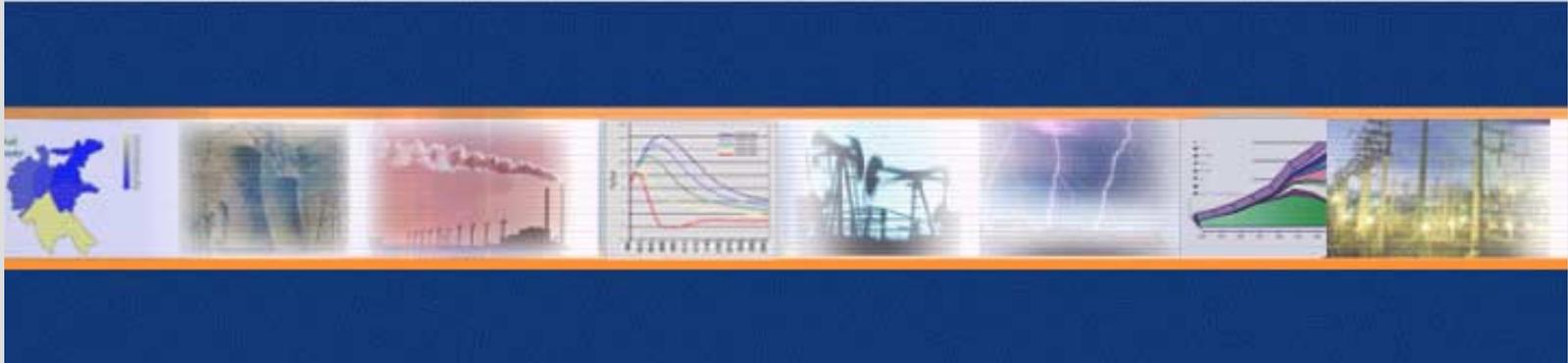




Indian Institute of Management, Ahmedabad

Integrated Environment Modeling and Analysis for India P.R. Shukla

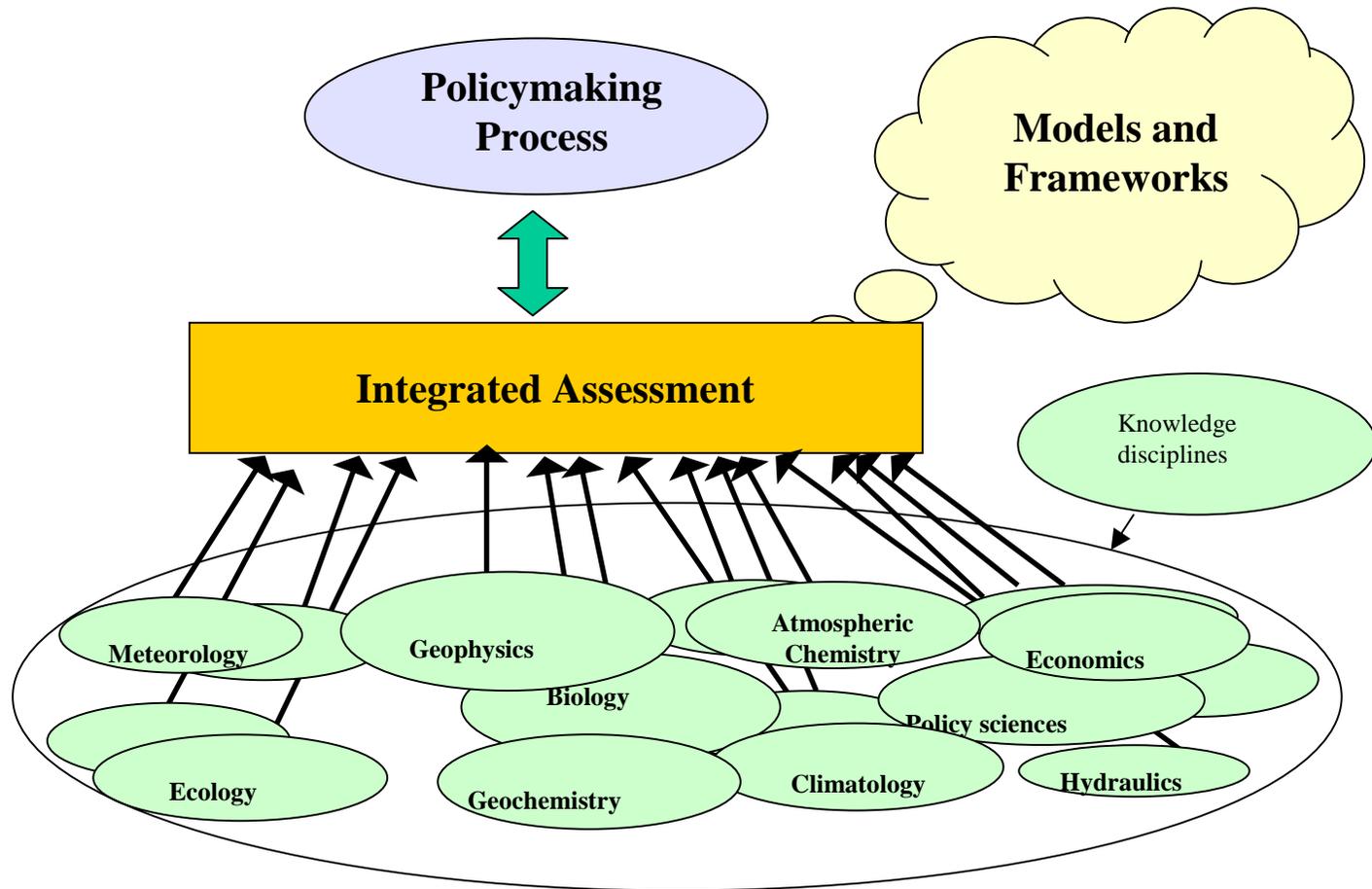


ECONOMIC AND ENVIRONMENTAL MODELING WORKSHOP
January 19-20, 2004, New Delhi



Integrated Economy-Environment Modeling: Why Integrate?

Multiple Interfaces of Environment Assessment



What to Integrate?

- Diverse Scientific Disciplines
- Diverse socio-economic scenarios
- Macro and micro-economies
- Local and regional boundaries
- Short and long time horizons
- Local and global environmental concerns
- Rural and urban perspectives
- Regional emissions and impact assessment
- Probability and Decision under uncertainty
- Technology

Why Integrated Assessment?

- To assemble, summarise, organise, interpret and reconcile pieces of existing knowledge
- To add value through integration (but not to add knowledge)
- To develop full range of policy outcomes
- To enhance Communication between scientific disciplines and policy formulation

Why Integrated Assessment Models?

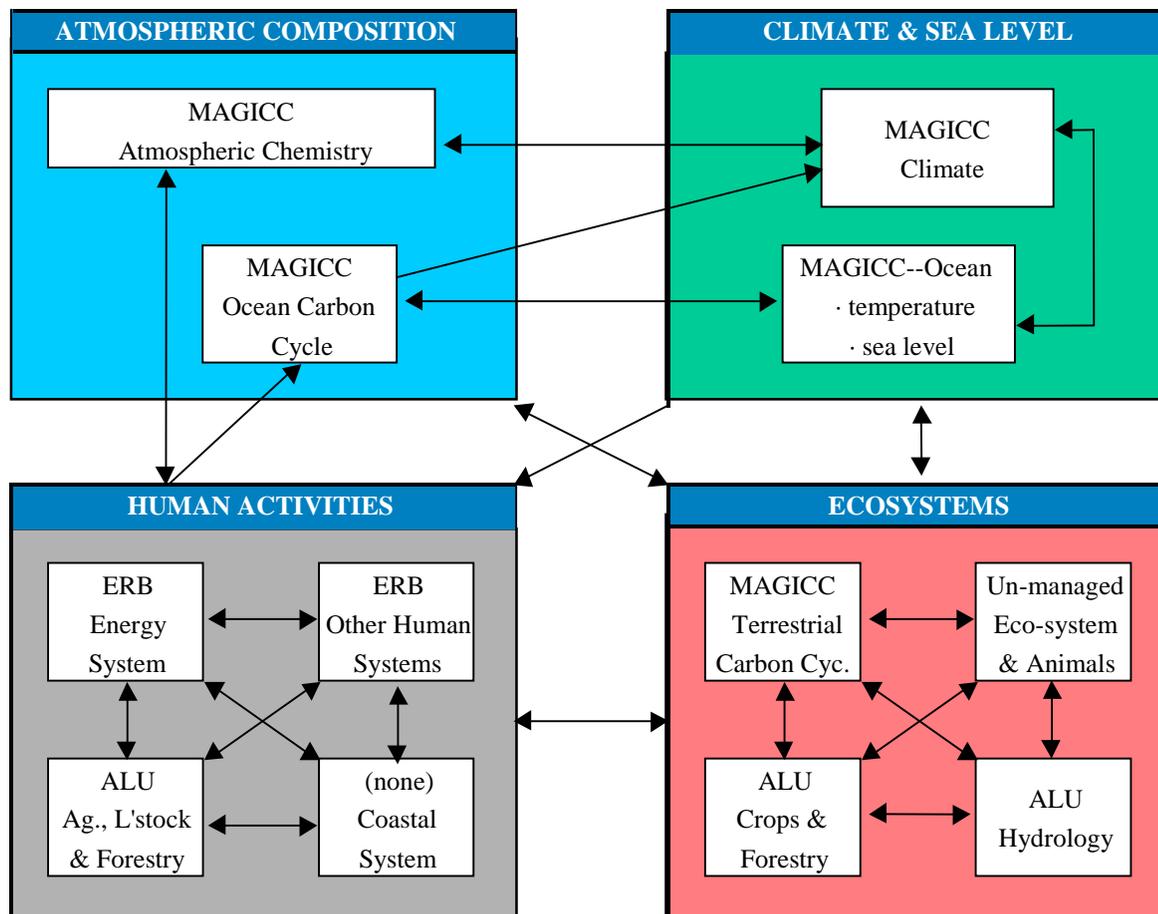
- Framework for conducting research ensuring consistency pointing to areas where more information is required
- IAMs are good 'forecasting' and 'heuristic' tools
- Communications tools between different sciences and between science and policy
- Insights from investigations in the domains of the sub-components



