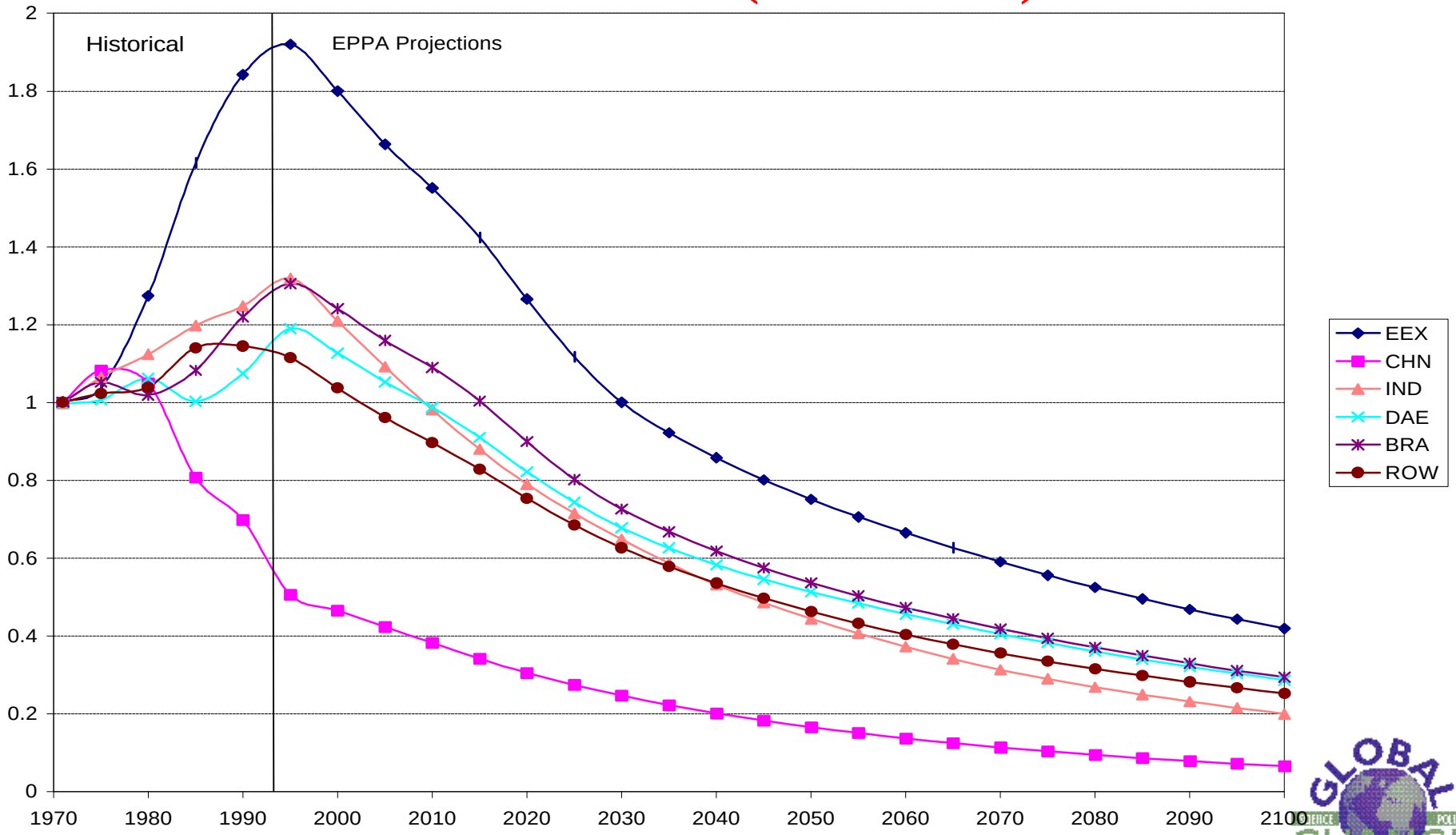
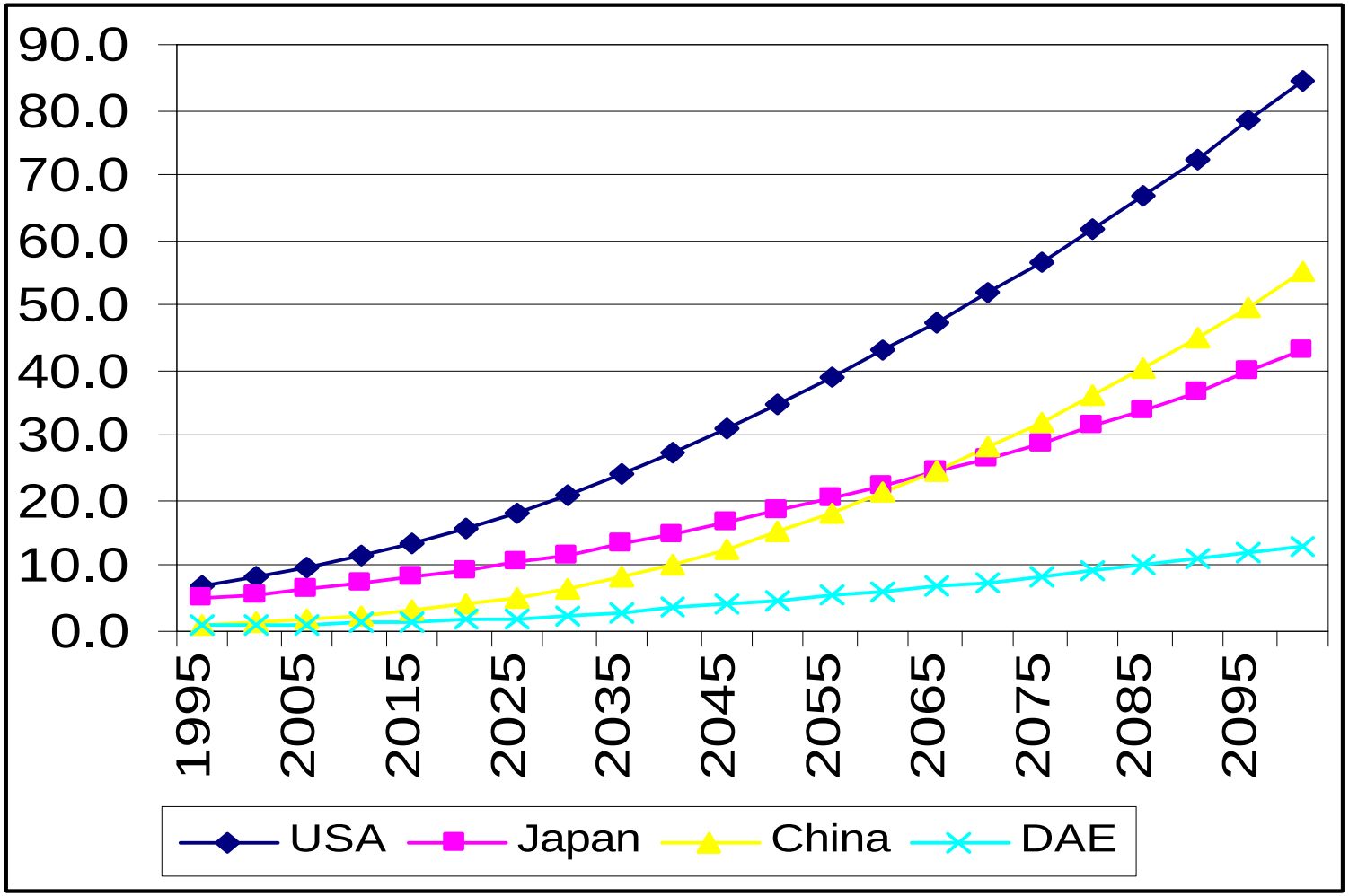
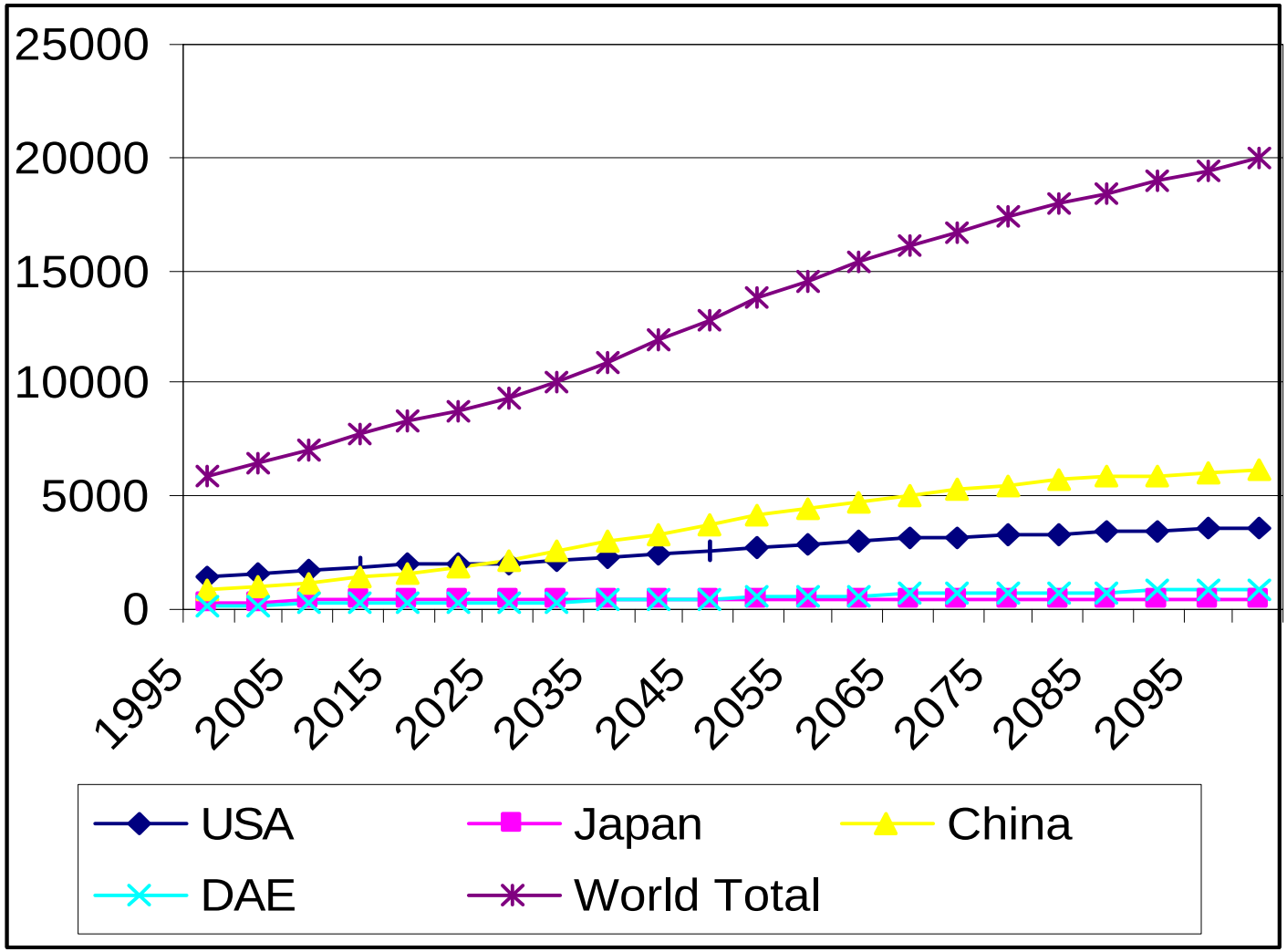


