Top-Down Economic Modeling of Developing Countries

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Overview

- Second Generation Model
  - Motivation for model development
  - SGM regions and partner institutions
  - Model structure
- Typical Analysis
  - Marginal abatement cost curves
  - Sample results for India and China
- Current Activities
  - Review by EPA Science Advisory Board
  - Dialogue with GTAP group
  - Embedding partial-equilibrium agriculture and land use model into a general-equilibrium model (SGM)

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

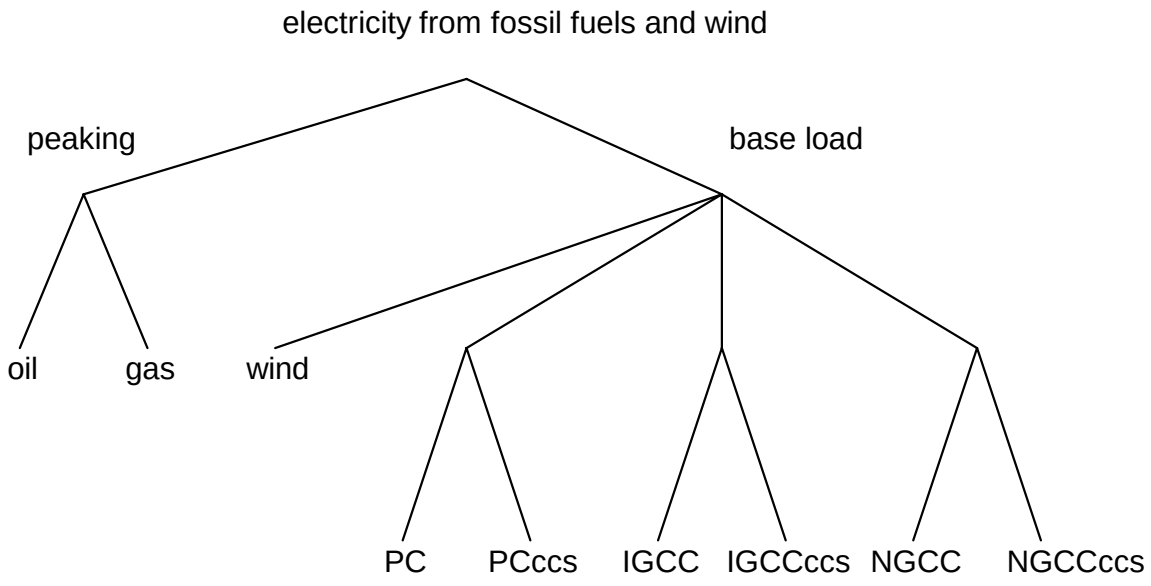
- Annex I
  - National Institute for Environmental Studies (Tsukuba, Japan)
  - German Institute for Economic Research (Berlin)
- Non-Annex I
  - Energy Research Institute (Beijing, China)
  - Indian Institute of Management (Ahmedabad)
  - Federal University of Rio de Janeiro (Brazil)
  - Instituto Mexicano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

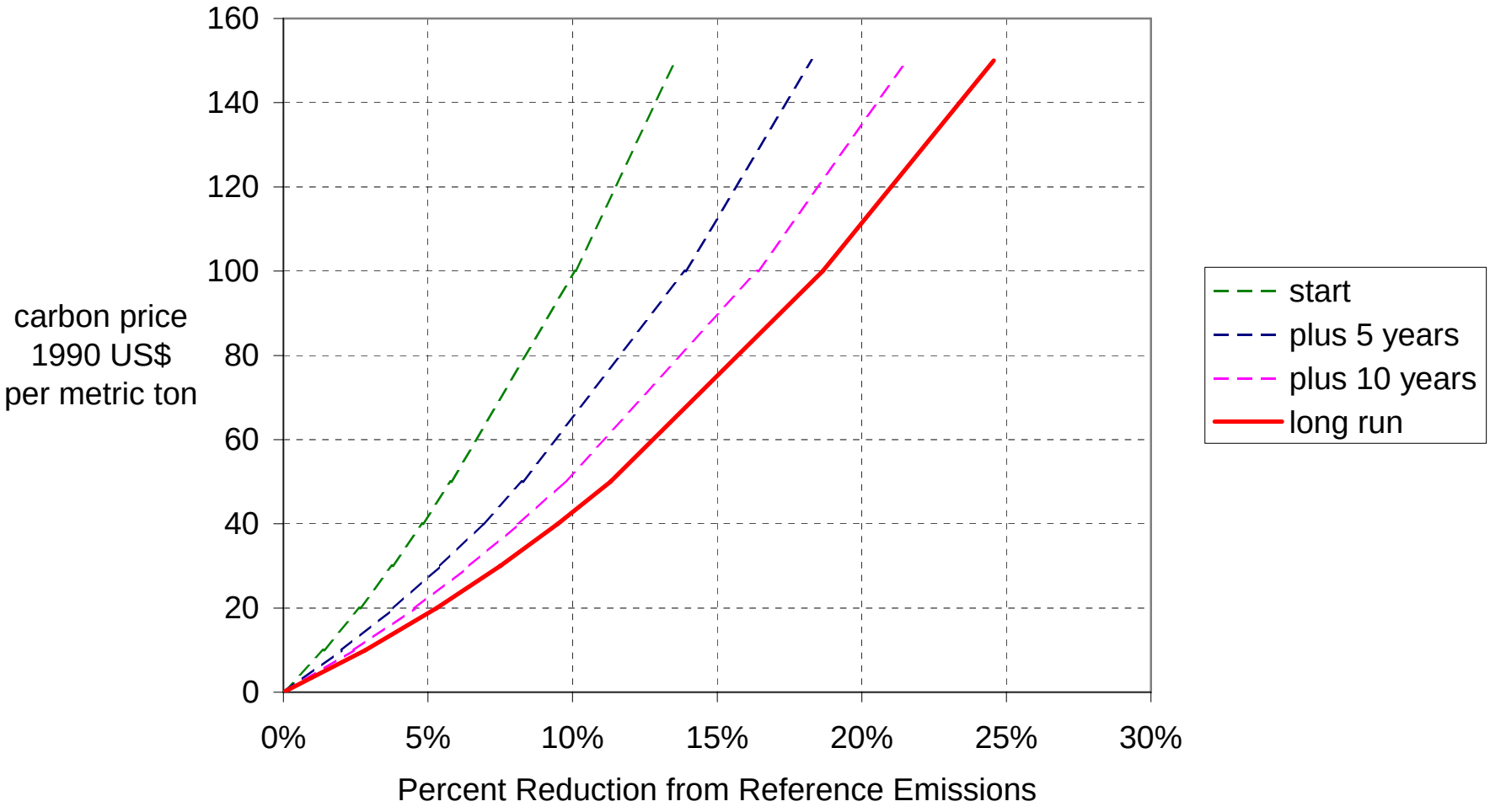
- All production sectors other than electricity represented by single CES production function
- Each electric generating technology represented by fixed-coefficient production function (or CES production function with very low elasticity of substitution)
- Electricity sector uses a nested logit structure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