Examples of Integrated Assessment Models

Models for Climate Change Policy Analysis

MiniCAM: An Integrated Modelling Framework



AIM Model System

AIM/Energy/Technology/Country

A bottom-up technology selection model of energy use and emissions at country and local level

AIM/Ecosystem/Water/Impact

A set of ecosystem models, including a vegetation dynamics model, a water resource model, an agricultural productivity model and a health impact model

AIM/Bottom-up

A bottom-up technology & land use model for Asia-Pacific region

AIM/Top-down

A general-equilibrium-type world economic model

AIM Family

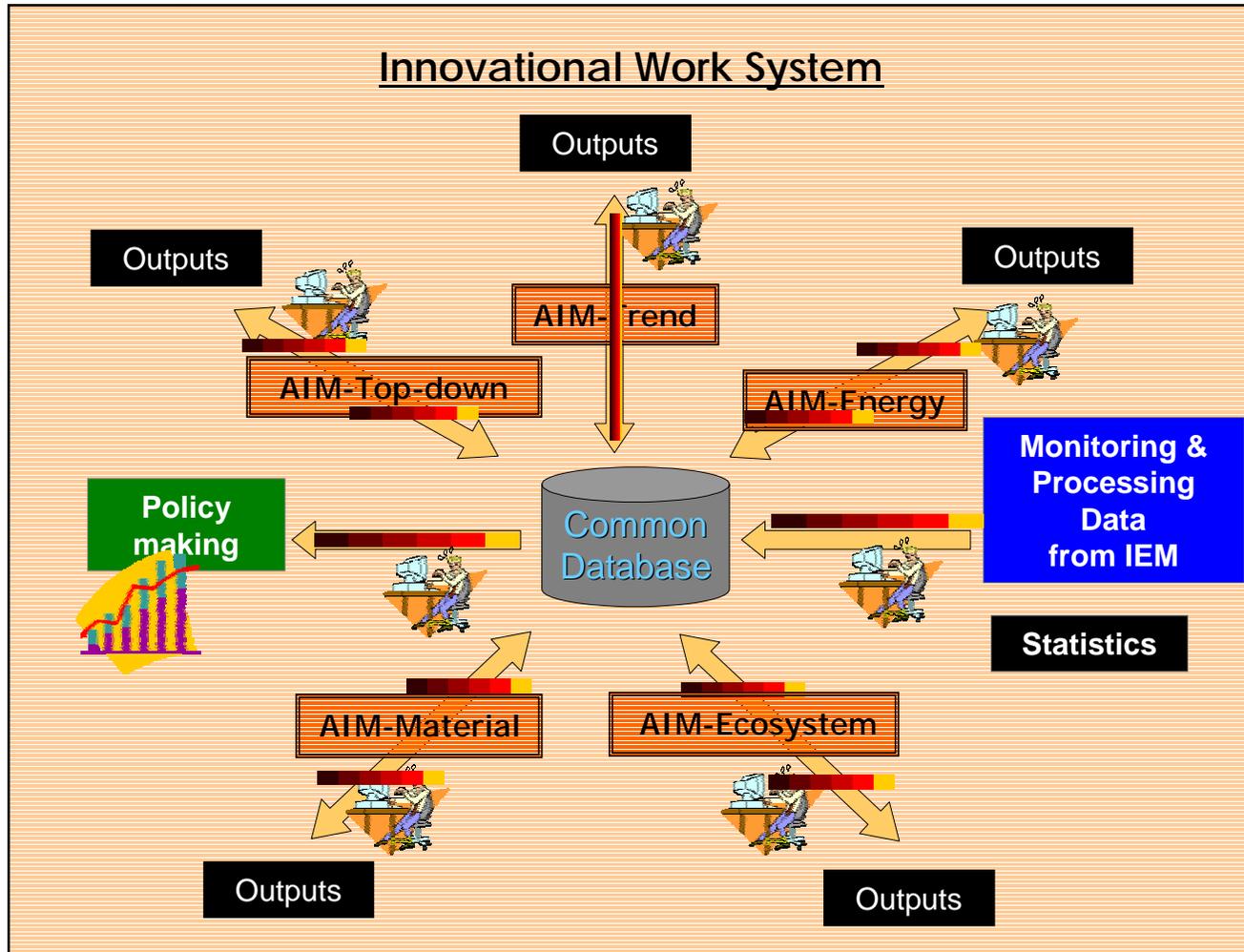
AIM/Material

An environment-economy integrated model with material balance and recycling process modules

AIM/Trend

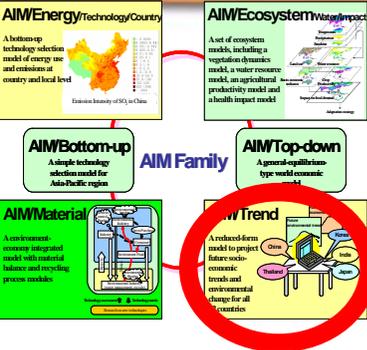
A reduced-form model to project future socio-economic trends and environmental change for all 42 countries

