Second Generation Model: A Global Economic-Environmental Framework

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Overview

- Second Generation Model
  - Motivation for model development
  - SGM regions and partner institutions
  - Model structure
- Typical Analysis
  - Energy Modeling Forum
  - Single-country studies
    - India
    - Germany
- Current Activities

SGM Introduction (1)

- Model type
  - Set of 14 multi-sector regional computable general equilibrium (CGE) models
  - Regional models (e.g., USA) can be run independently or as a system for international trade in carbon emissions rights
  - Dynamic-recursive with a time frame of 1990 through 2050 in five-year time steps
- Designed to address climate problem
  - Greenhouse gas emissions
  - Potential consequences of alternative policy options

SGM Introduction (2)

- Special features
  - Many of the regional models are developed jointly with analysts from that region
  - Model constructed in local currency
  - Capital stocks are segmented into five-year vintages
  - Calibration to base-year energy balances
  - Specific electric generating technologies
- Objectives
  - Analysis of energy system and cost of reducing greenhouse gas emissions
    - Support to U.S. Government
    - Participation in Stanford Energy Modeling Forum
    - Country studies
  - Improve realism of models for developing countries
  - Build analytical capability outside U.S.

SGM Regions

- Annex I
  - United States
  - Canada
  - Western Europe
  - Japan
  - Australia and New Zealand
  - Former Soviet Union
  - Eastern Europe
- Non-Annex I
  - China
  - India
  - Brazil
  - Middle East
  - Mexico
  - South Korea
  - Rest of World

Partner Institutions

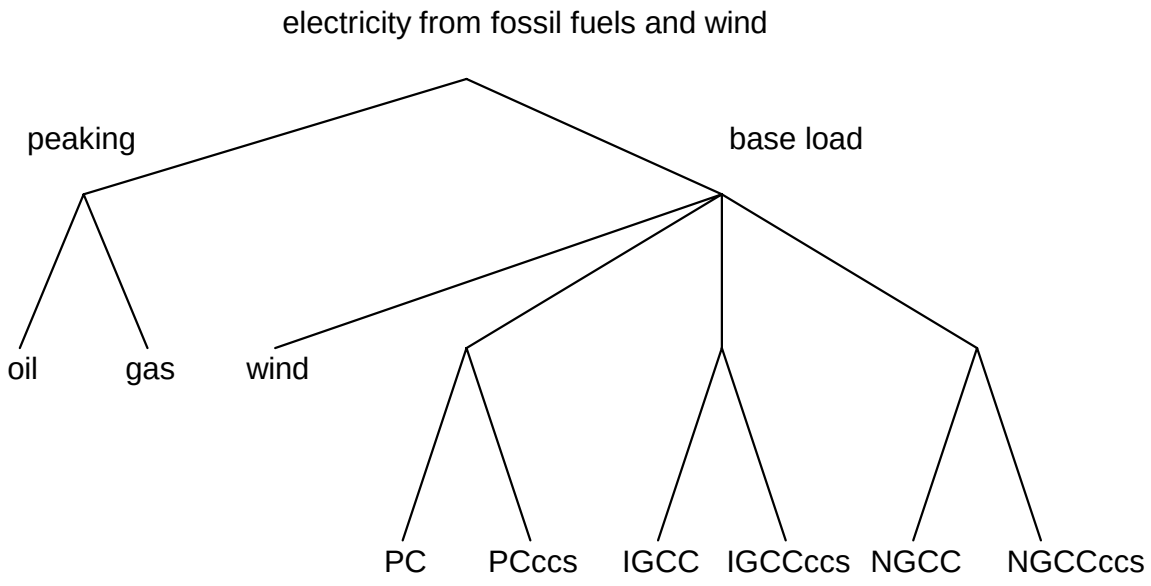
- Annex I
  - National Institute for Environmental Studies (Tsukuba, Japan)
  - German Institute for Economic Research (Berlin)
- Non-Annex I
  - Energy Research Institute (Beijing, China)
  - Indian Institute of Management (Ahmedabad)
  - Federal University of Rio de Janeiro (Brazil)
  - Instituto Mexicano del Petroleo (Mexico City)
  - Sungkyunkwan University (Seoul, South Korea)

Typical Set of SGM Production Sectors

1 agriculture
2 everything else (including services)
3 crude oil production
4 natural gas production
5 coal production
6 coke
7 electricity generation
8 oil refining
9 distributed gas
10 paper and pulp
11 chemicals
12 non-metallic minerals
13 primary metals
14 food processing
15 other industry and construction (including other mining)
16 rail and land transport
17 other transport