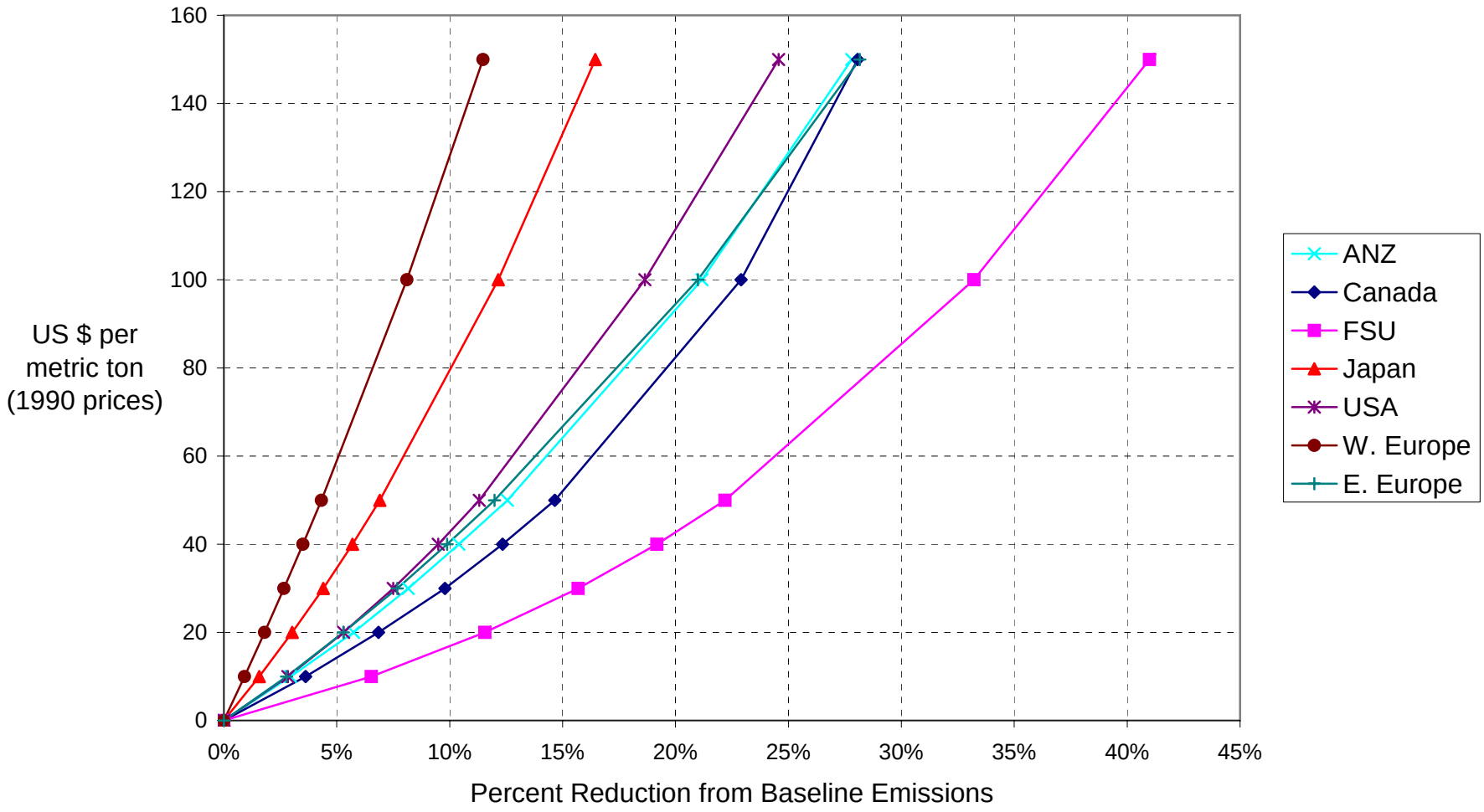
Energy Modeling Forum Studies

- 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