Strategic Database

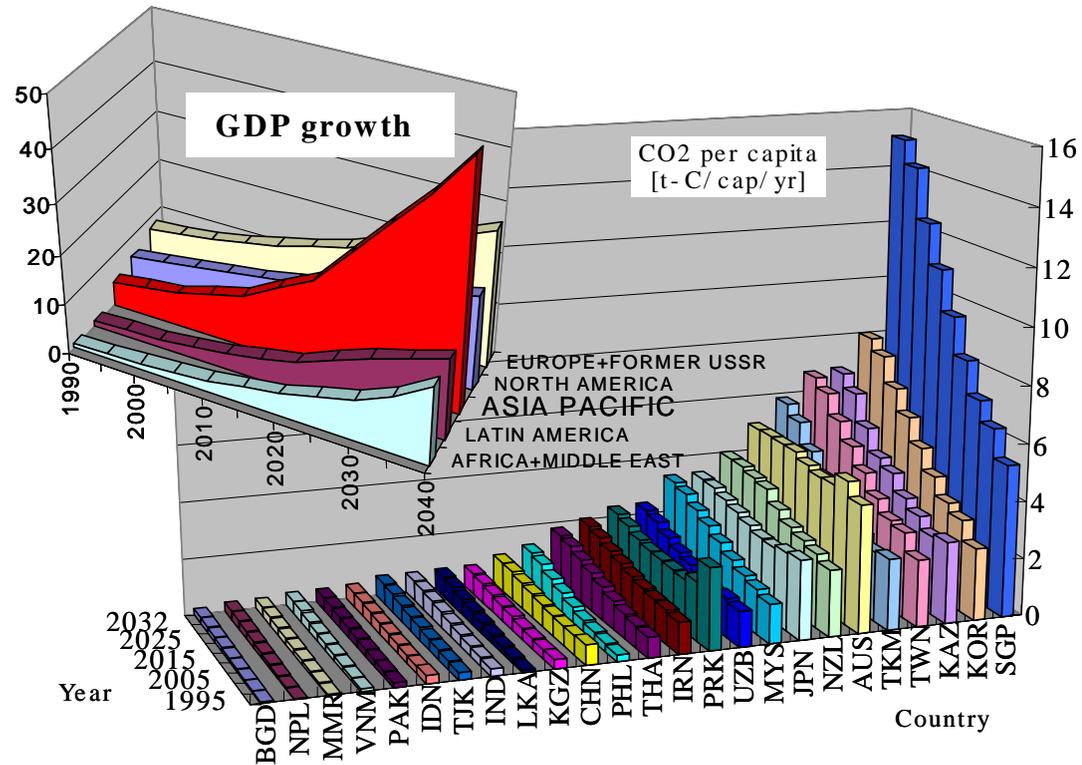




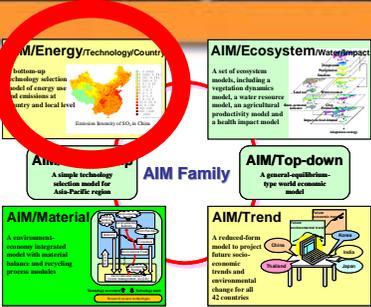
Component Models



GDP and CO2 Emissions: AIM/Trend Model

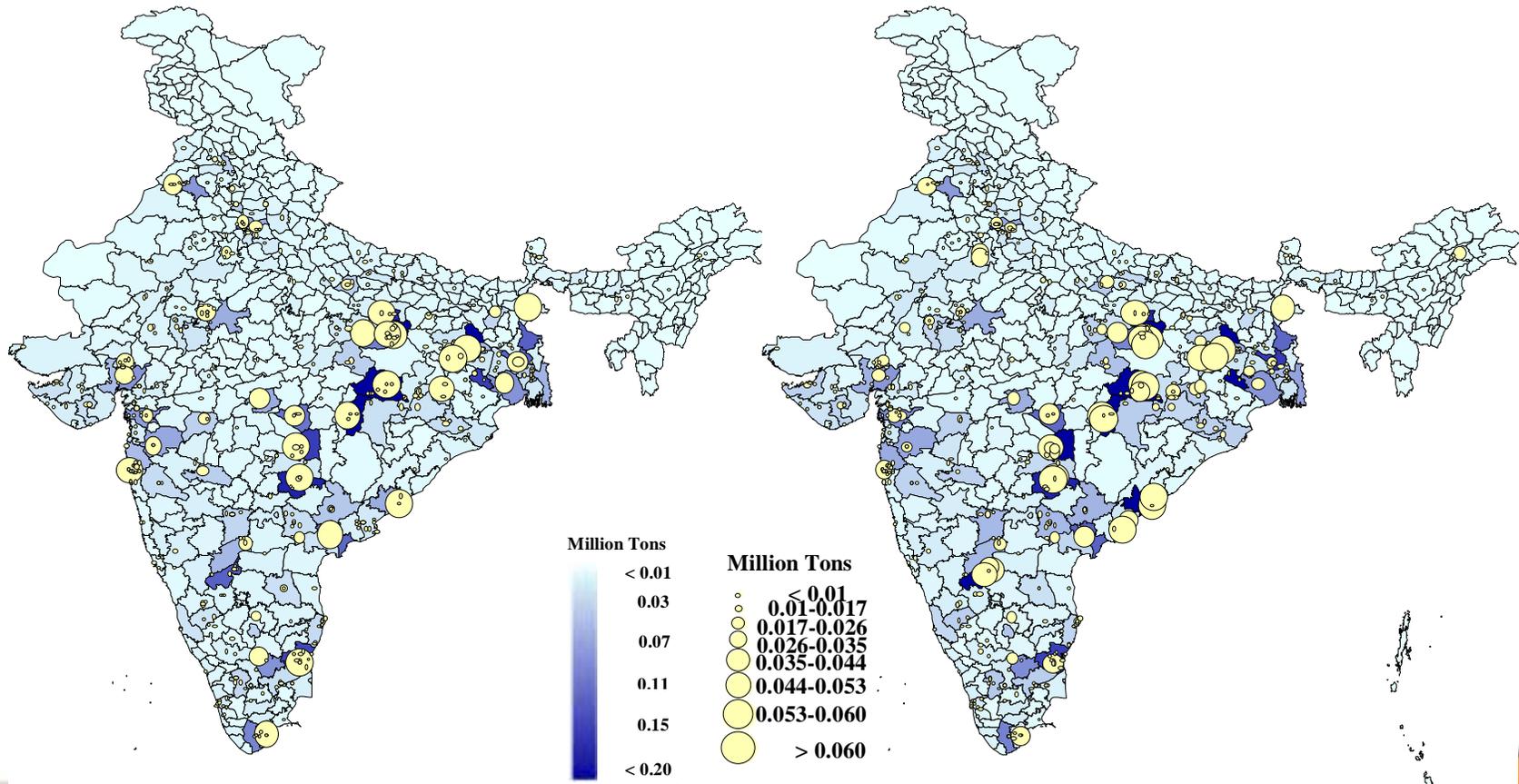


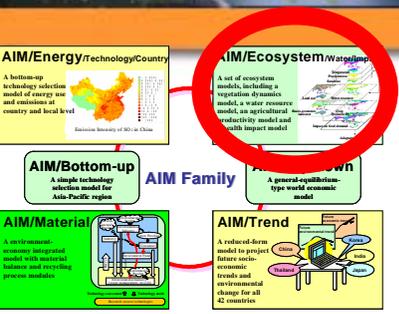
SO₂ Emission: AIM/Emission Model



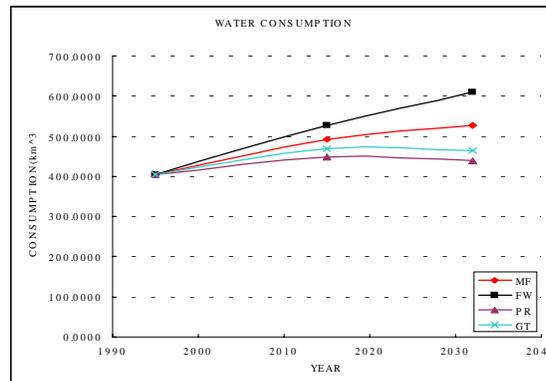
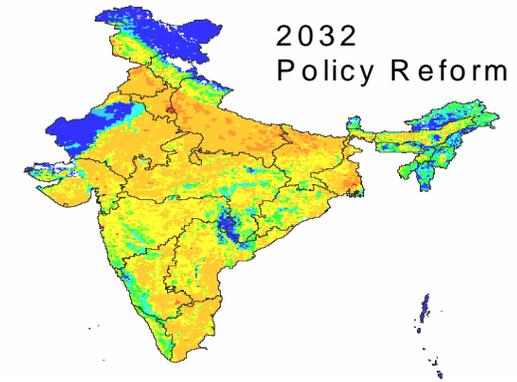
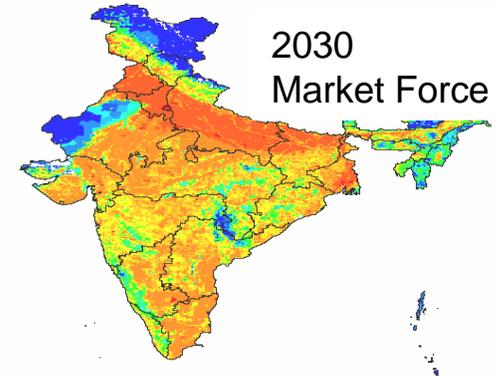
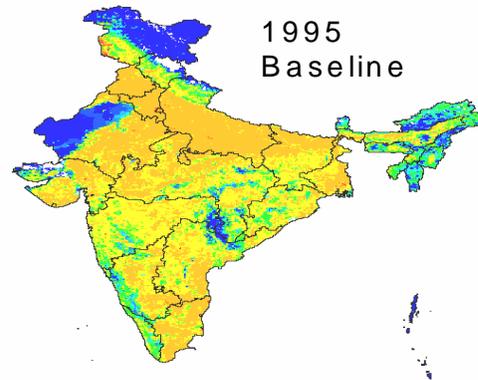
2000

2030

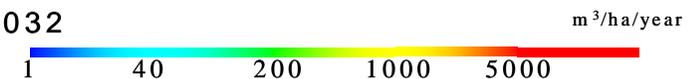




Water Consumption: AIM/Ecosystem Model



Change of water consumption from 1995 to 2032
(Domestic + Agriculture + Industry)