GDP, Selected Regions in 1995 US$



Carbon Emissions, 10^6 tons



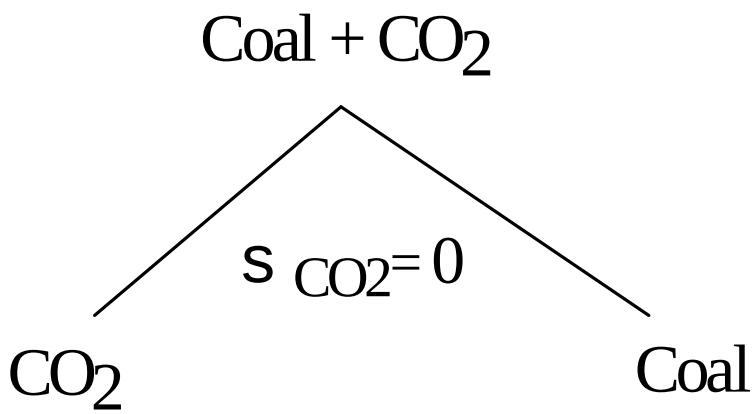
EPPA With Endogenous Methane Abatement

- Results from Rob Hyman's Master's Thesis
- Methane emissions and activities in EPPA
- Method for including
- Some policy simulations