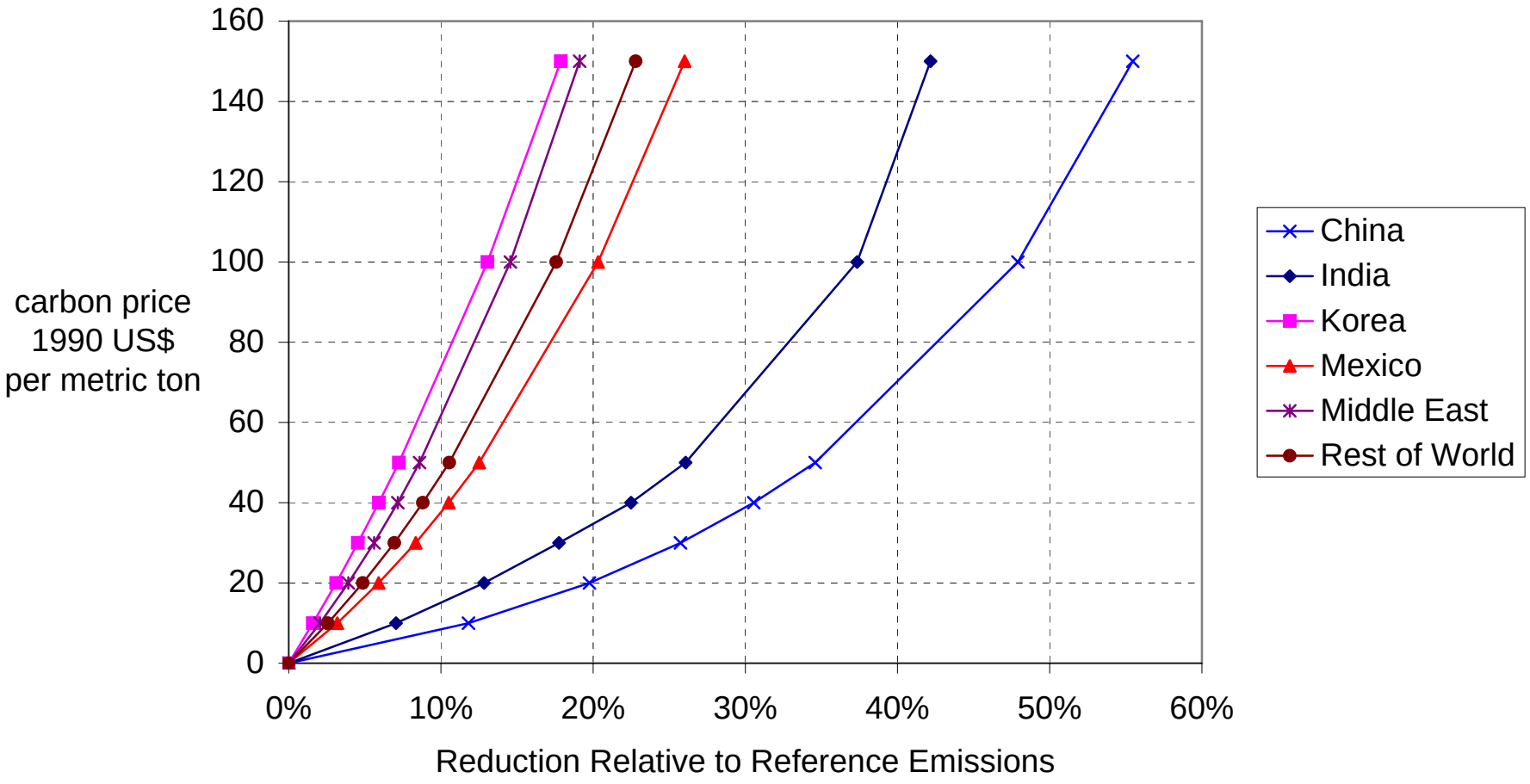
Marginal Abatement Curves
United States



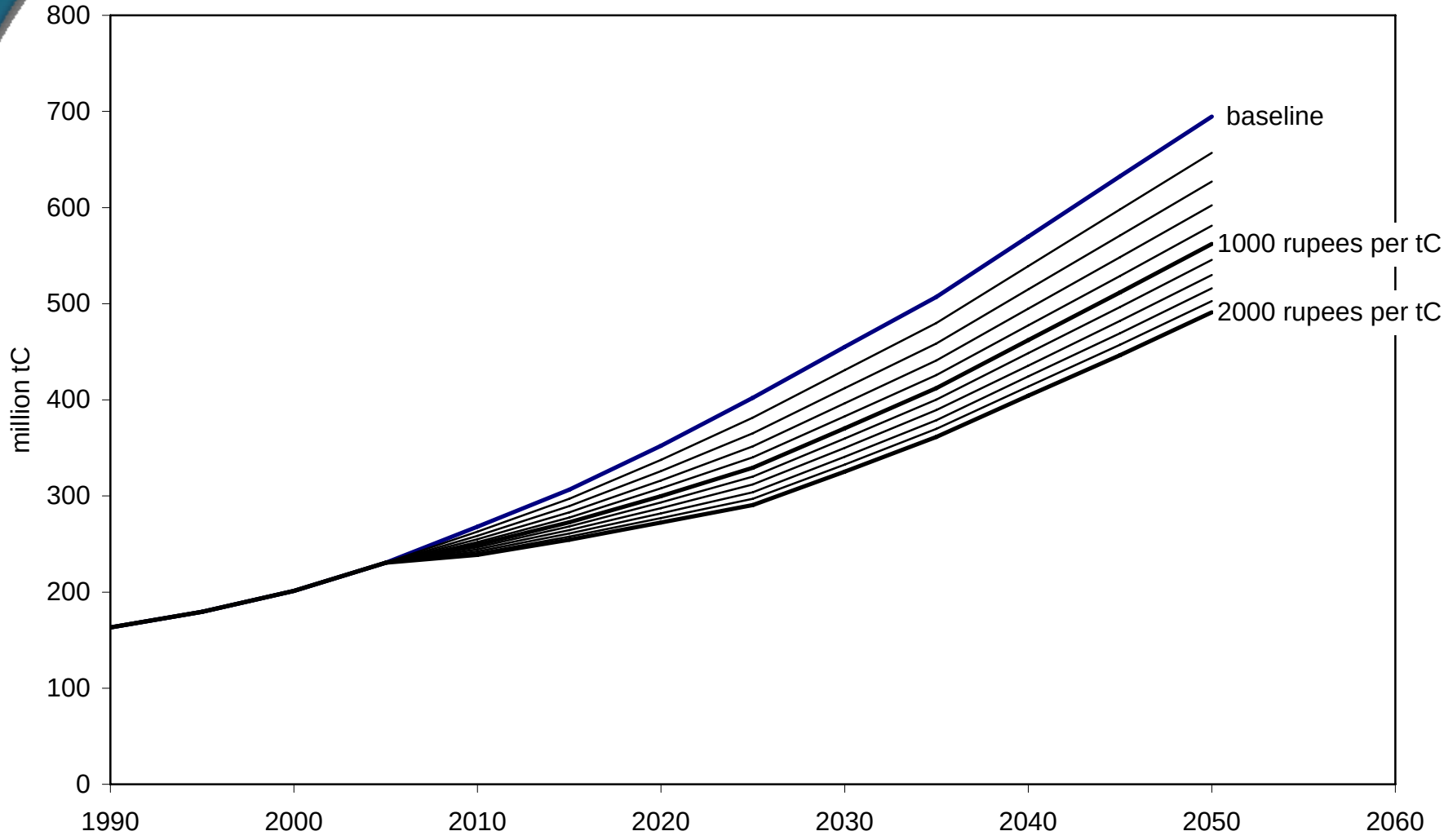