Electricity Sector

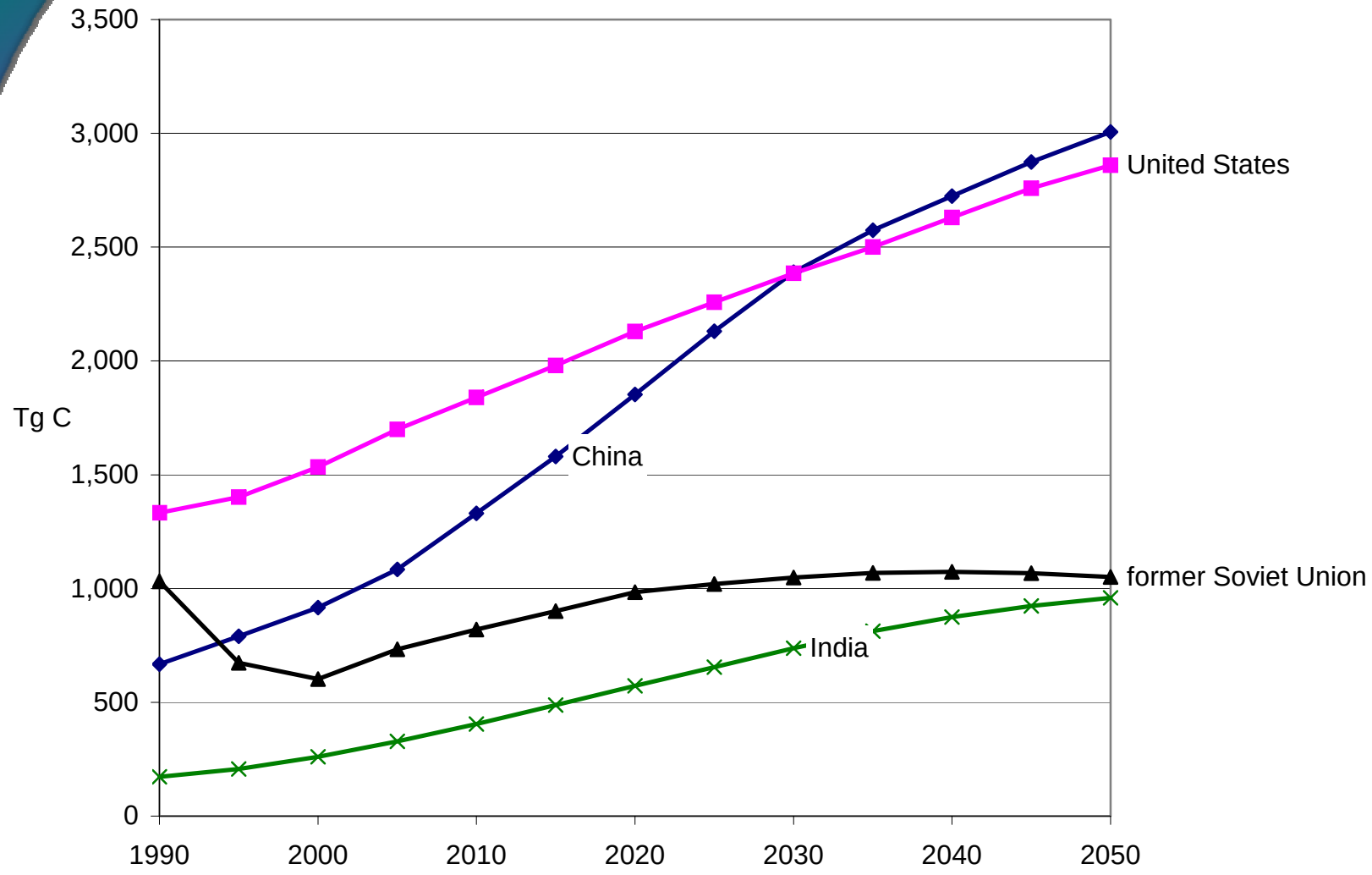
- All production sectors other than electricity represented by single CES production function
- Each electric generating technology represented by fixed-coefficient production function (or CES production function with very low elasticity of substitution)
- Electricity sector uses a nested logit structure to allocate new investment to generating technologies



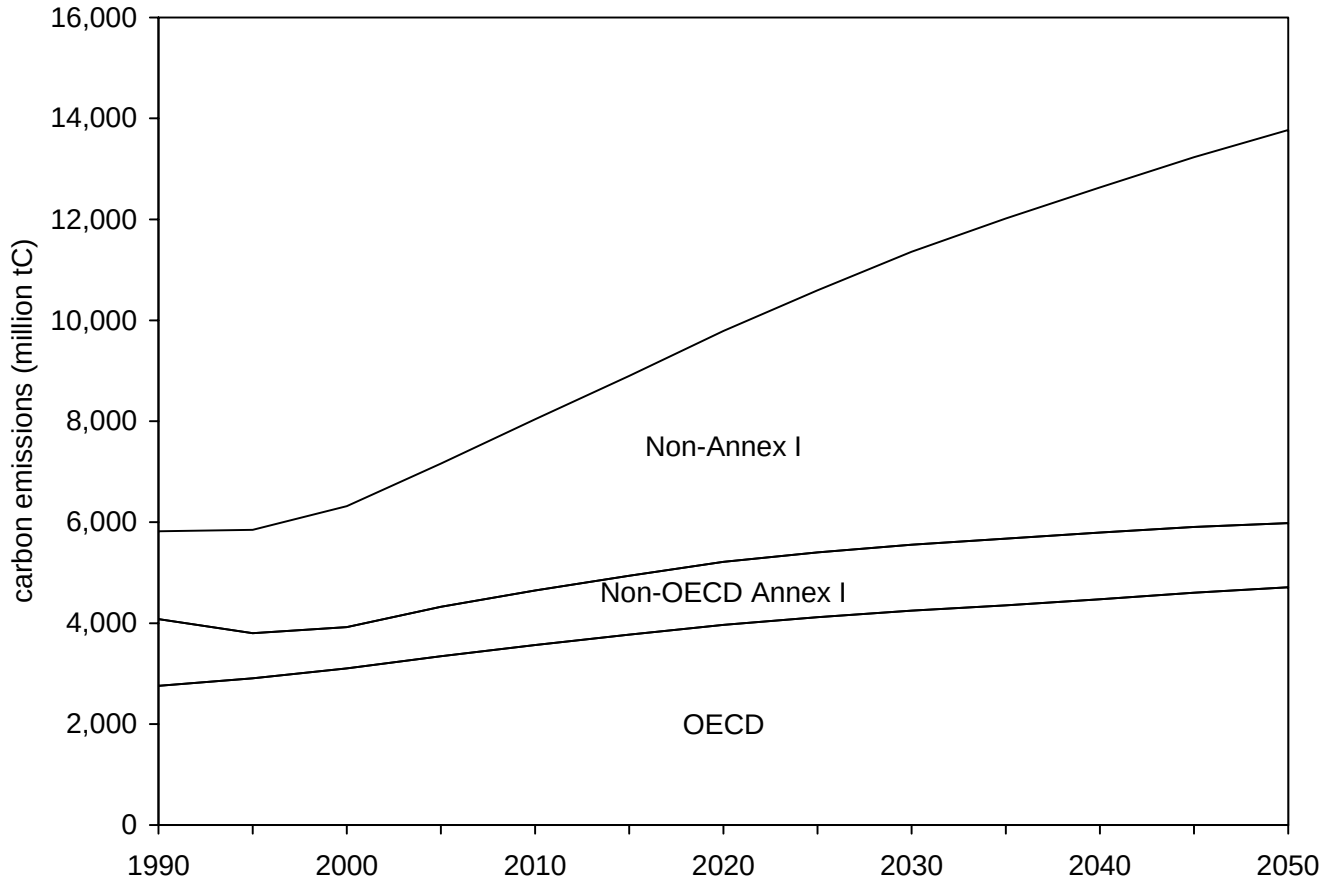
Energy Modeling Forum Studies

- EMF-14
  - Stabilize concentrations of CO_2
- EMF-16
  - Cost of meeting Kyoto targets
- EMF-19
  - Role of advanced energy technologies
- EMF-21
  - Non-CO_2 greenhouse gases and carbon sinks
- EMF-22
  - Transition scenarios toward atmospheric stabilization
  - Land-based sequestration and greenhouse gas mitigation