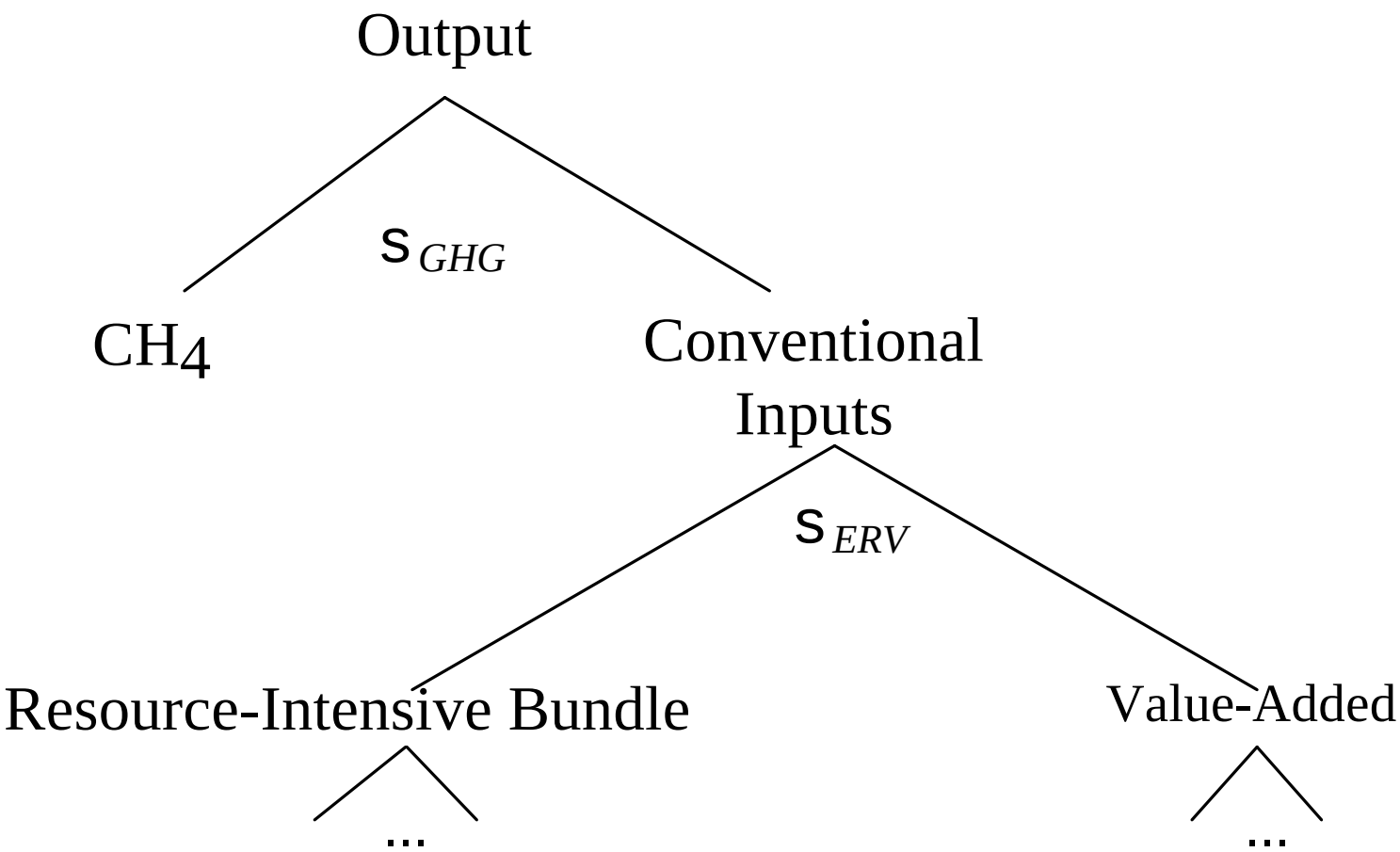
Methane Sources and EPPA Sectors

Emissions Source	EPPA Sector
Coal Mining	Coal Production
Gas Flaring	Oil Production
Natural Gas Distribution	Gas Consumption
Livestock, Rice, Biomass	Agriculture Production
Landfills/waste water	Household consumption
Industrial sewage (paper and chemicals)	Energy intensive industry
Industrial sewage(food processing)	Other industry

CES Nest Structure for CO_2: Coal



CES Nest Structure for CH_4:Agriculture



Substitution Elasticity & Bottom-Up Costs

- CES Unit Cost function

$$P_O = \left[\mathsf{q} \left[\frac{P_{i1}}{P_O} \right]^{1-\mathsf{s}} + (1-\mathsf{q}) \left[\frac{P_{i2}}{P_O} \right]^{1-\mathsf{s}} \right]^{\frac{1}{1-\mathsf{s}}}$$

- Derived demand for input

$$X_1 = \mathsf{q} \left[\frac{P_O}{P_{i1}} \right]^{\mathsf{s}}$$

- Relationship to bottom-up supply of abatement

$$\mathsf{s} = -\frac{\mathsf{e}_{di}}{1-\mathsf{a}}$$

Method

- Use detailed cost information to construct supply curves (MACs) from US Environmental Protection Agency, IEA