Long-Run Marginal Abatement Curves
Annex I Regions



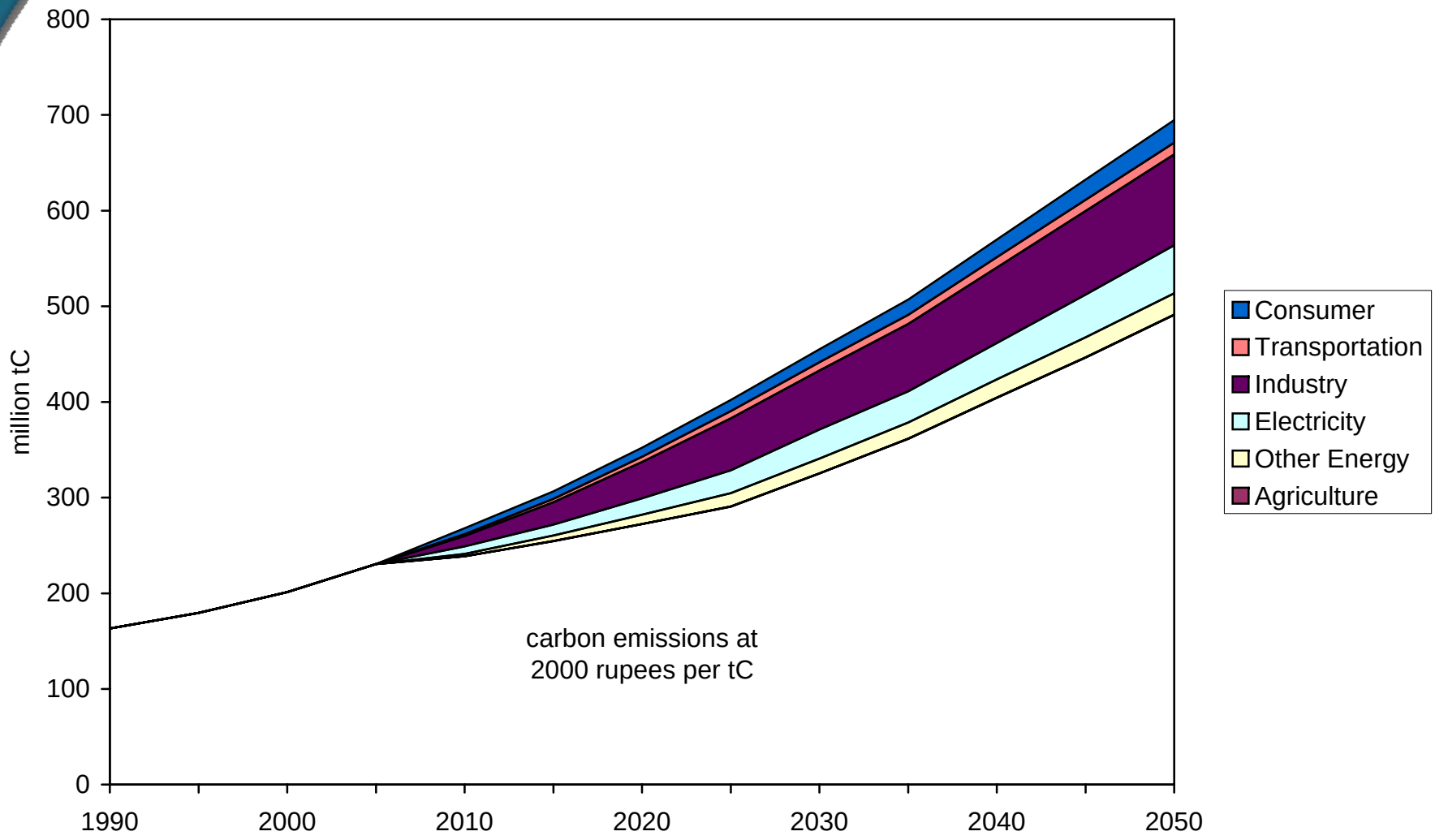
Marginal Abatement Curves for Non-Annex I Regions