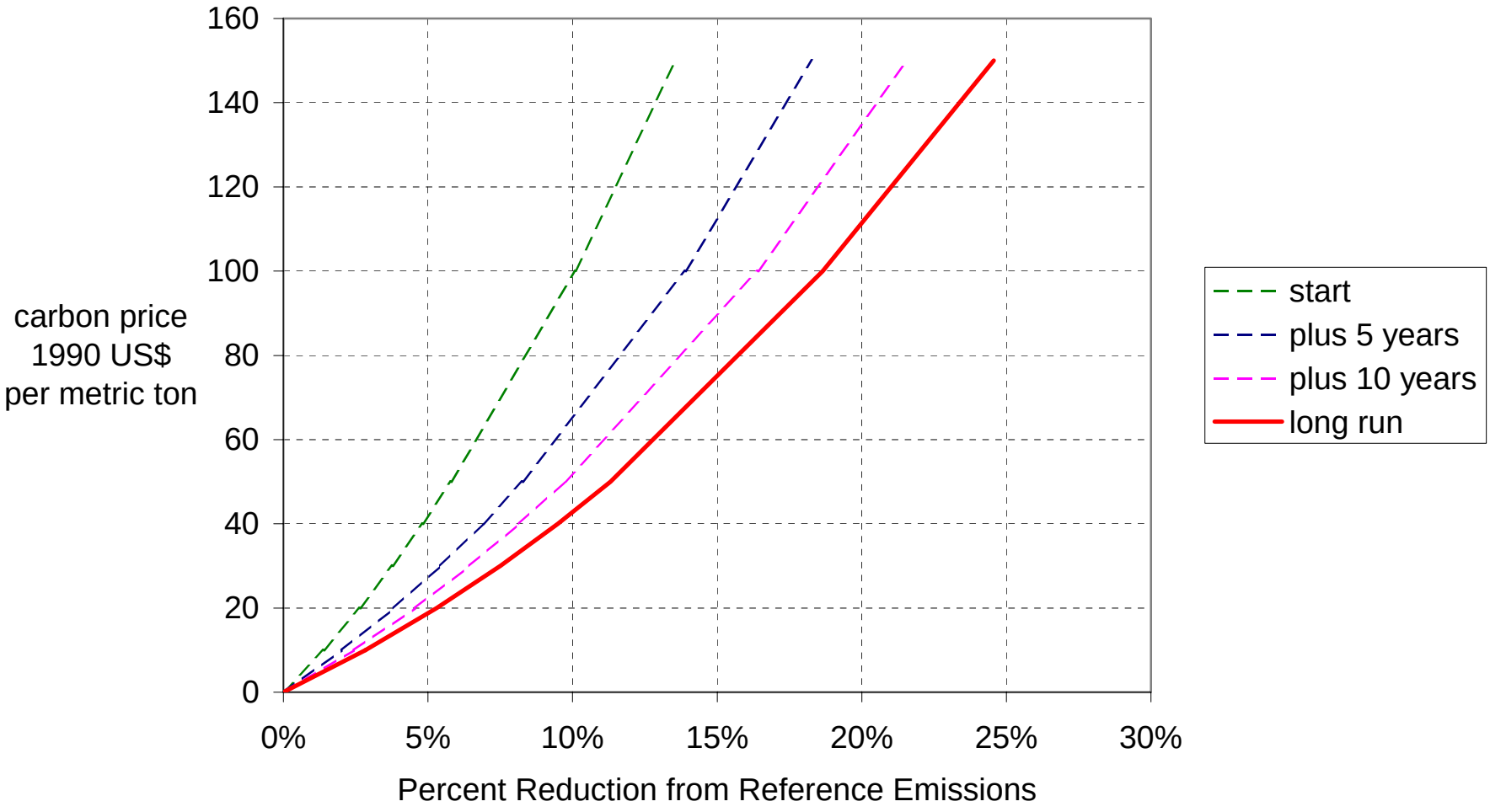
SGM Reference Carbon Emissions: Selected Regions