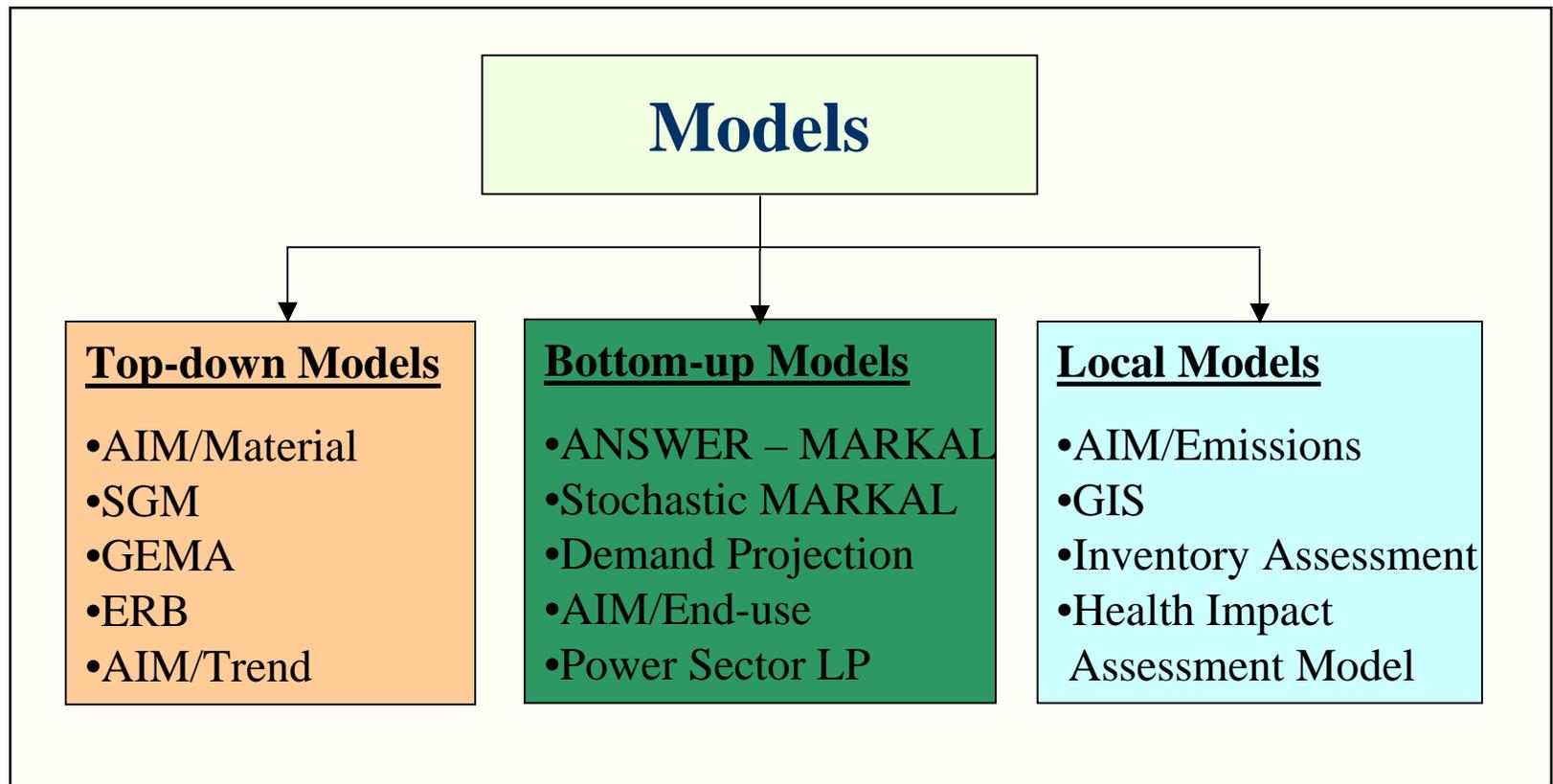




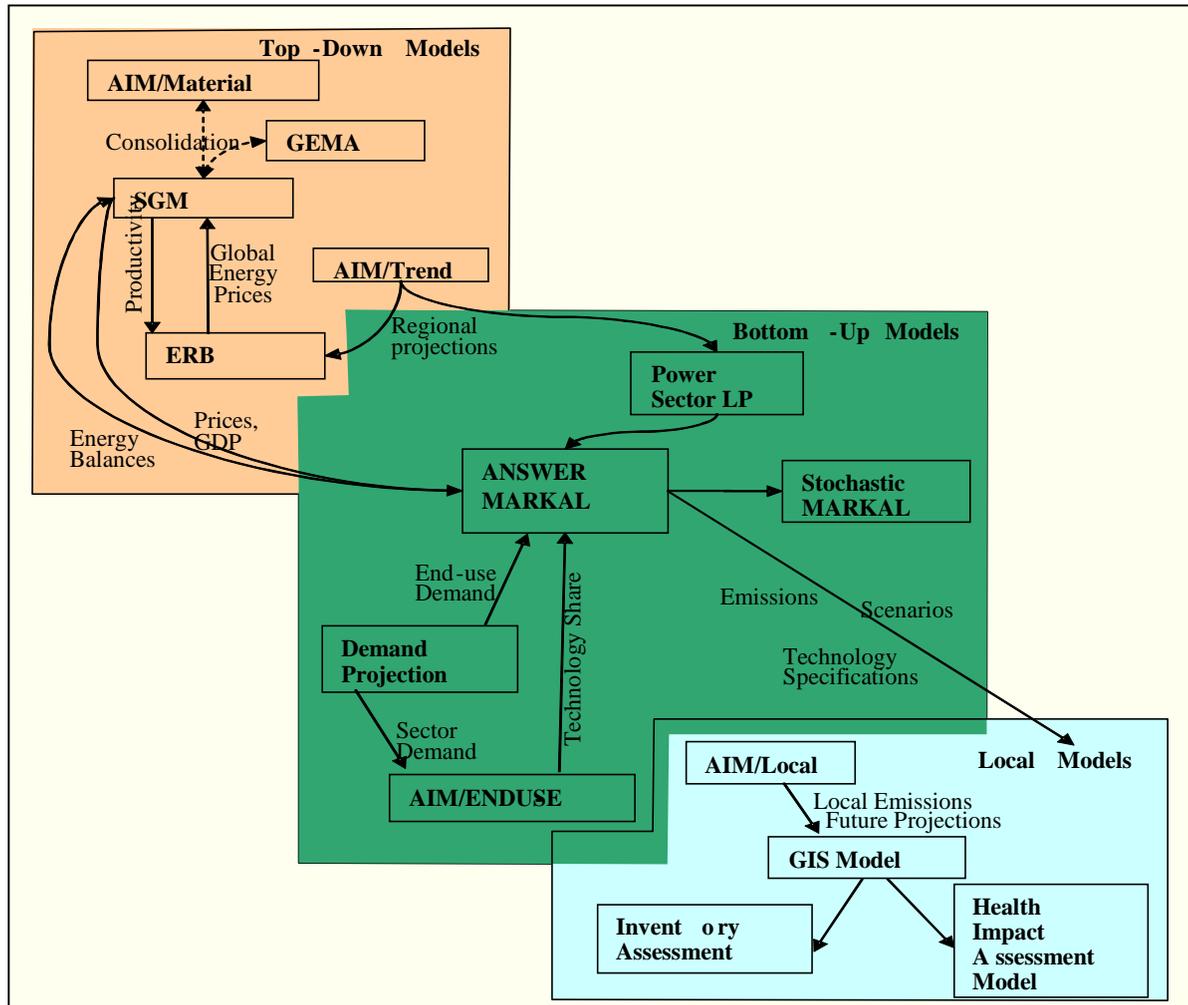
Integrated Economy-Energy-Environment Modeling System for India



Model System for India's Emissions Policy Analysis



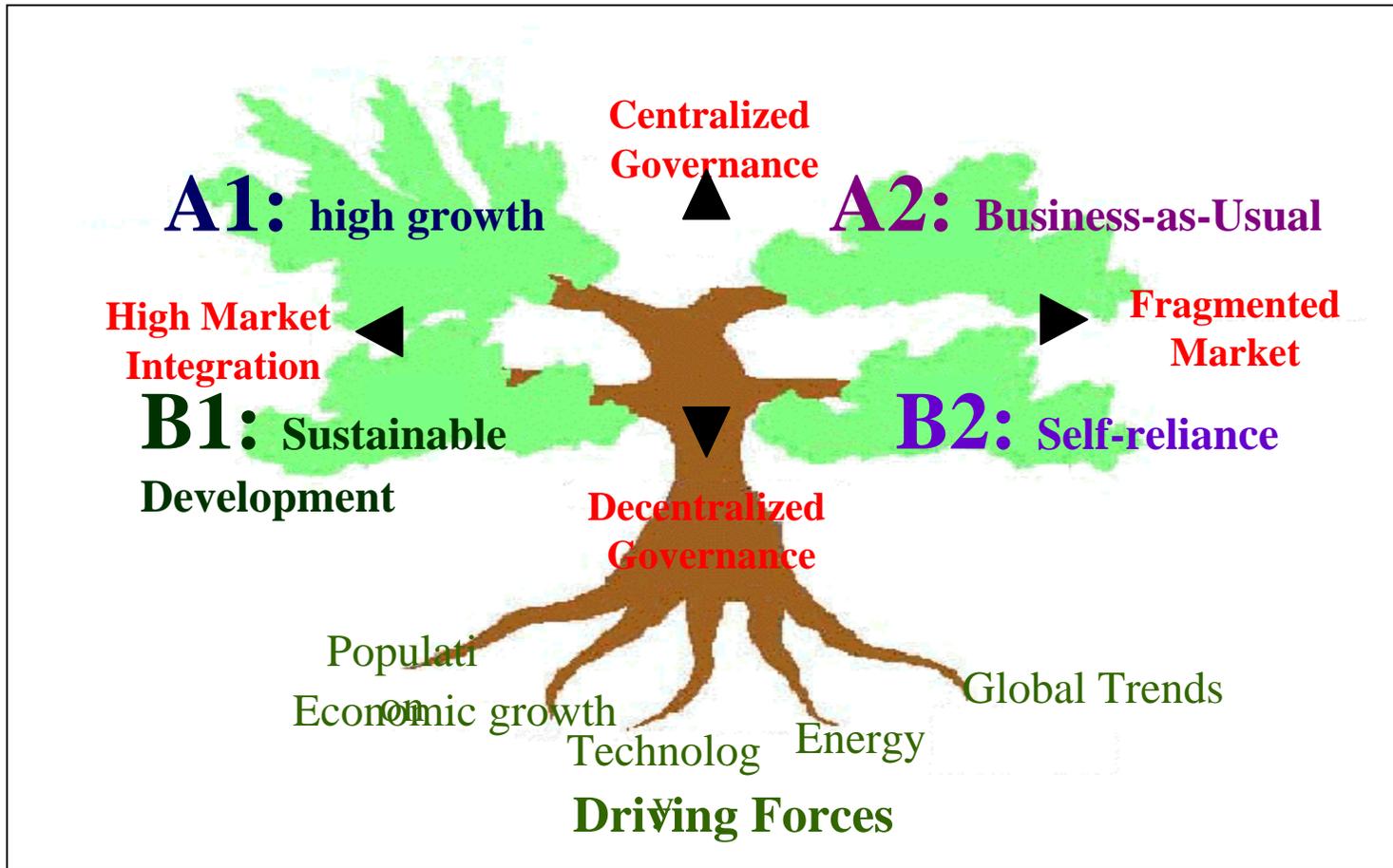
Soft-linked Models Framework





National Scenarios (for Emissions Projections)

Indian Scenario Tree



Indian Scenarios

Market integration

		<i>Market integration</i>	
		Integrated	Fragmented
<i>Governance</i>	Centralization	IA1 China	IA2 Pre-reform (Mixed Economy Model)
	Decentralization	IB1 Sustainable Development	IB2 Self Reliance Model

Governance

Centralization

Supply-side orientation
 State Monopoly
 Top-down development
 Central planning/ policies
 Focused Industries
 Low/medium population
 Medium/high GDP
 Growth

Decentralization

Demand-side orientation
 Competition
 Regional development
 Rural focus
 Distributed utilities
 Medium/high population
 Low/medium GDP
 growth