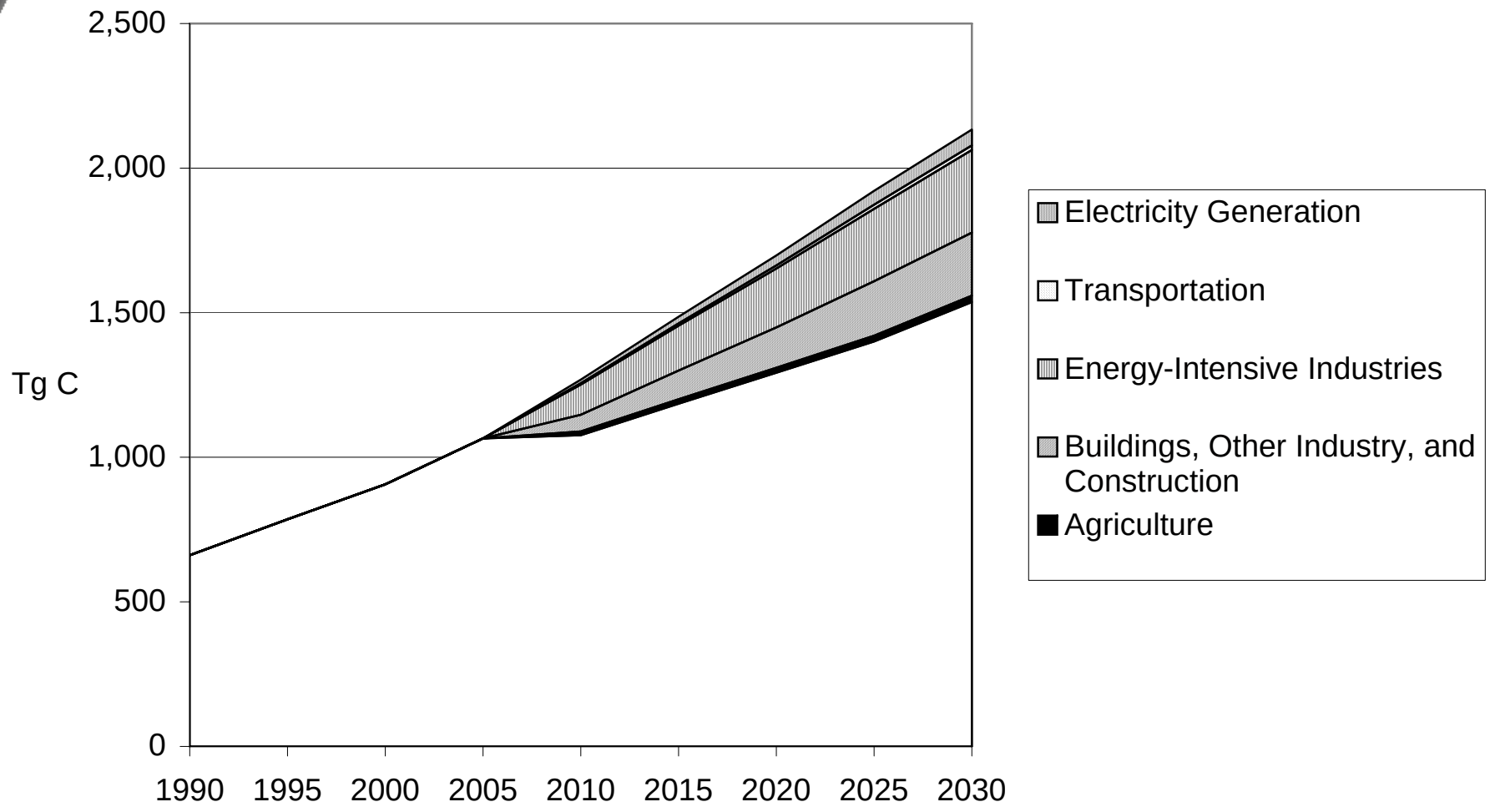
SGM-India Carbon Emissions



SGM-India: Components of Emissions Reduction



SGM-China Carbon Emissions
Response to 300 yuan per ton carbon price in 2010



Current Activities

- EPA Science Advisory Board
  - Intense review of SGM theory, data, and behavioral parameters
  - Draft advisory and areas for model enhancement
- Dialogue with GTAP
  - GTAP – SGM data comparison for China
  - Improving GTAP data base for analysis of climate and energy policy
- Agriculture, Land Use, and CGE Models
  - Topic of EMF-22 land use subgroup
  - Porting PNNL Agriculture and Land Use (AgLU) to SGM
  - Disaggregate regions into land classes

EPA Science Advisory Board

"The U.S. Environmental Protection Agency's (EPA) Office of Atmospheric Programs (OAP) requested that the SAB provide advice on a computable general equilibrium (CGE) model known as the Second Generation Model (SGM). The OAP is requesting the SAB to provide comments on the appropriateness and usefulness of the SGM model for estimating the economic effects of climate policies."

http://www.epa.gov/sab/panels/sgm_adv_panel.htm

SGM documentation can be found at:

http://www.epa.gov/air/sgm-sab.html

SAB Process

- US EPA Assembled Group of 11 Economists in Fall 2004
- PNNL Provided Model Documentation
- Series of Conference Calls and One Face-to-Face Meeting
- Product will be an “Advisory”
- Interim Draft Advisory Identified Several Areas for Model Development
  - Update the data set
  - Model simulation exercises
  - International trade
  - Household utility and welfare
  - Production functions
  - Other greenhouse gases
  - Sector-specific policies

Current Model Development: Update Data Set

- Move model base year forward
  - Most SGM regional models use 1990 as base year
- Support for full international trade
  - Current framework clears international market for emissions permits, but not other goods
  - Need to standardize set of tradable sectors across SGM regions
- Determine the extent that data from the GTAP group (Global Trade Analysis Project) can be useful
  - Base years are 1997 (GTAP 5.4) and 2001 (GTAP 6)
  - GTAP provides benchmark data set with balanced trade for all goods, but all data are in US dollars and the energy balances are not as detailed as can be obtained elsewhere
  - One strategy is to begin with GTAP data and enhance with other data as appropriate