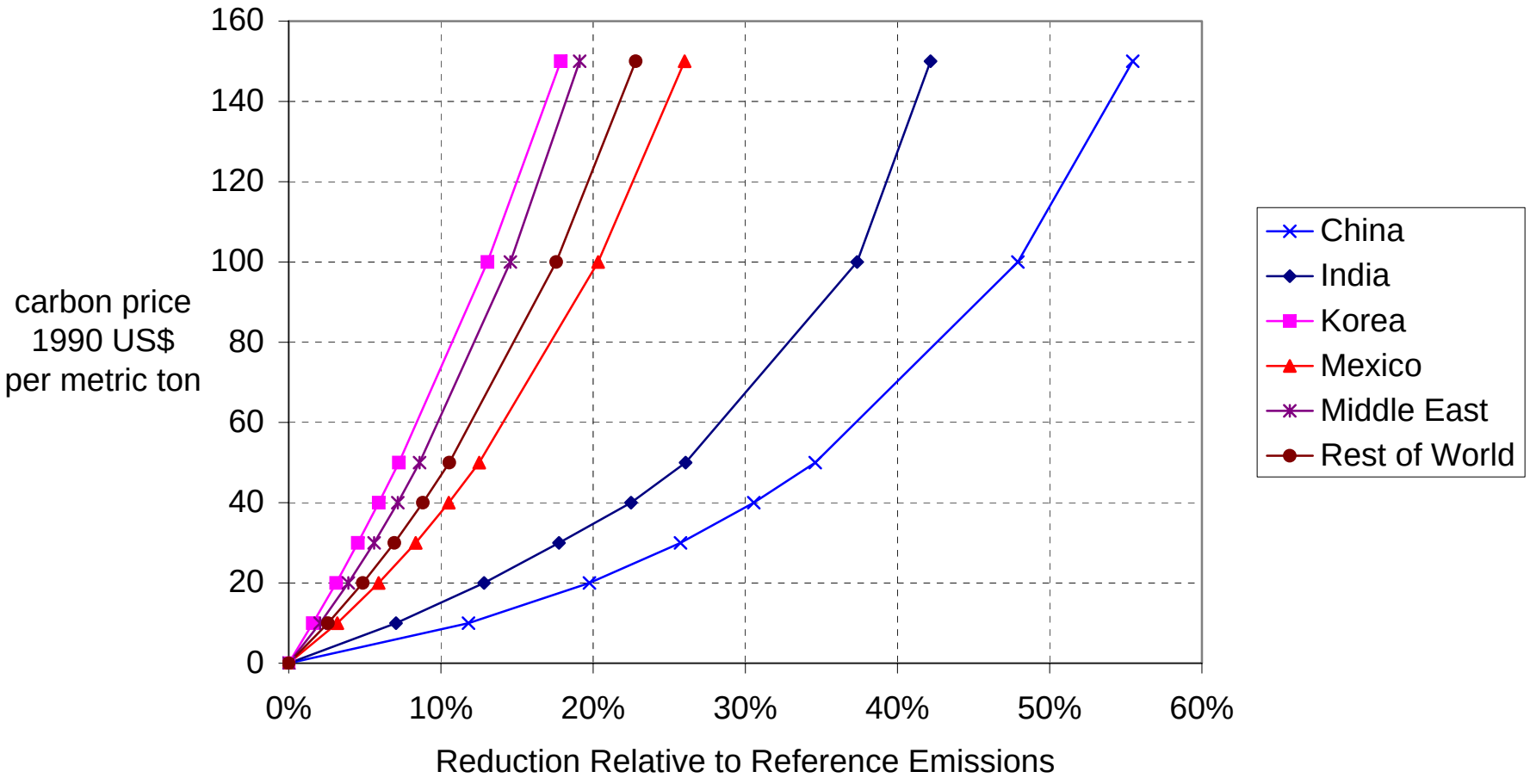
EMF-19 Baseline Scenario



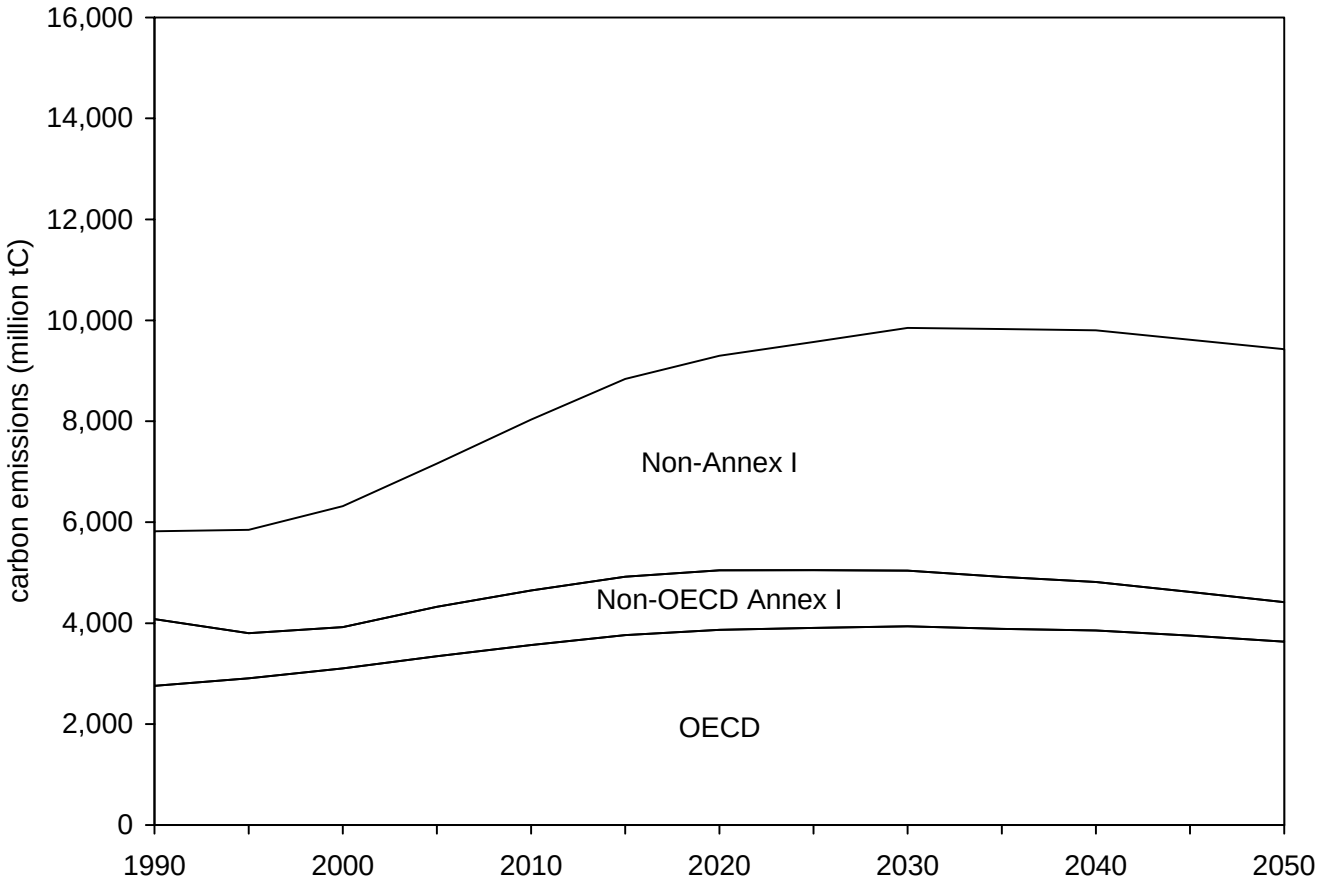
Marginal Abatement Curves
United States