Market Integration

High integration

High-medium growth

Low tariffs

Technology transfer

External investment

Globalization/
competition

Low integration

Low-medium growth

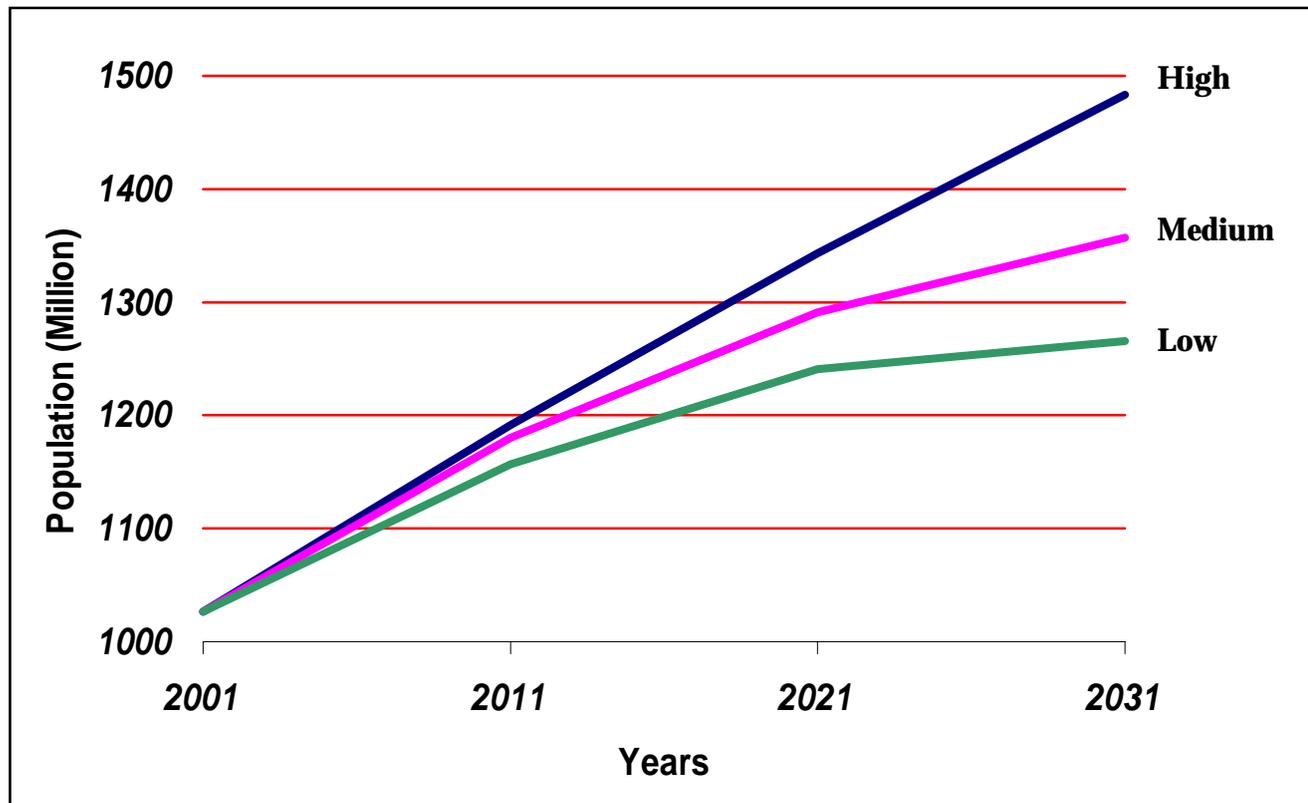
High tariffs

Indigenous technology

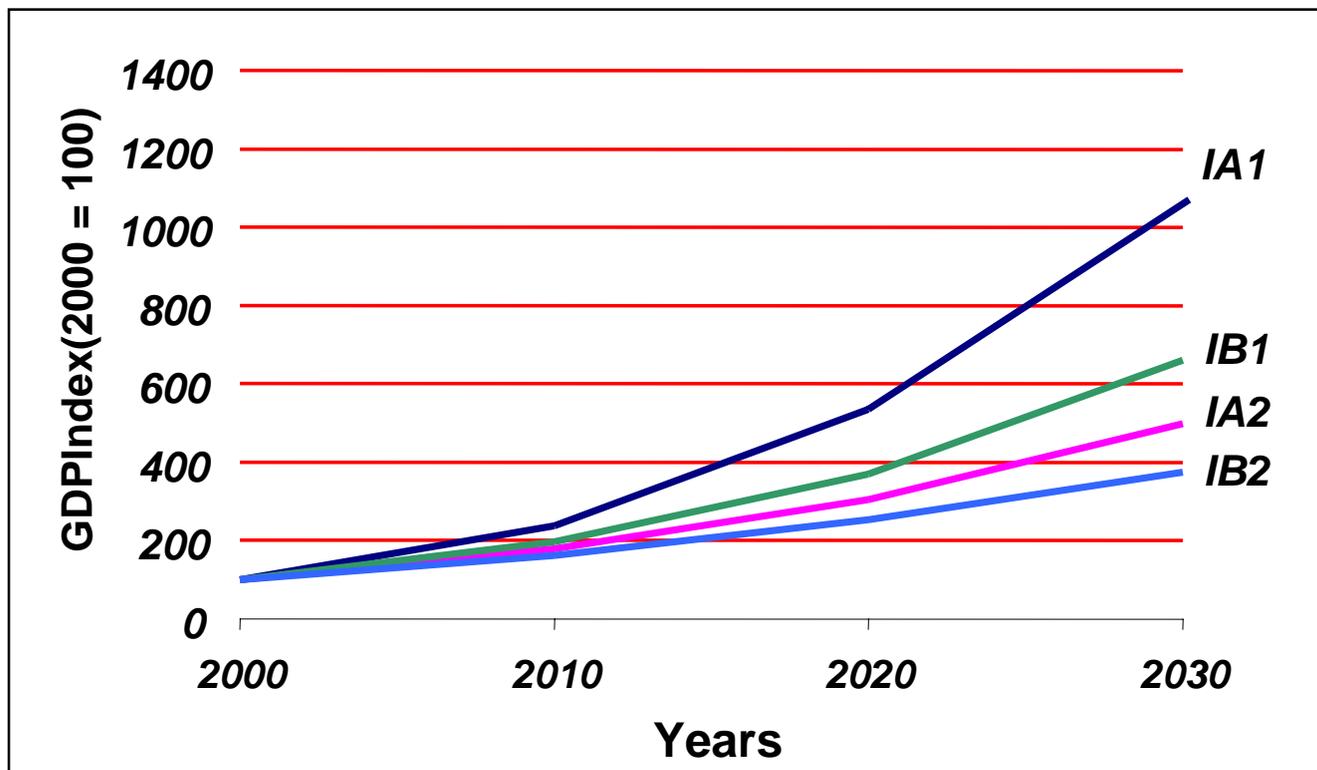
Self reliance model

Fragmanted market

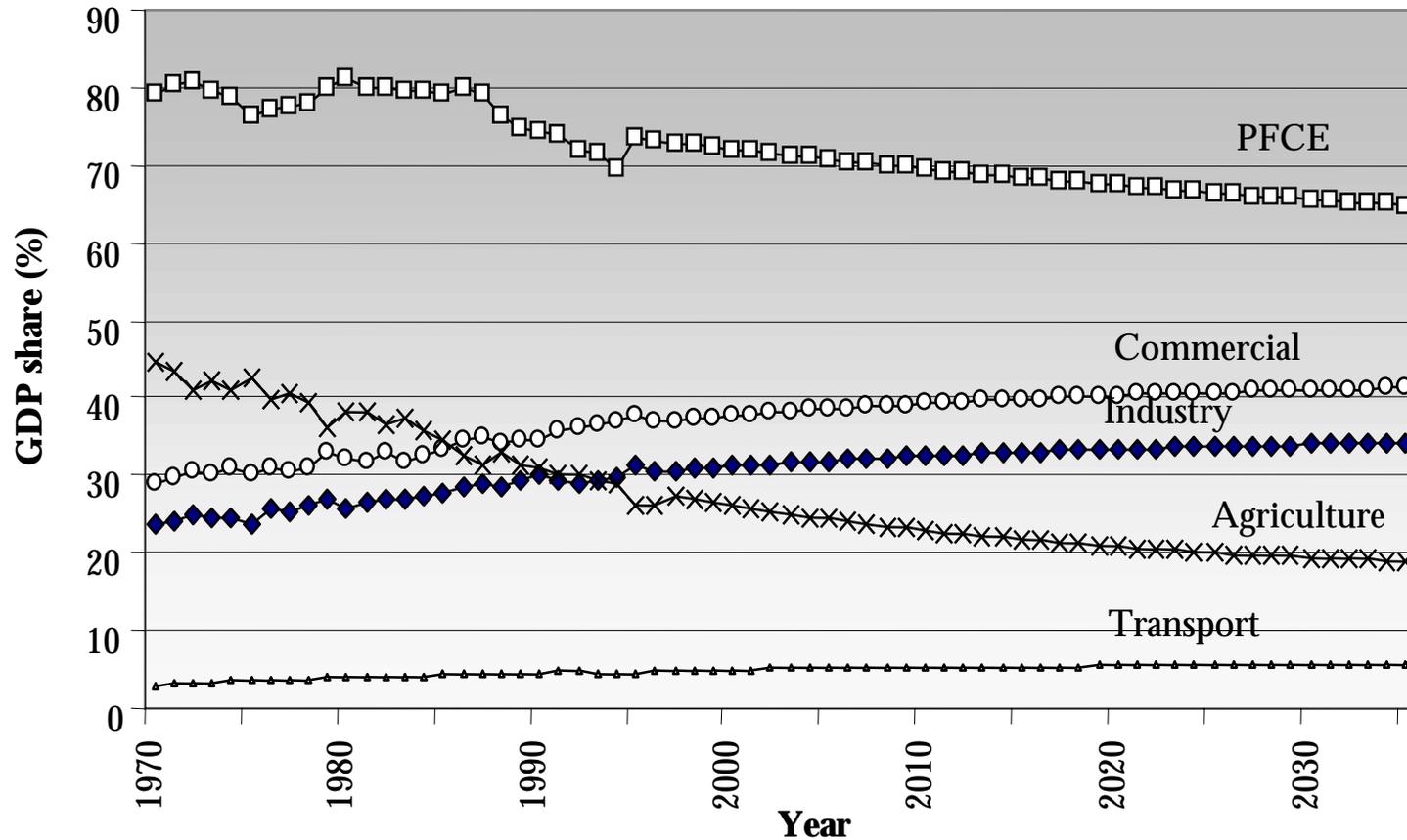
India: Population Projection



India: GDP Projection



Share of Major Sectors in GDP



Energy Resources

	Oil and Gas	Coal	Renewables
IA1	High	Moderate	Moderate
IA2	Moderate	High	Low
IB1	Moderate	Low	High
IB2	Low	Moderate	Low