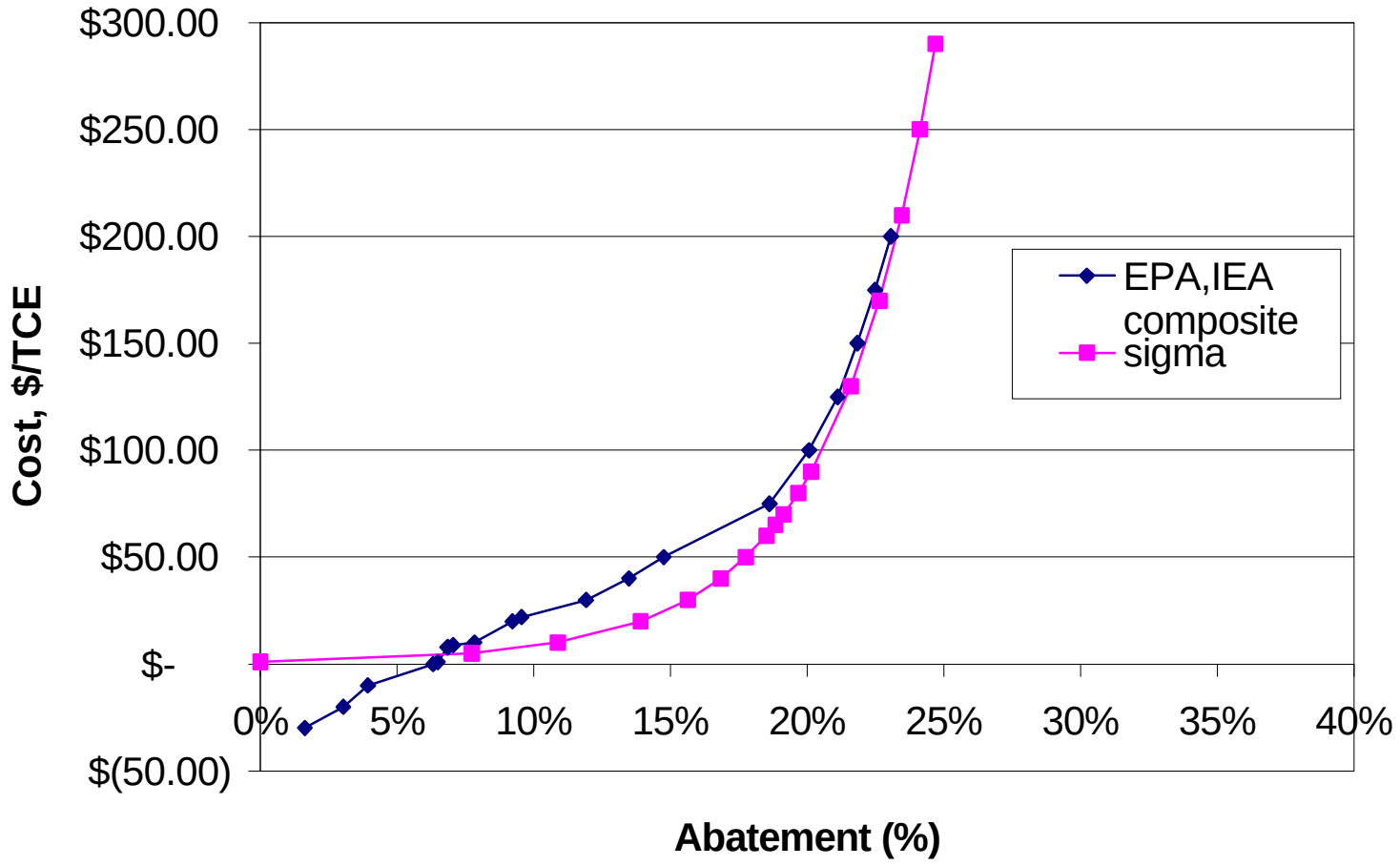
- Fit S MAC

- Create CES nests in EPPA for CH_4

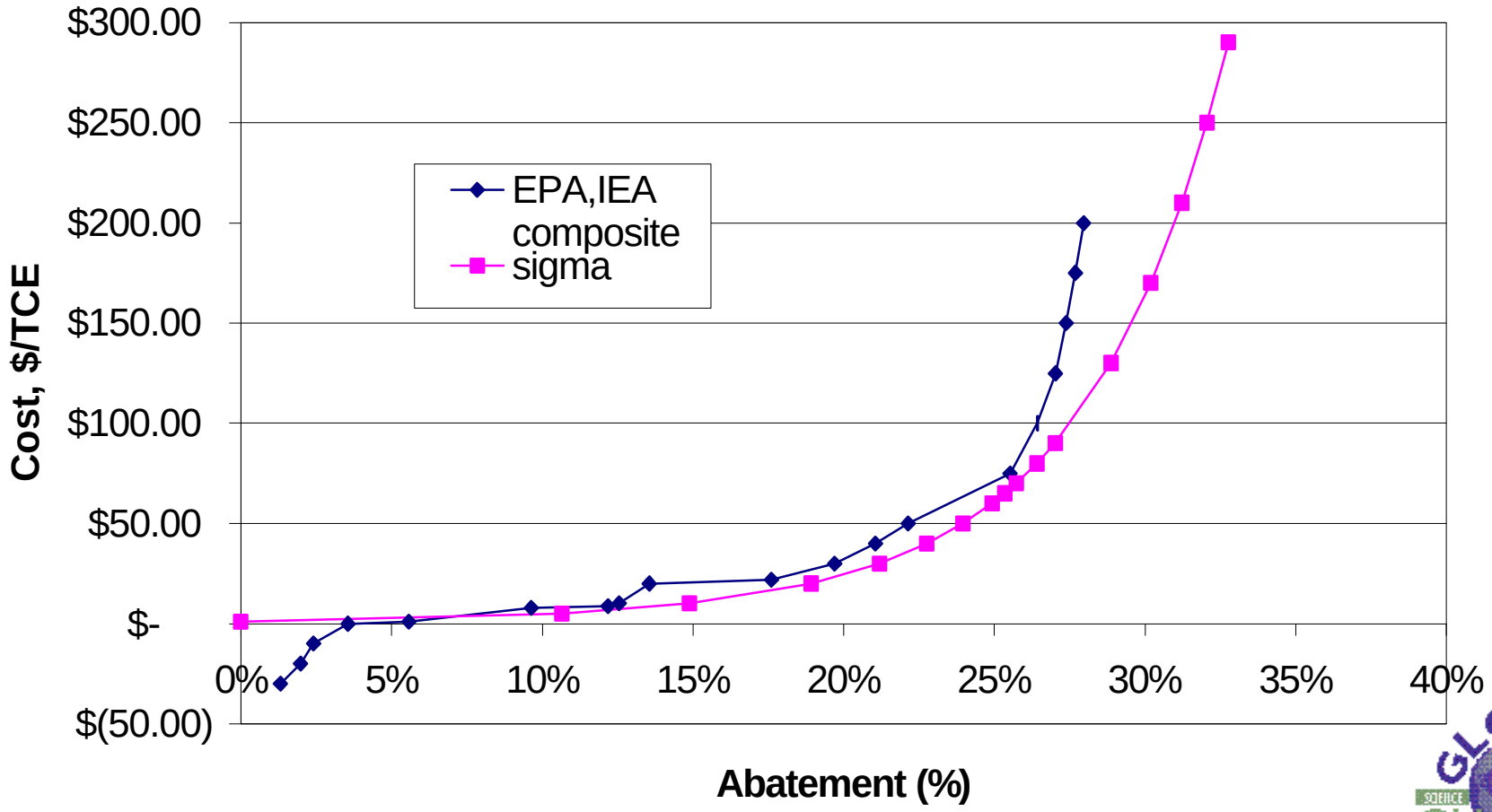
Data Sources

EPPA Sector	Emissions Source	MAC Data Sources
AGRIC	Enteric fermentation	Assumed no abatement
	Manure decomposition	US EPA
	Rice cultivation	IEA
GAS	Gas production and distribution	US EPA
OIL	Oil production	Assumed same MAC as GAS
COAL	Coal production	US EPA
ENERINT	Industrial sewage	IEA
OTHERIND	Industrial sewage	IEA
Final Demand	Landfill	US EPA
	Domestic sewage	IEA