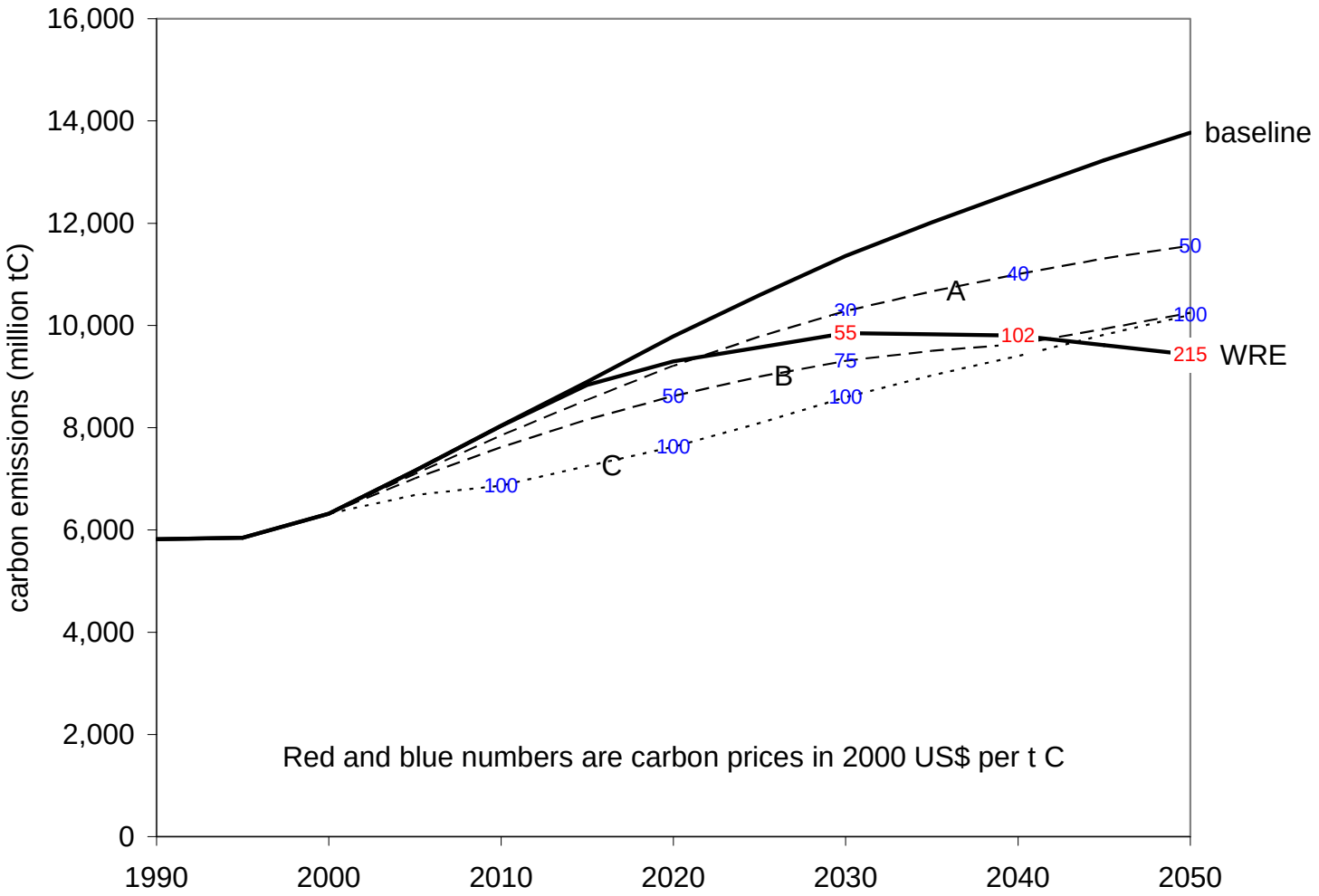
Marginal Abatement Curves for Non-Annex I Regions



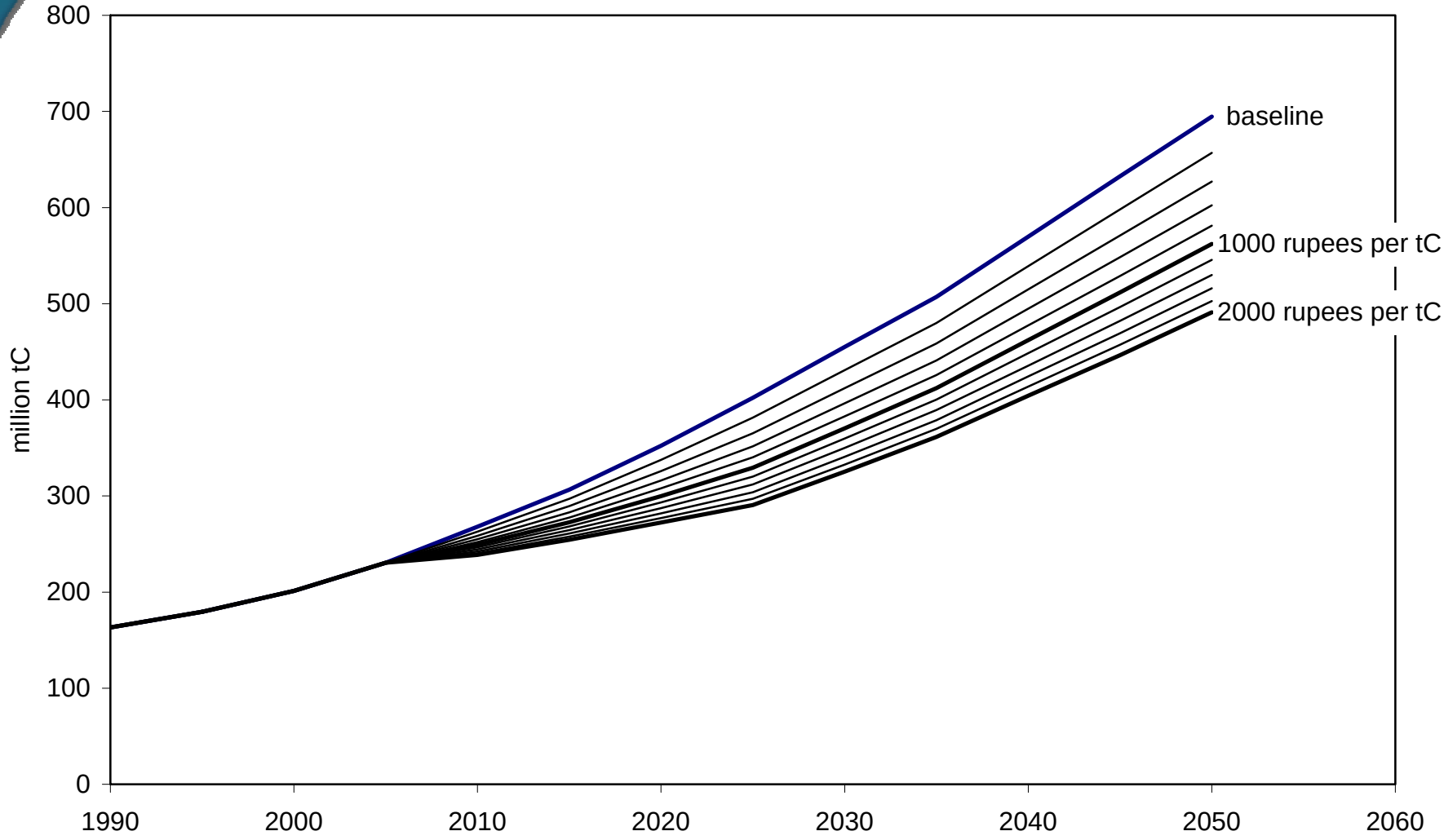
EMF-19 Stabilization Scenario (WRE 550 ppm)