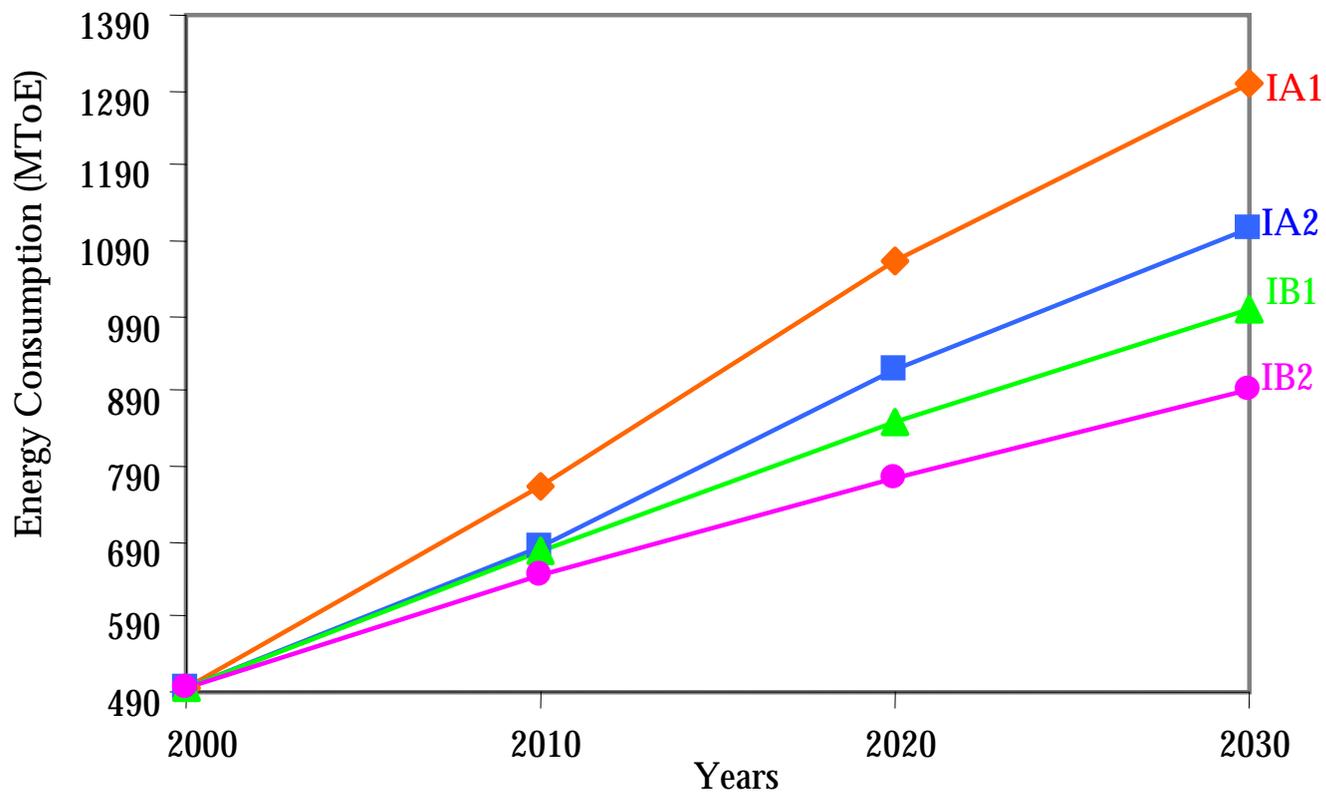
National Development Goals

- 1) Economic Security
- 2) Energy Security
- 3) Environment Security
- 4) Water Security
- 5) Food Security
- 6) Health Security