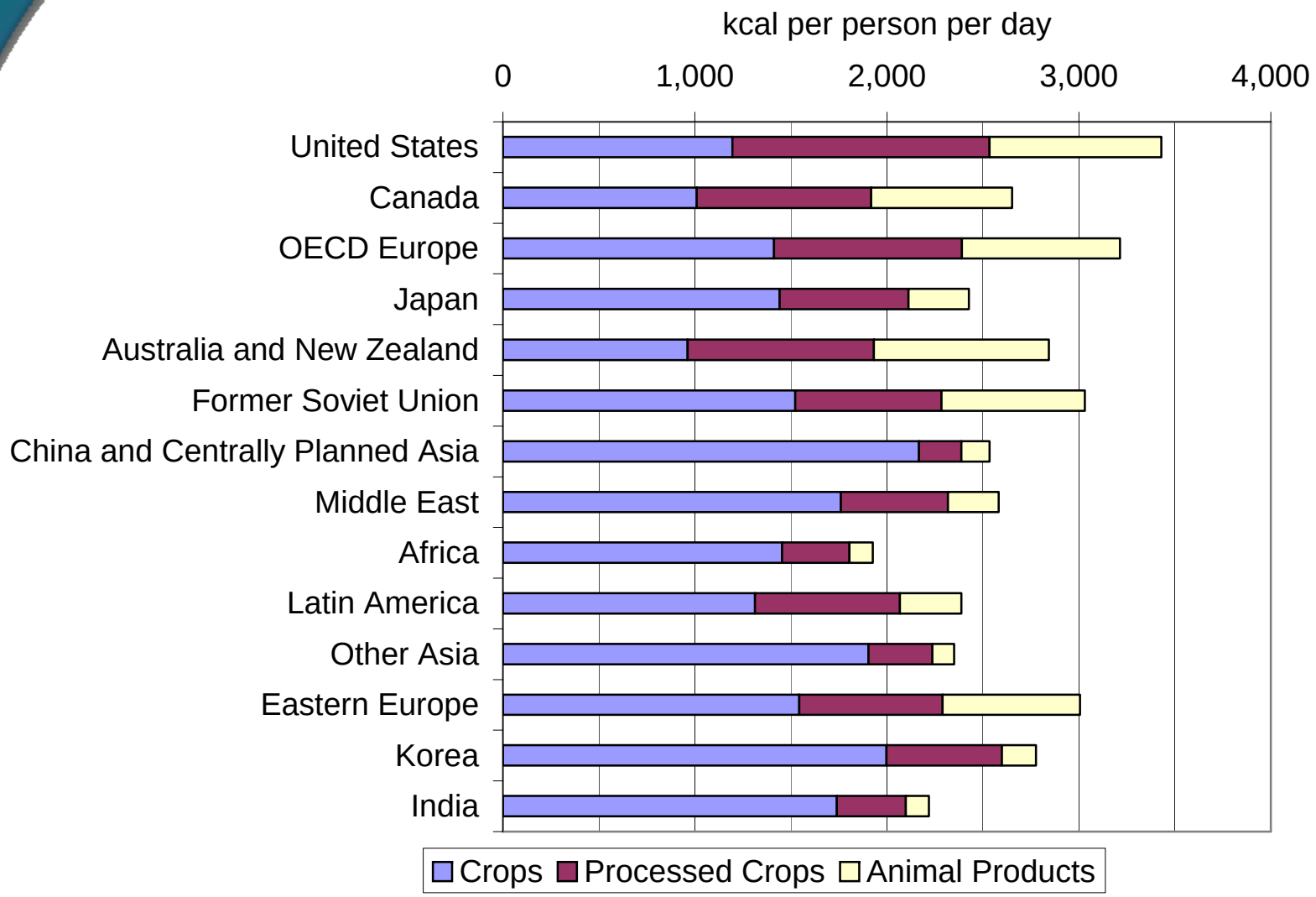
GTAP - SGM Data Comparison

- Begin with identical data sets
  - 1997 China input-output table
  - 1997 energy balances from International Energy Agency
- Compare approaches for constructing benchmark data set