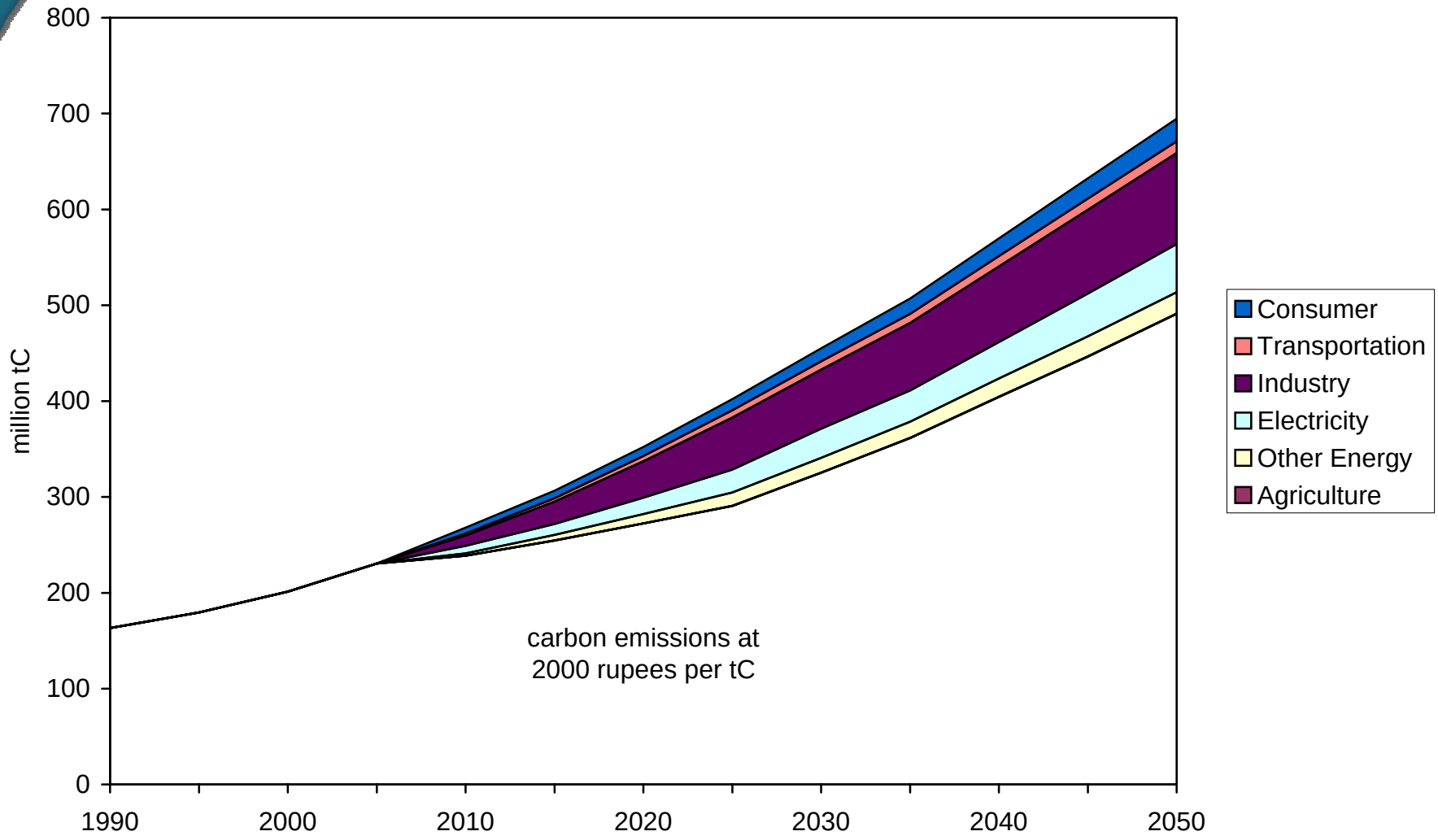
EMF-19 Global Mitigation Scenarios



SGM-India Carbon Emissions



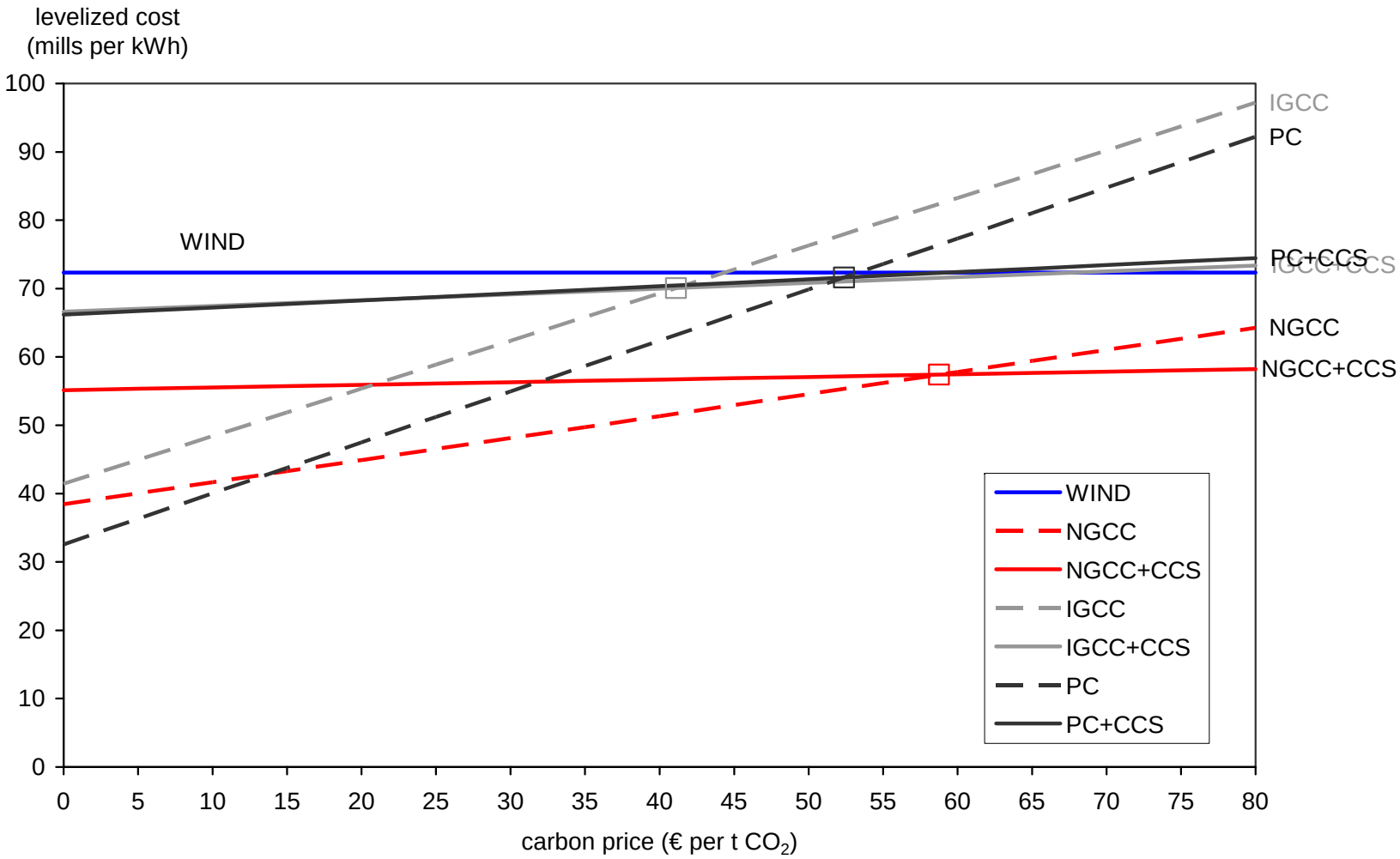
SGM-India: Components of Emissions Reduction