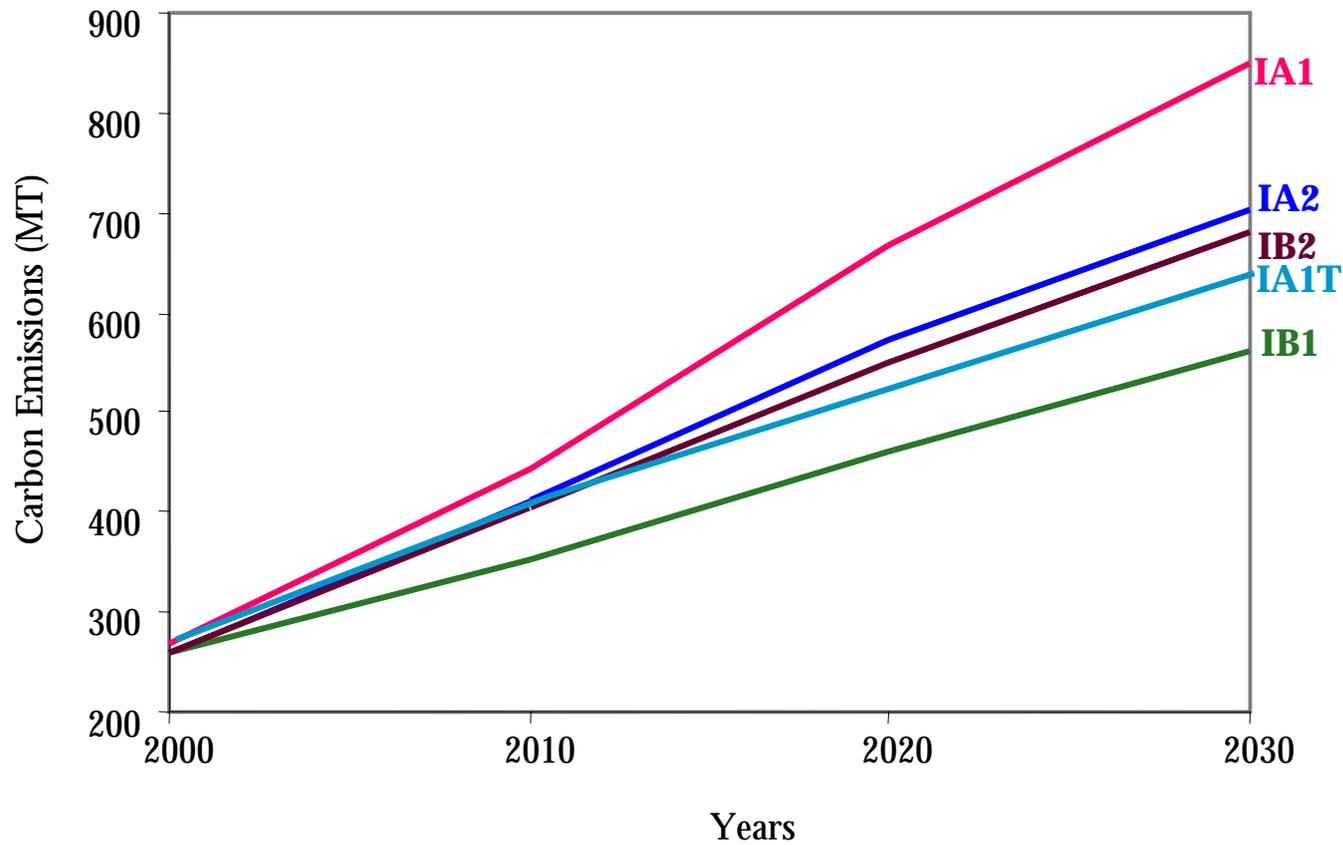


Future Energy and Emissions Projections for Scenarios

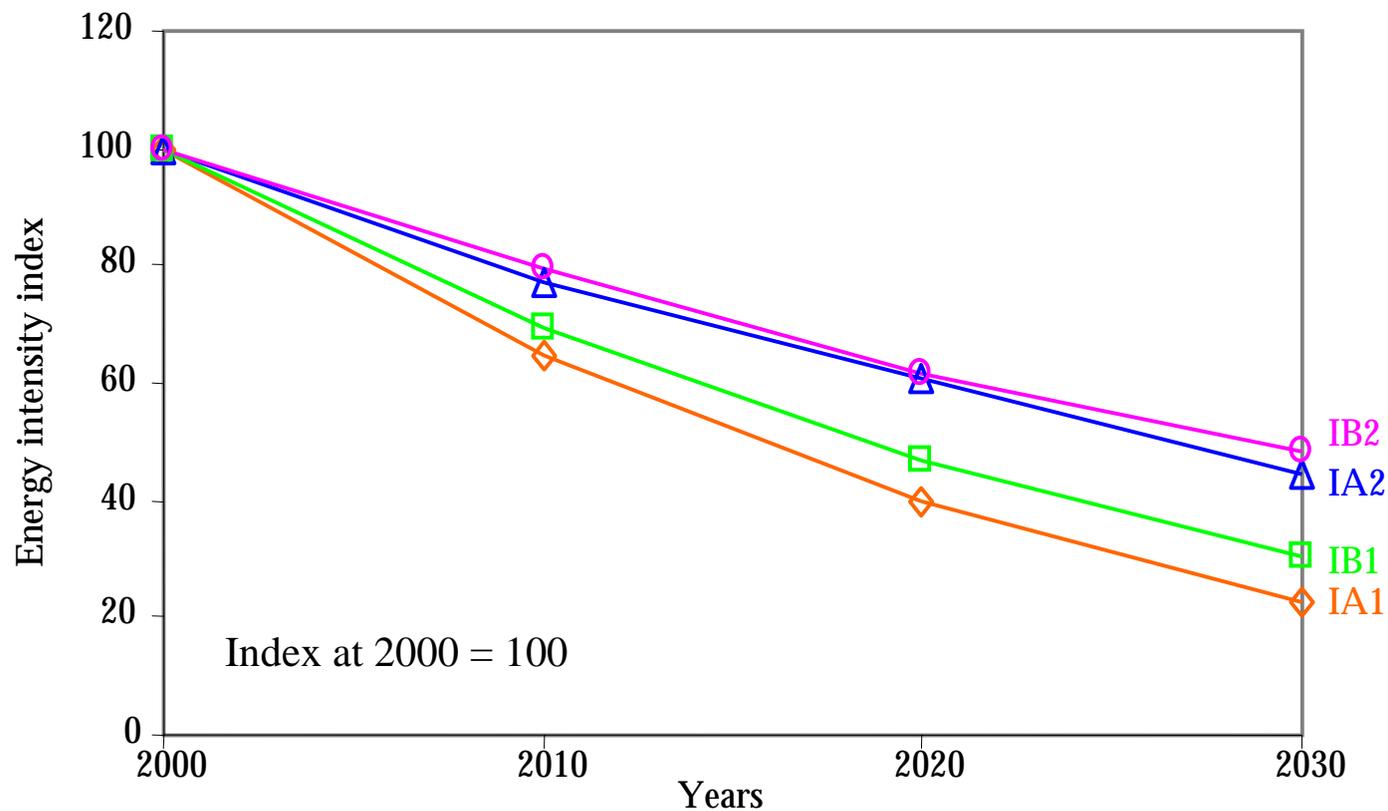
Energy Consumption



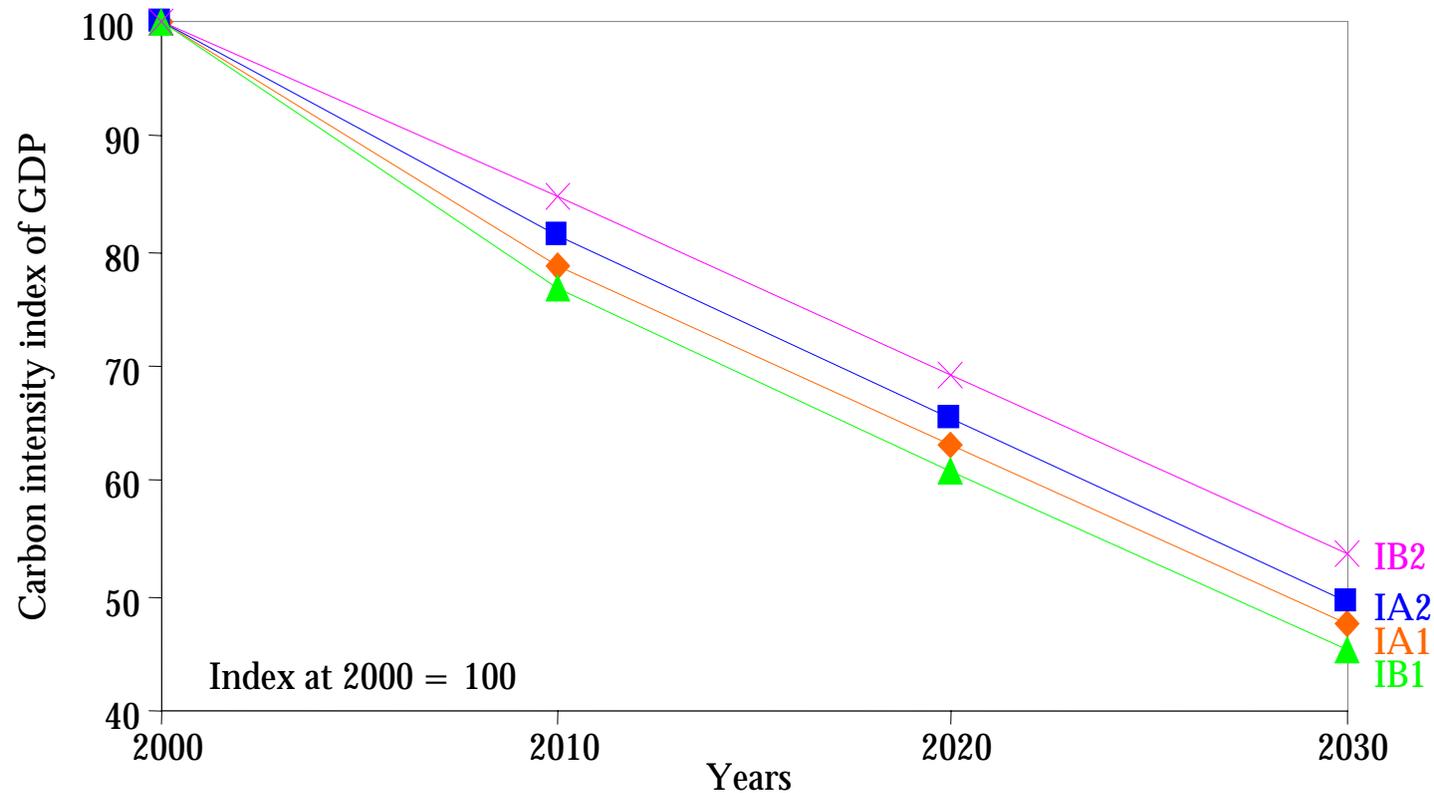
Carbon Emissions (MT)



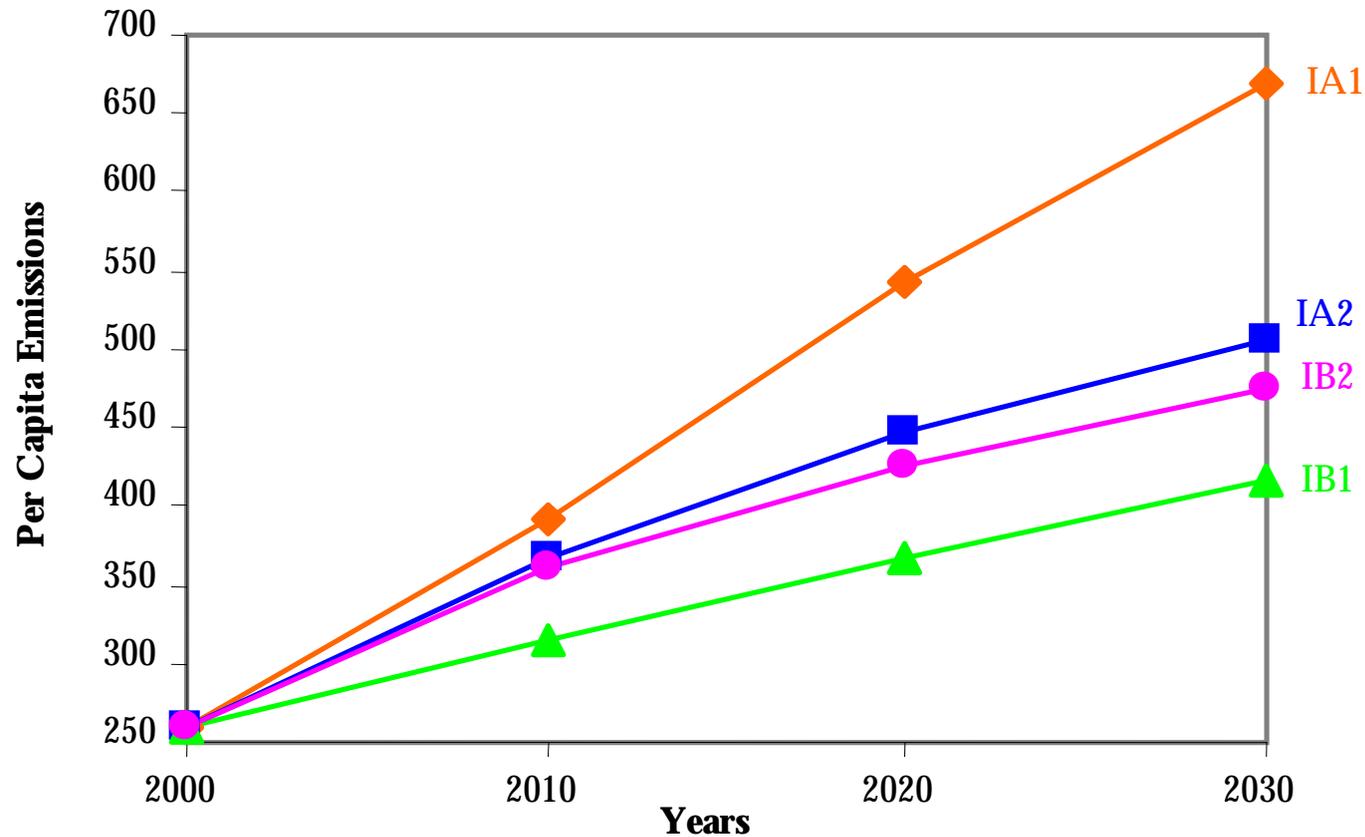
Energy Intensity (Index 2000=100)



Carbon Intensity Index of GDP

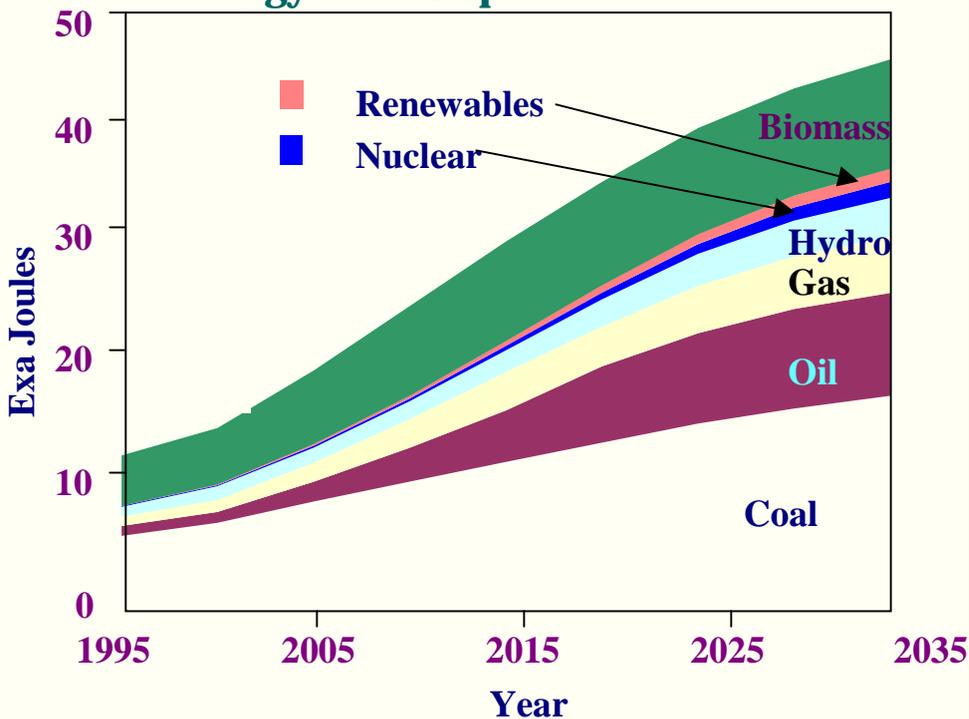


Per Capita Carbon Emissions (kgC/person)