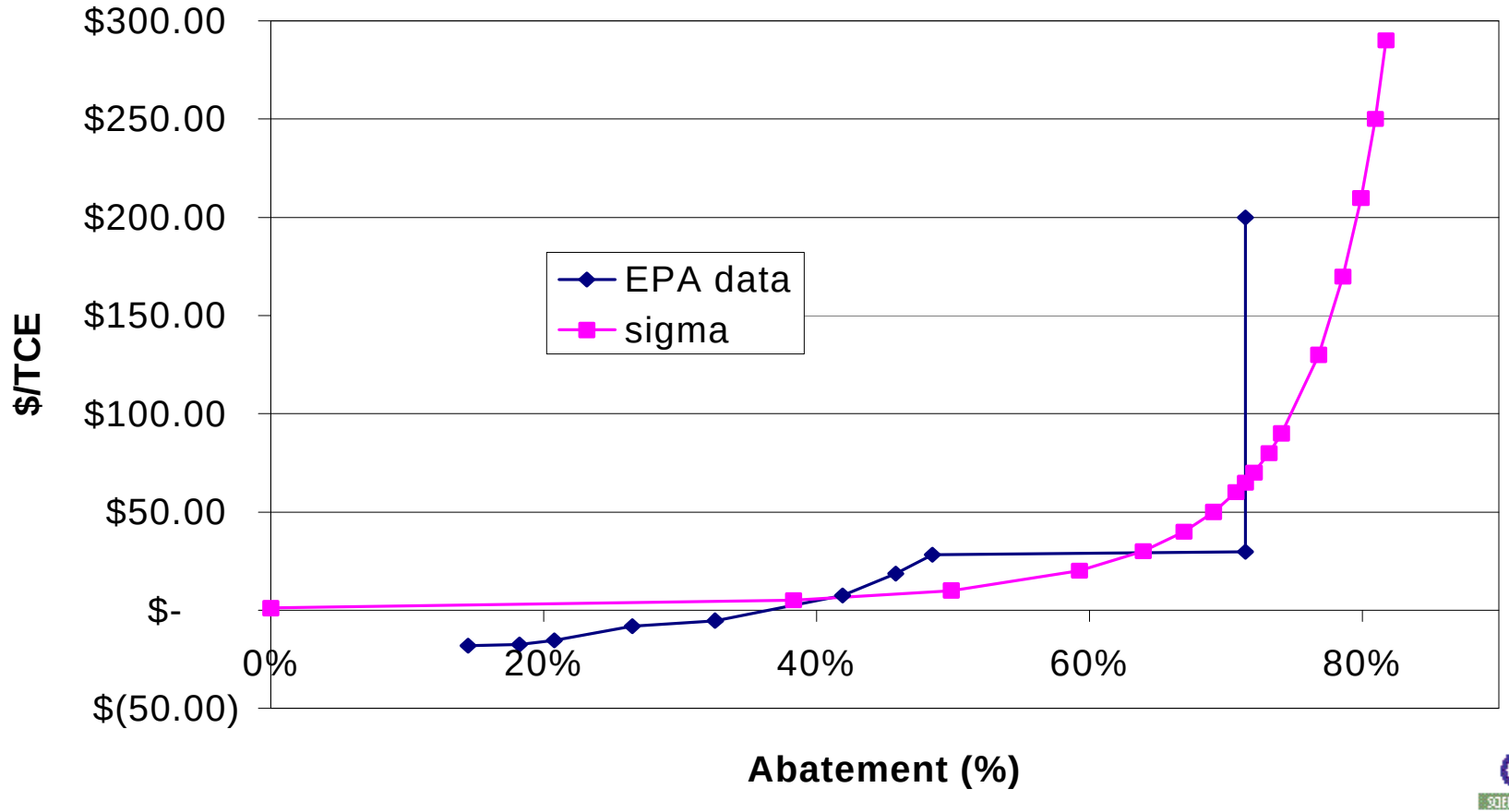
Agriculture: USA



Agriculture: China

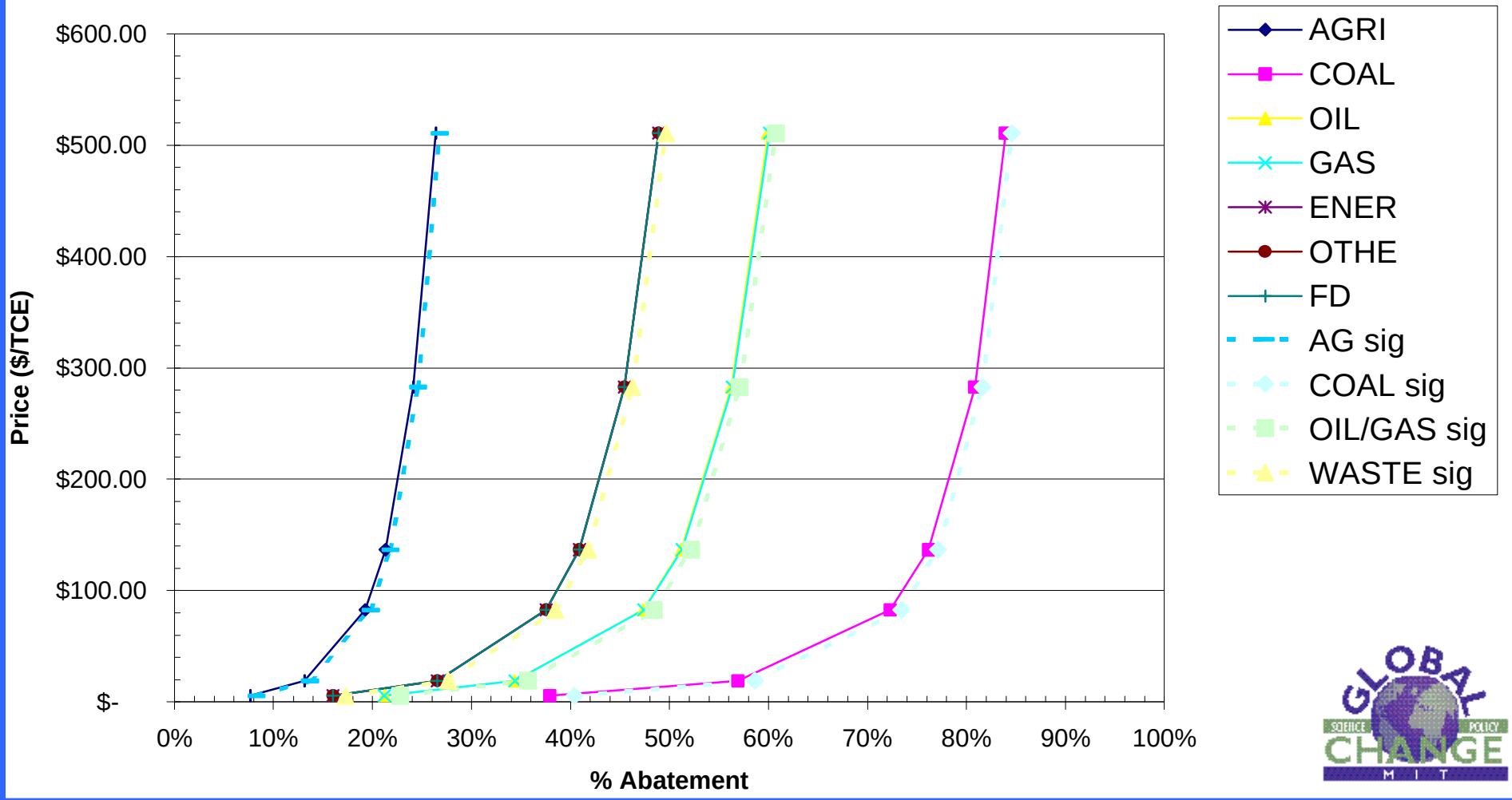


Coal Production: USA

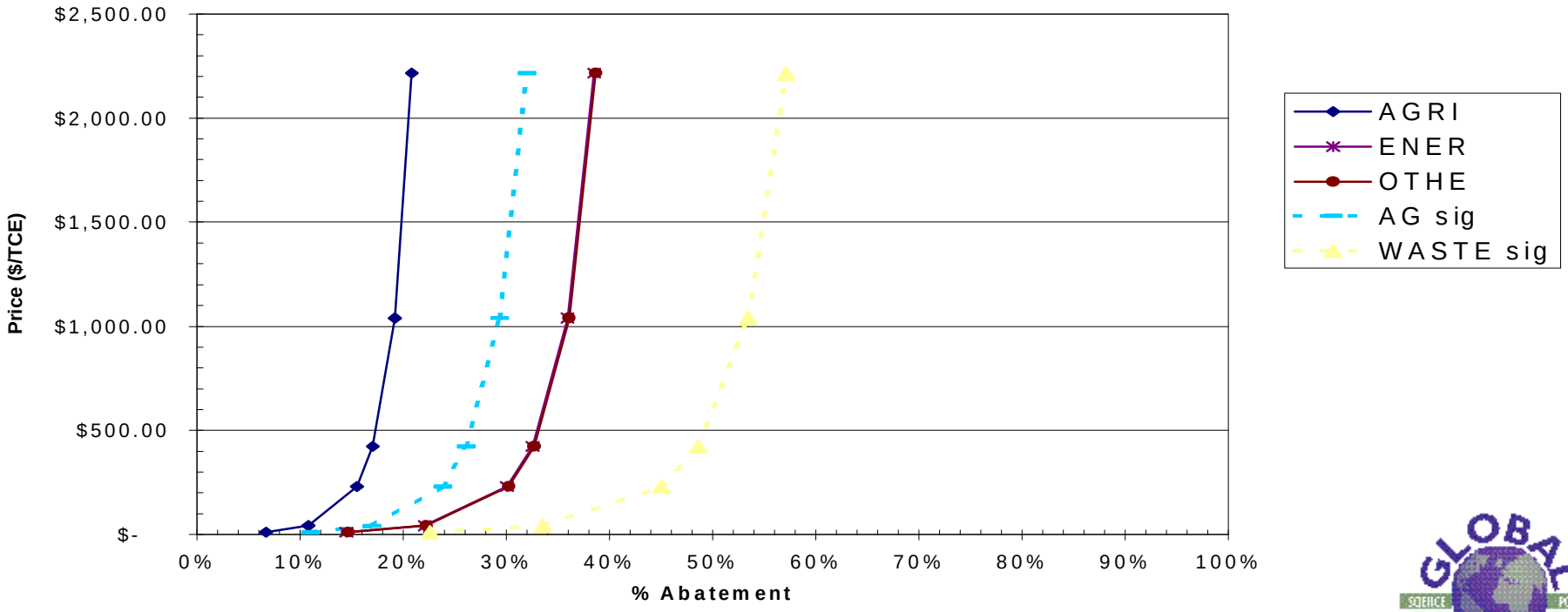


EPPA Results vs. Partial Equilibrium:

1995, No vintaging, Methane only constraint



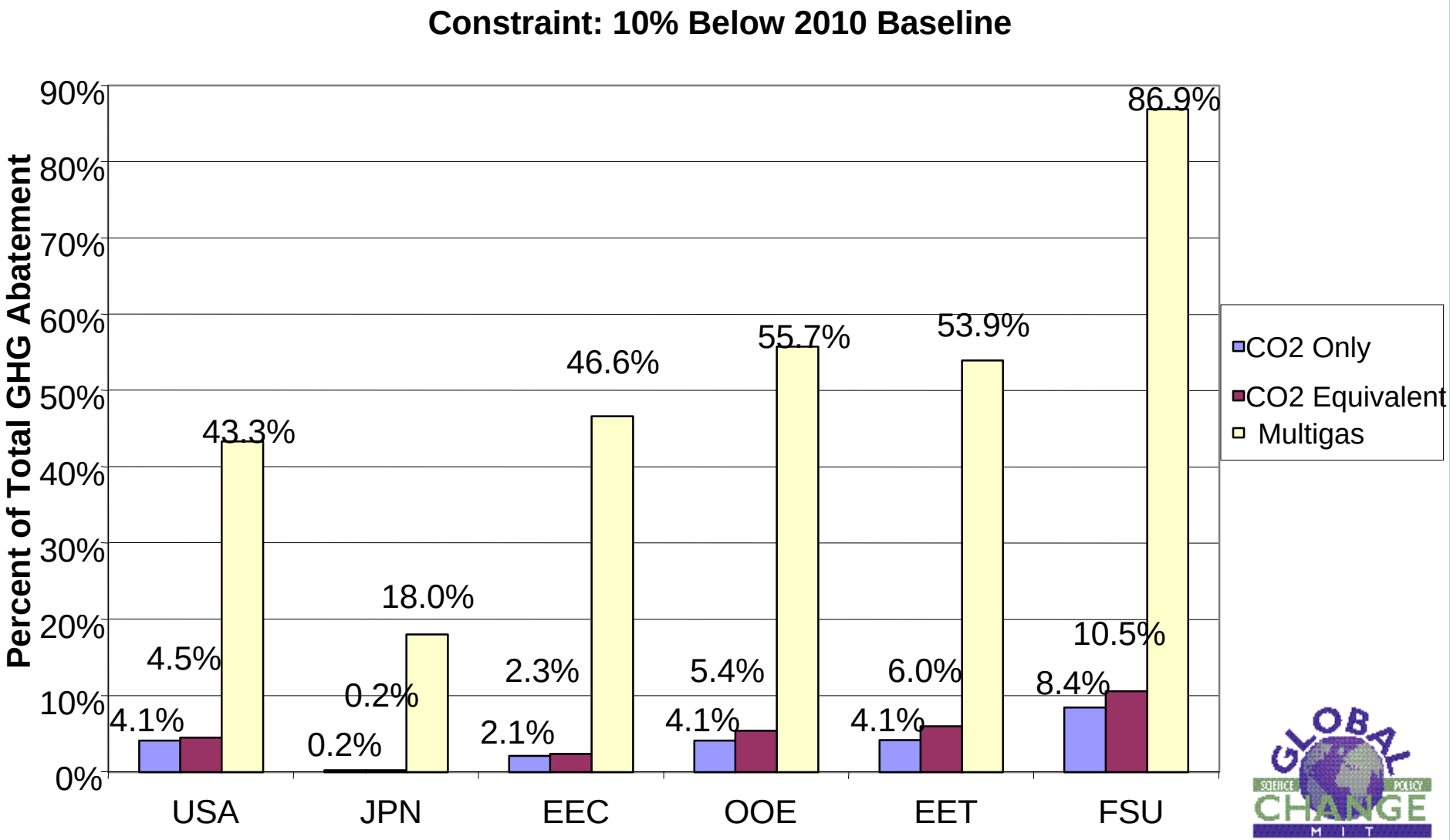
EPPA Results vs. Partial Equilibrium: 2010, With vintaging, Methane only constraint



Policy Results

- Consider 10 and 30 percent reductions **from 2010 Reference**
- 3 Cases
  - Reduction based on CO2 reference only
  - Reduction based on CO2+CH4 reference but no restrictions on CH4
  - Reduction based on CO2+CH4 reference with restrictions on CH4

Methane Abatement-Developed Countries



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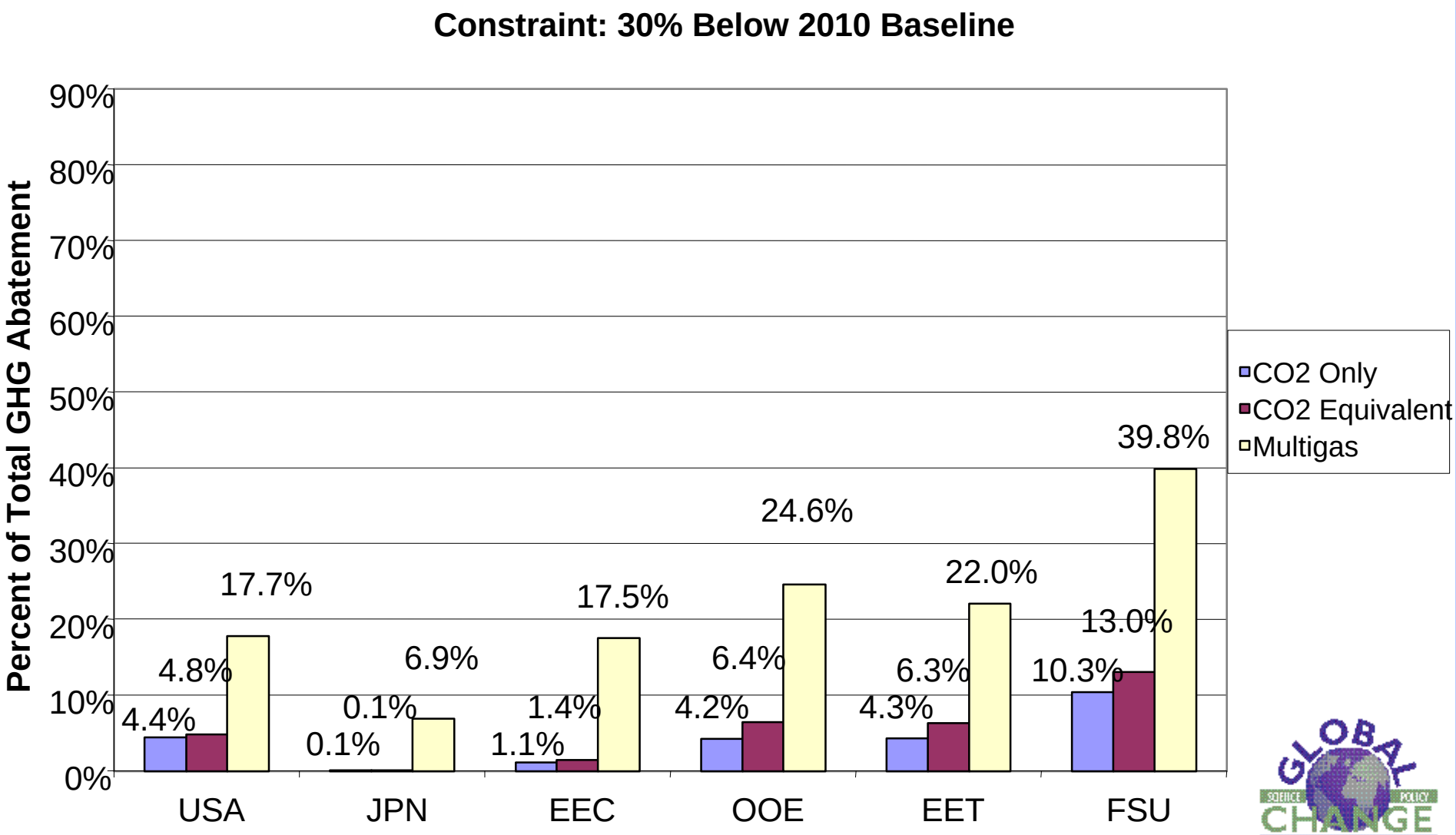
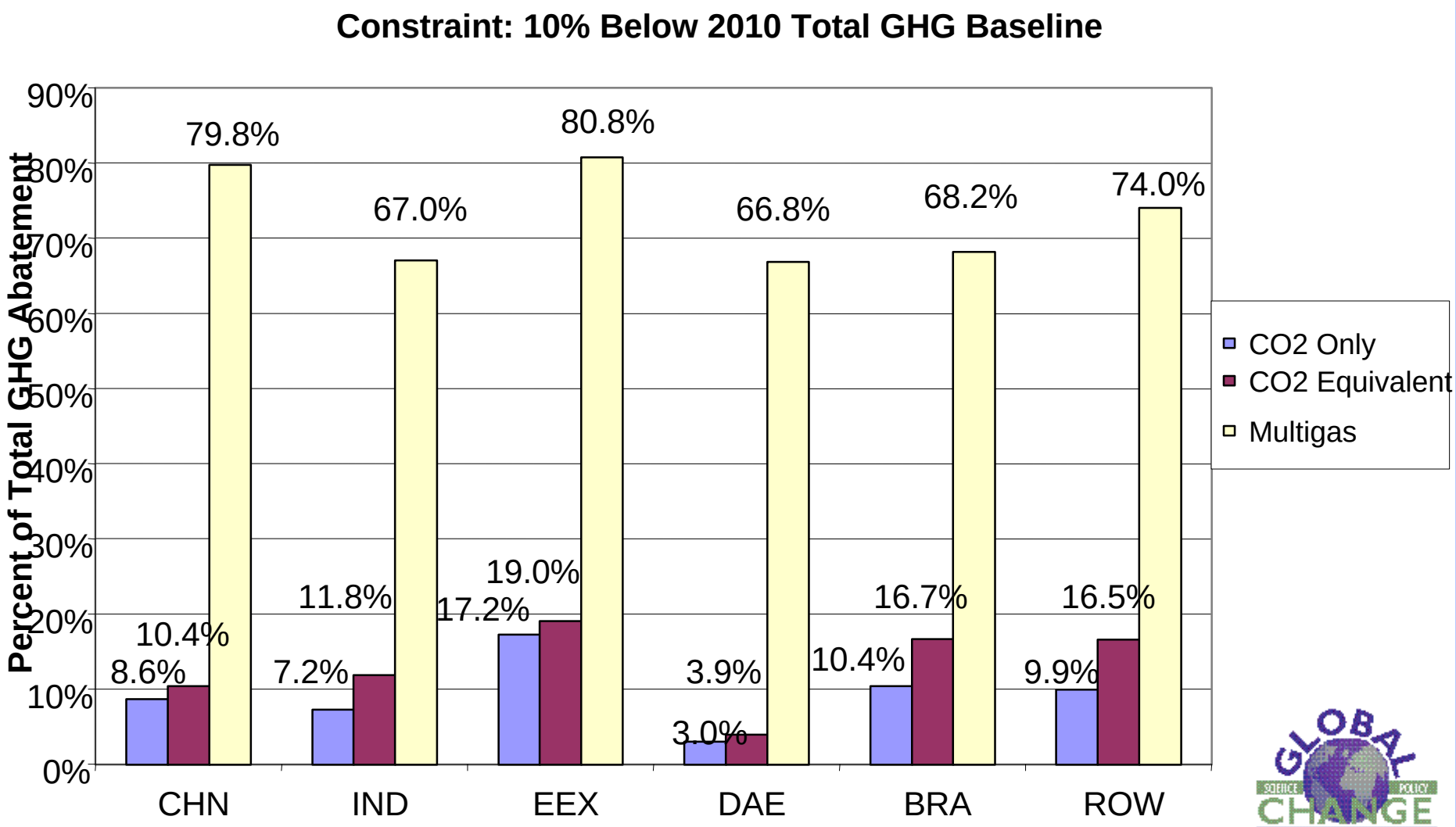