Engineering Cost Model for Electricity

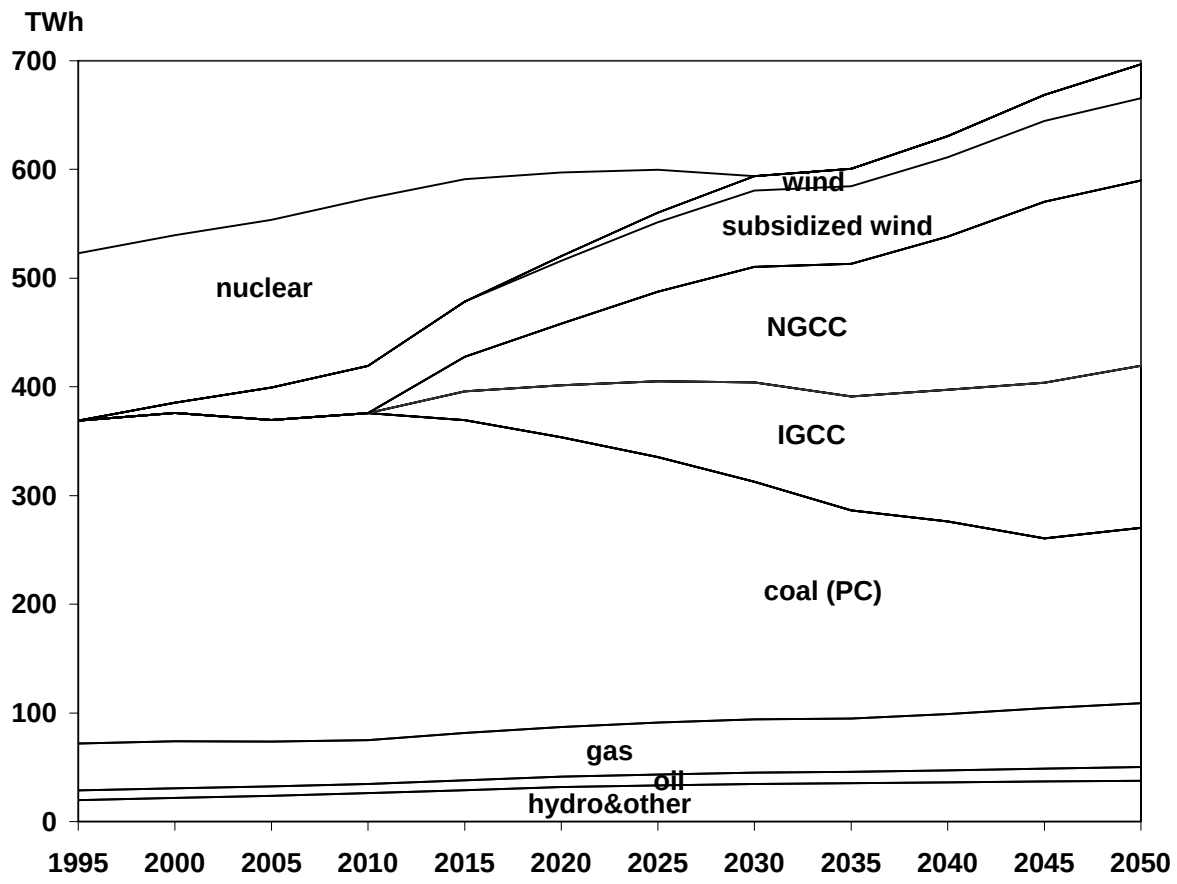
- Hypothetical plant
  - First cost of capital ($ per kW)
  - Interest rate
  - Equipment lifetime (years)
  - Heat rate (efficiency)
  - Operation and maintenance (mills per kWh)
  - Price of fuel ($ per GJ)
  - Carbon emissions coefficient (kg C per GJ)
- Calculate levelized cost per kWh for each generating technology

Crossover price for electricity technologies (SGM-Germany)