  - GTAP procedures
  - SGM hybrid input-output table
- Dialogue started between PNNL, EPA, and GTAP group on ways to enhance GTAP data sets

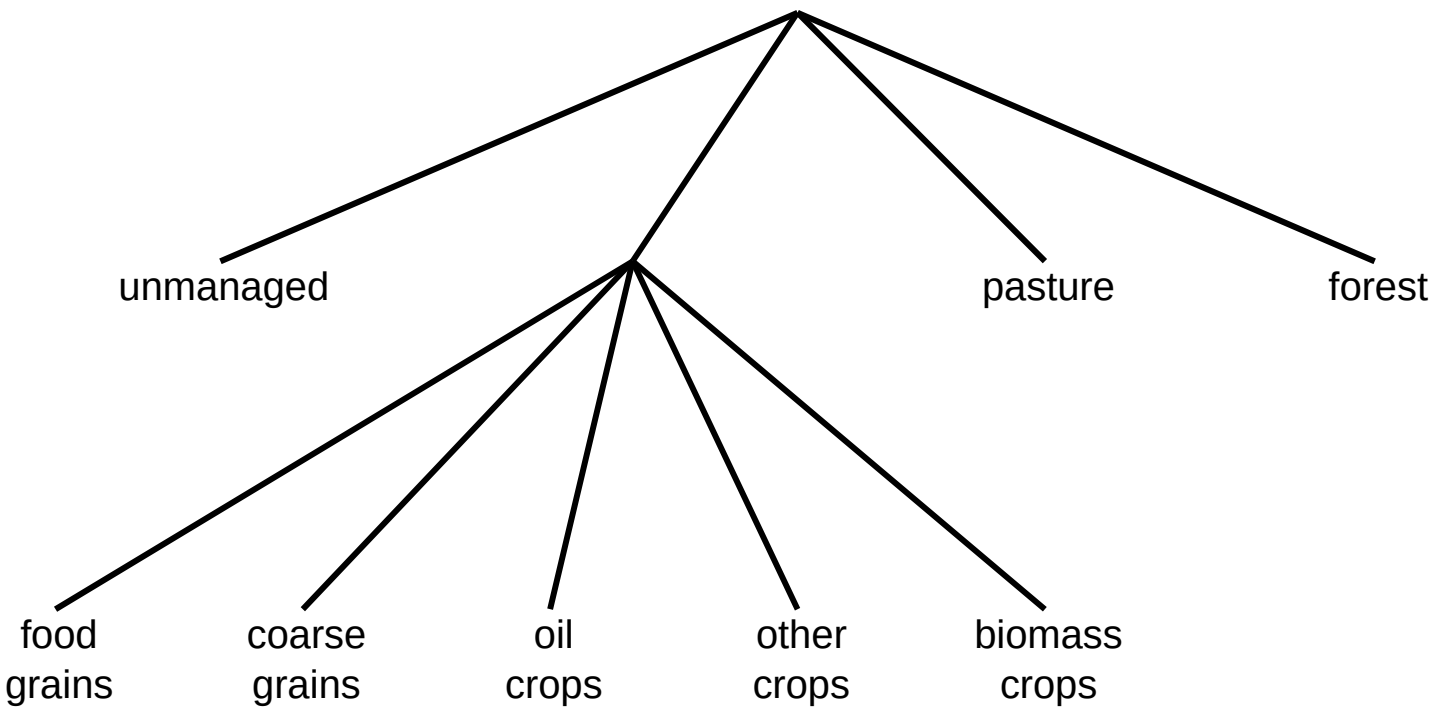
Agriculture and Land Use in a CGE Framework