Methane Abatement-Developing Countries



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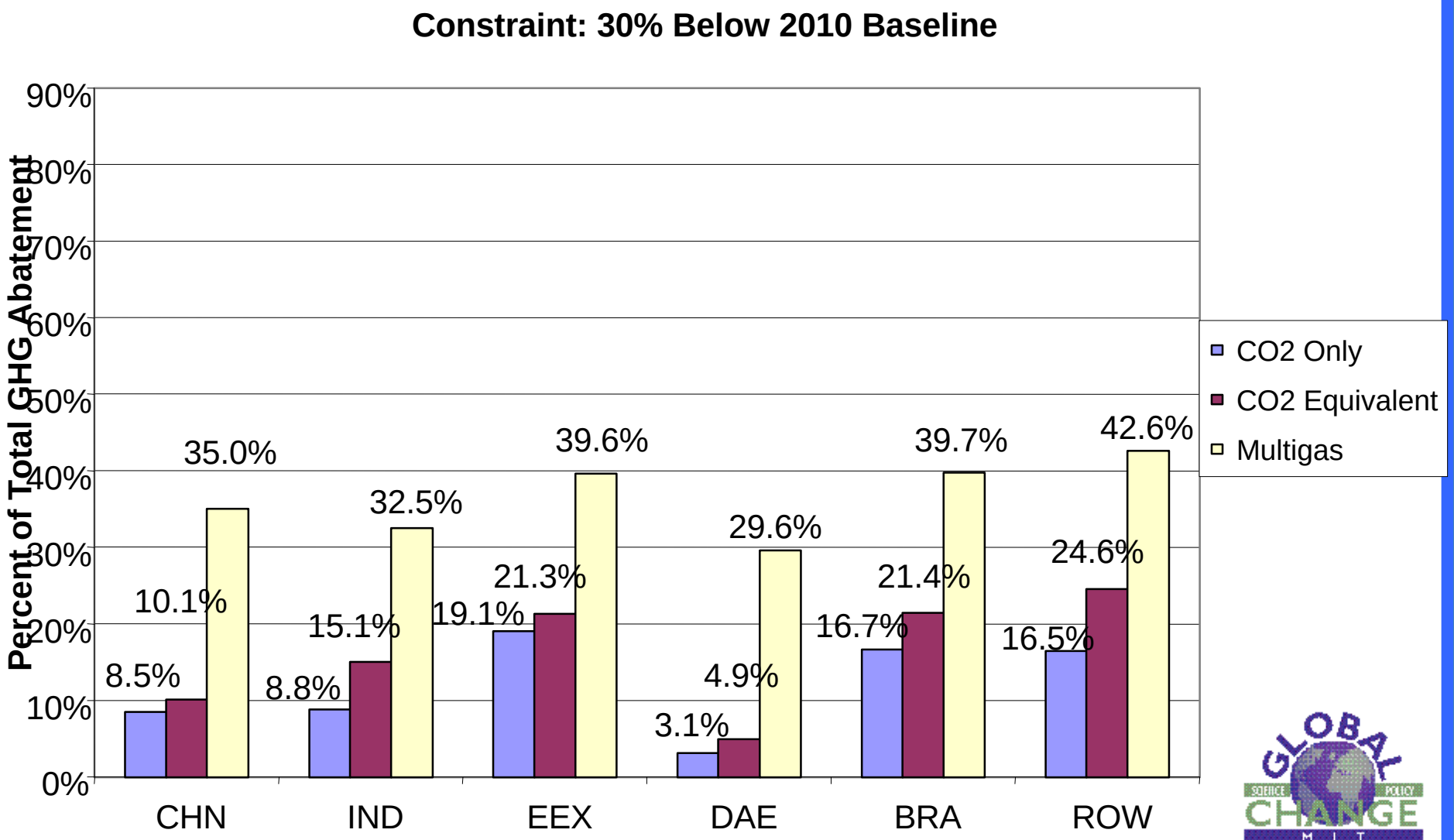
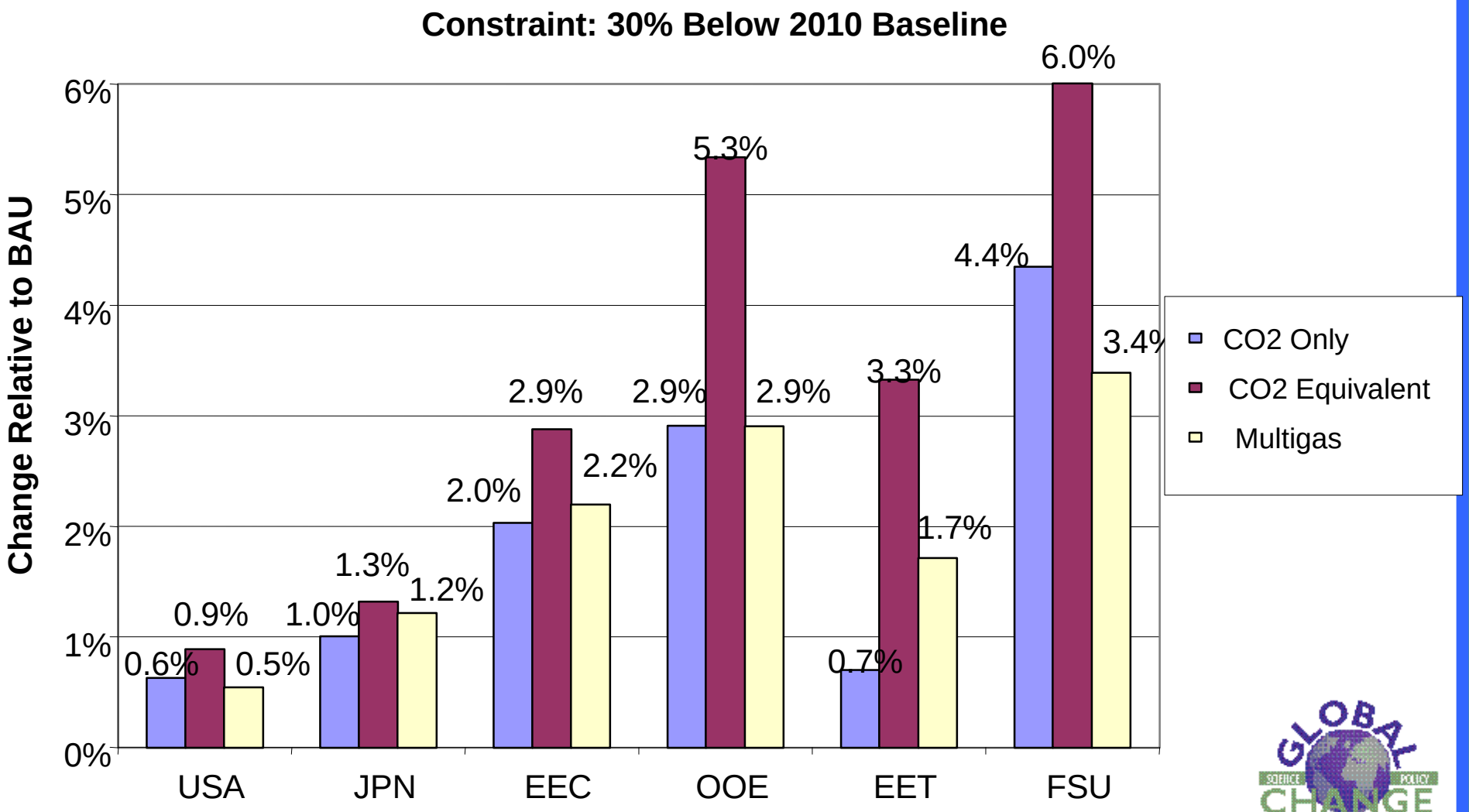