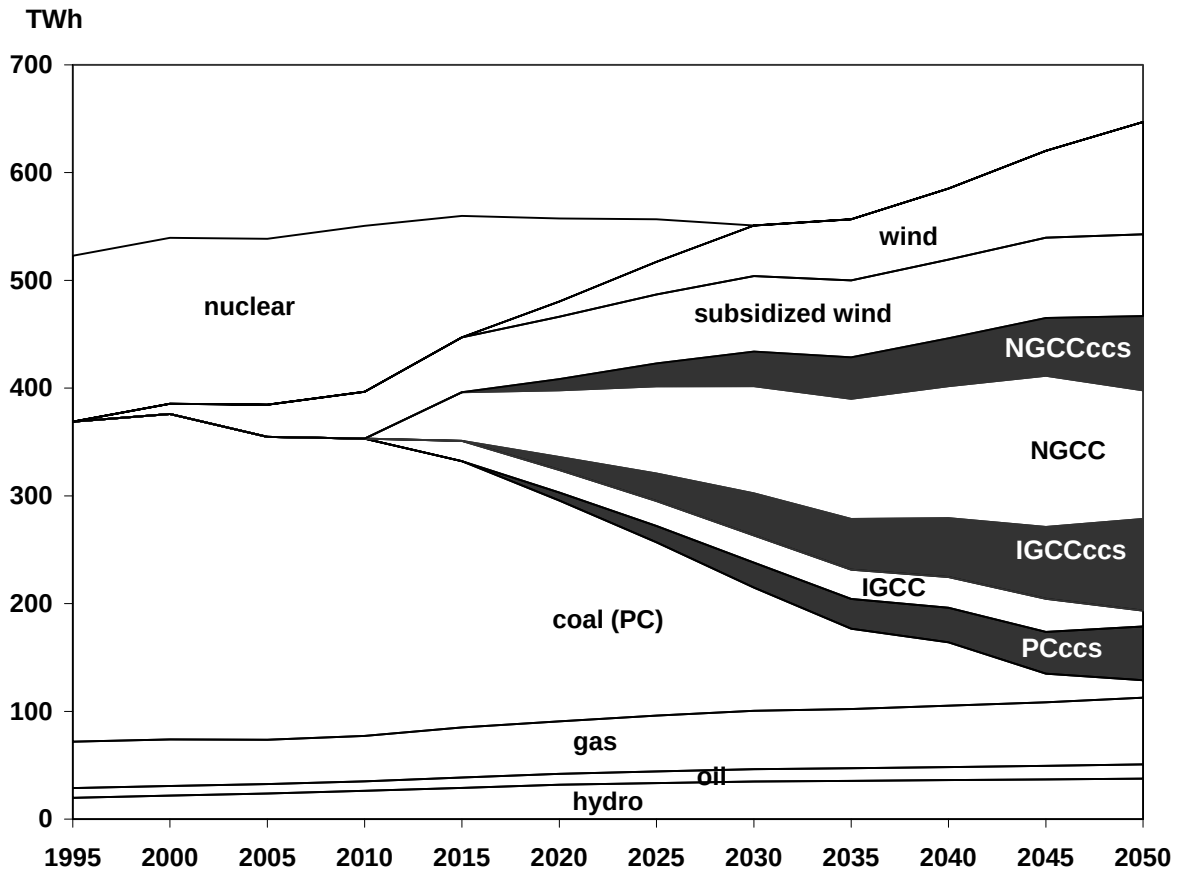


Assuming 7% interest rate, 2010 fuel prices (4.71€/GJ gas, 1.76 €/GJ coal)

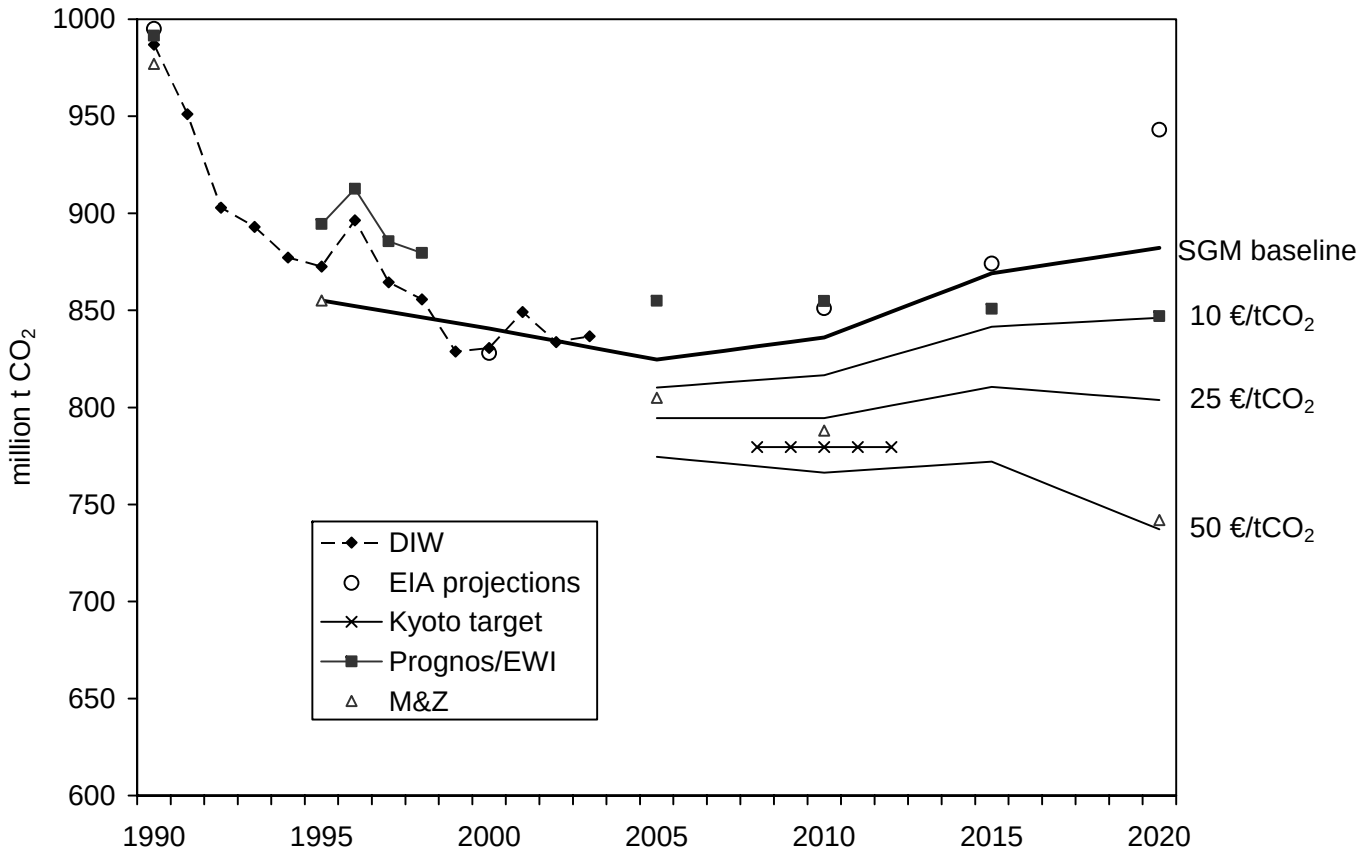
Electricity Baseline in SGM-Germany



Electricity Sector at 50 € per t CO_2 in SGM-Germany



Projections of Carbon Dioxide Emissions in Germany (Mt CO_2)



Current Activities

- Update global SGM data set
  - Advance base year
  - Selective use of data from Global Trade Analysis Project (GTAP)
  - Support for full international trade in model
- Analysis of near-term mitigation opportunities
  - SGM-Japan
  - SGM-Germany
- Improve representation of developing countries
  - Potential for biofuels in India and China
  - SGM-Mexico