- Goals
  - Better representation of agricultural system in SGM, especially for developing countries
  - Provide SGM with the capability to simulate all major classes of greenhouse gas mitigation options, including biofuels
  - Allow SGM to be used for studies of climate impacts
  - Provide a platform for broader participation of developing country researchers in the Stanford Energy Modeling Forum
- Approach is to combine system equations for AgLU with CGE system equations
- Embed AgLU in a computable general equilibrium model (SGM)
  - Full set of inputs to production
  - Land allocator replaces land market
  - Biomass as a link between agricultural and energy systems

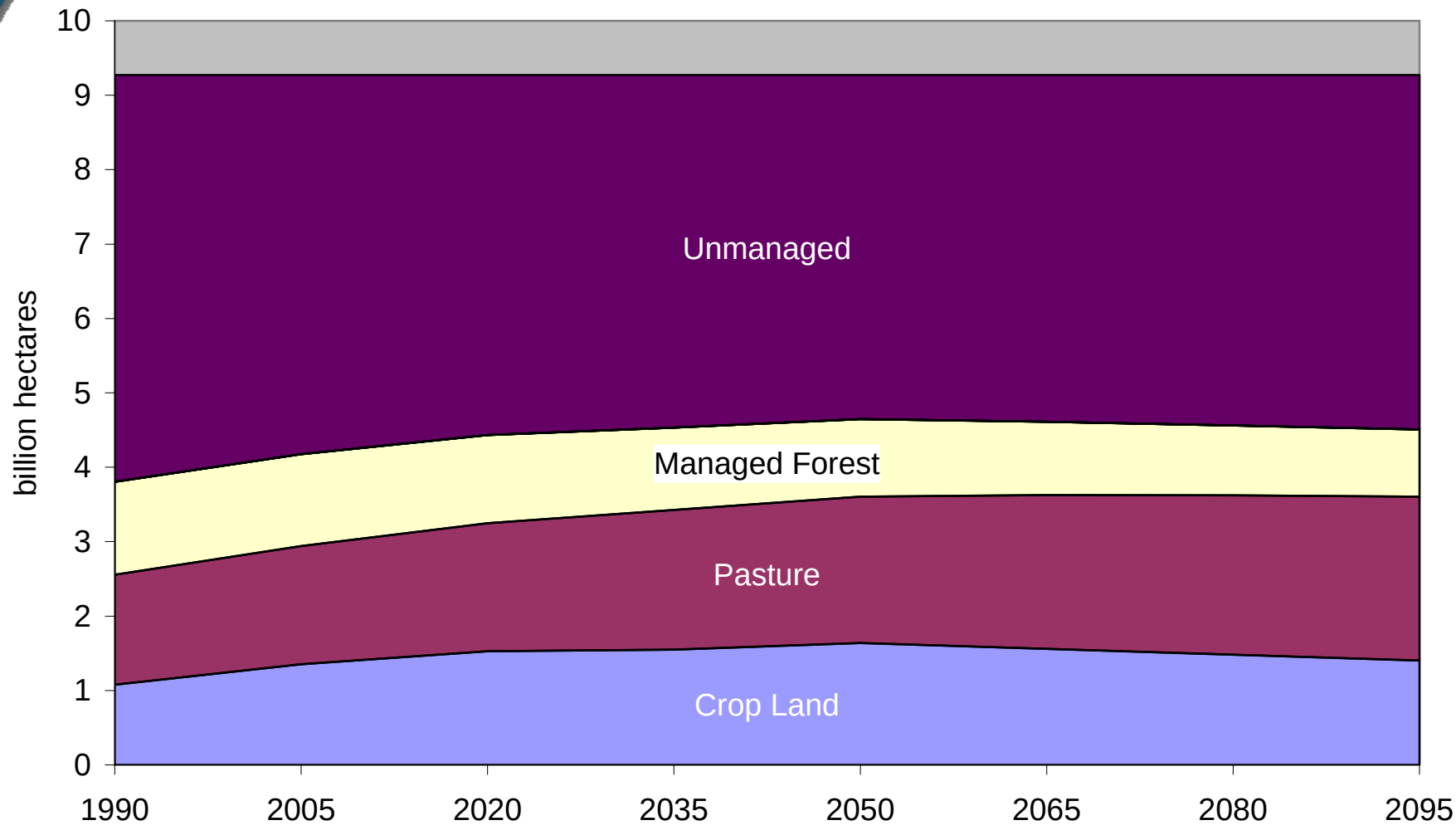
Food Consumption by AgLU Region



AgLU Land Allocation



Land Use (without carbon policy)



Future Directions

- International Trade
  - We are working to close SGM markets in all internationally traded commodities
- Production Functions
  - Improve empirical support for nesting structure and behavioral parameters (elasticities)
- Utility Function-Based Household Sector
  - We are replacing the current set of demand equations with a set of demand equations derived from a utility function. This change will allow the calculation of economic costs in terms of welfare.
- Endogenous Non-CO2 Greenhouse Gas Emissions
  - We plan to explore the option of modeling non-CO2 GHG emissions as a fully endogenous behavior
- Computational Environment
  - We are converting to an object-oriented computational environment to replace the present Fortran version of the model