2010 Welfare Impacts-DevelopingCountries



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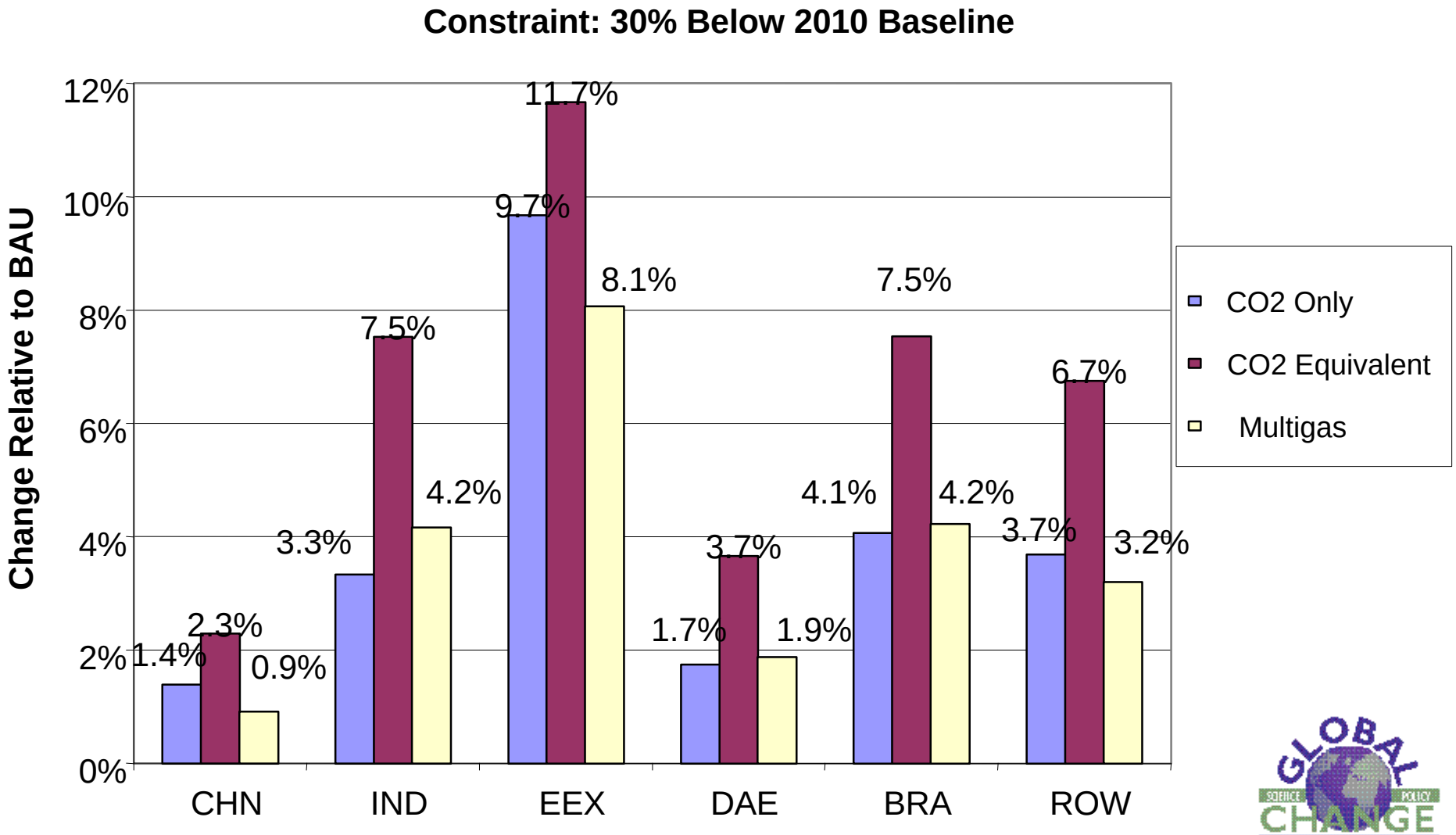

Conclusions

- Costs among countries are far different with equal percentage reductions and methane included than under Kyoto targets and CO2-only
- Equal percentage reductions for CO2 compared with Kyoto targets
  - Kyoto differences dominated by reference growth
  - Our cases show effects of economic structure
- Reasons for Differences
  - Energy exporters (e.g.FSU/EEX) and importers (e.g. US)
  - Reliance on coal (US, China, India)
  - Current energy taxation (Europe)
  - Efficiency of the economy (Japan)

Conclusions (cont.)

- Methane is very important, more so in developing countries.
  - In a CO2 and methane abatement strategy with small reductions from reference (10%), methane contributes 40 to 55% of abatement in most developed countries and 65 to 80% in developing countries
  - Methane abatement opportunities are limited, at least based on assessment of current technology, so that with larger reductions (30%) methane contributes 17 to 25% of the reduction in developed countries and 32 to 43% in developing countries.