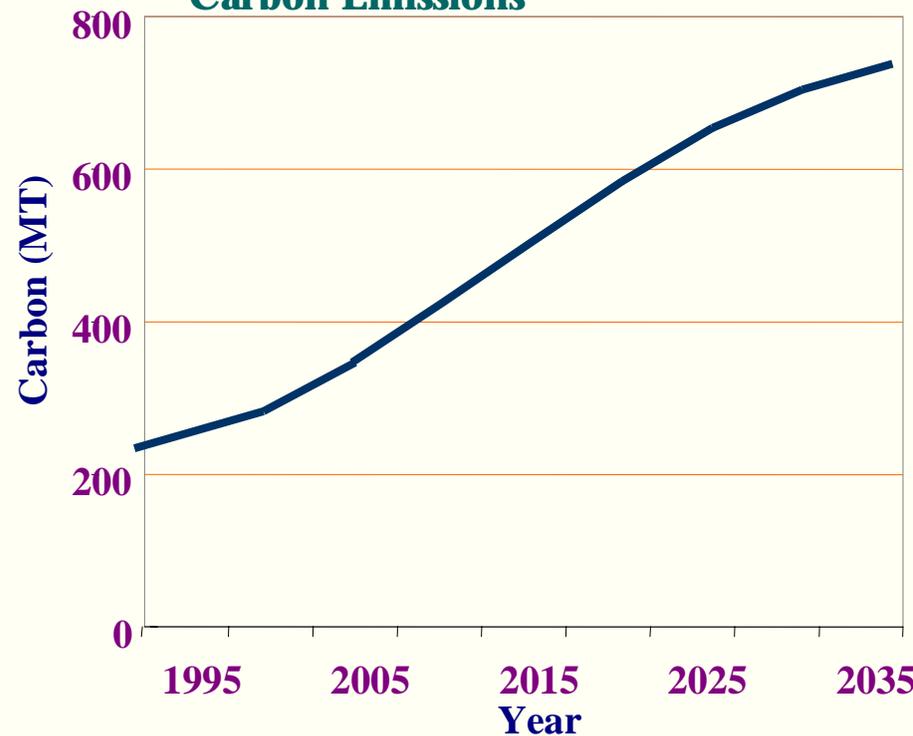


Energy and Carbon Emissions for India (IA2 Scenario): AIM/MARKAL Model Analysis

Energy Consumption



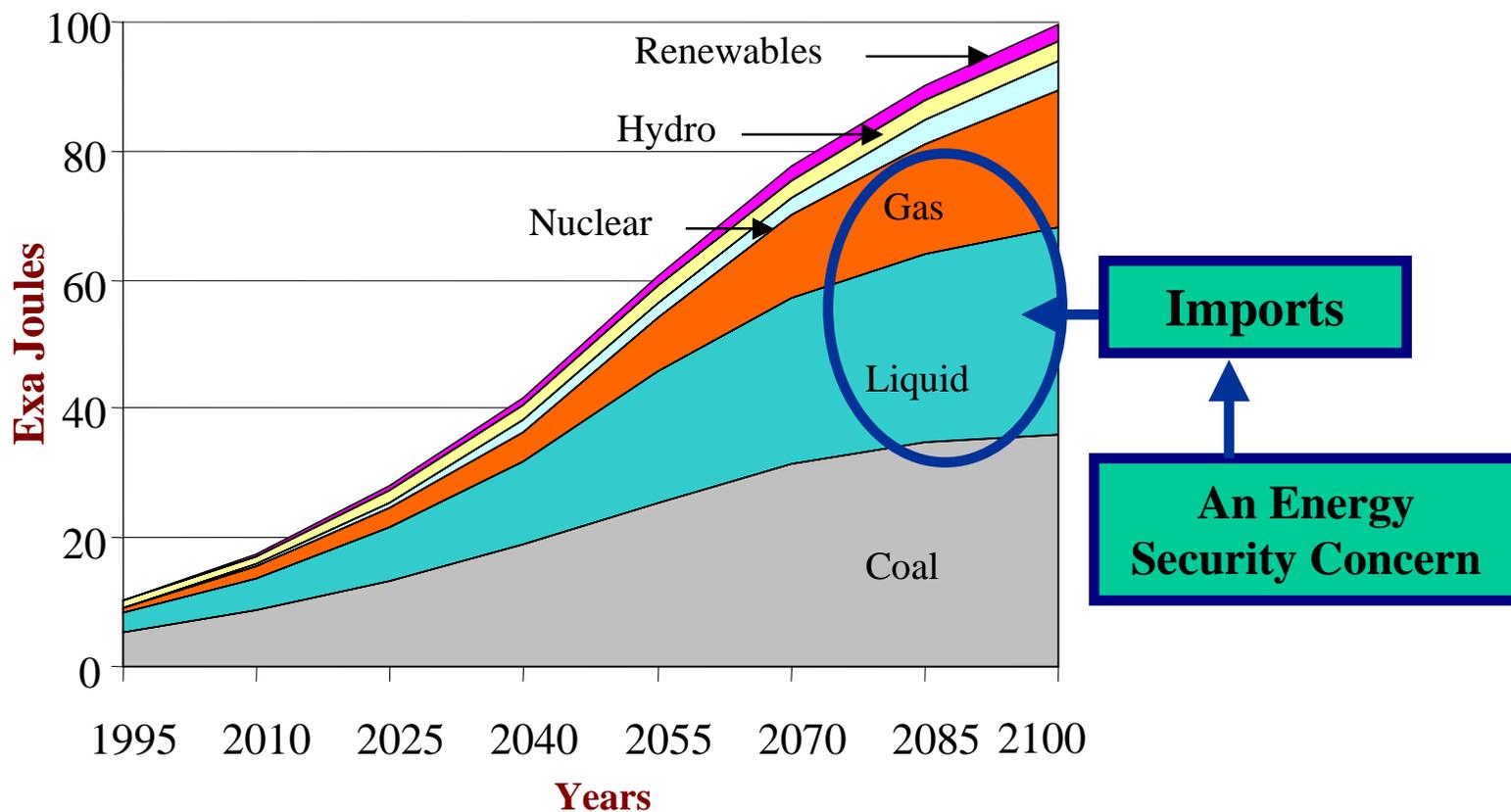
Carbon Emissions



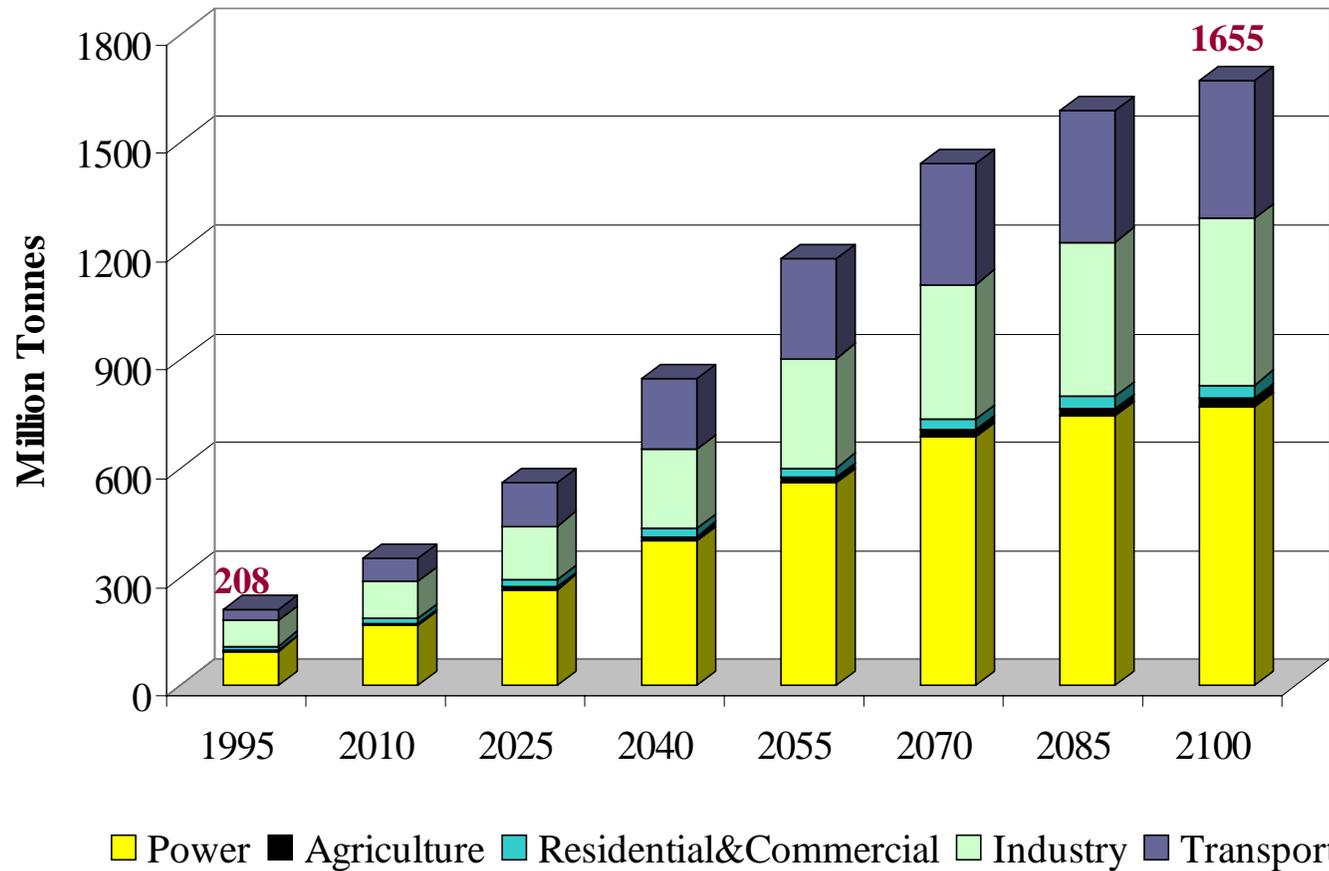


Long-term Scenarios

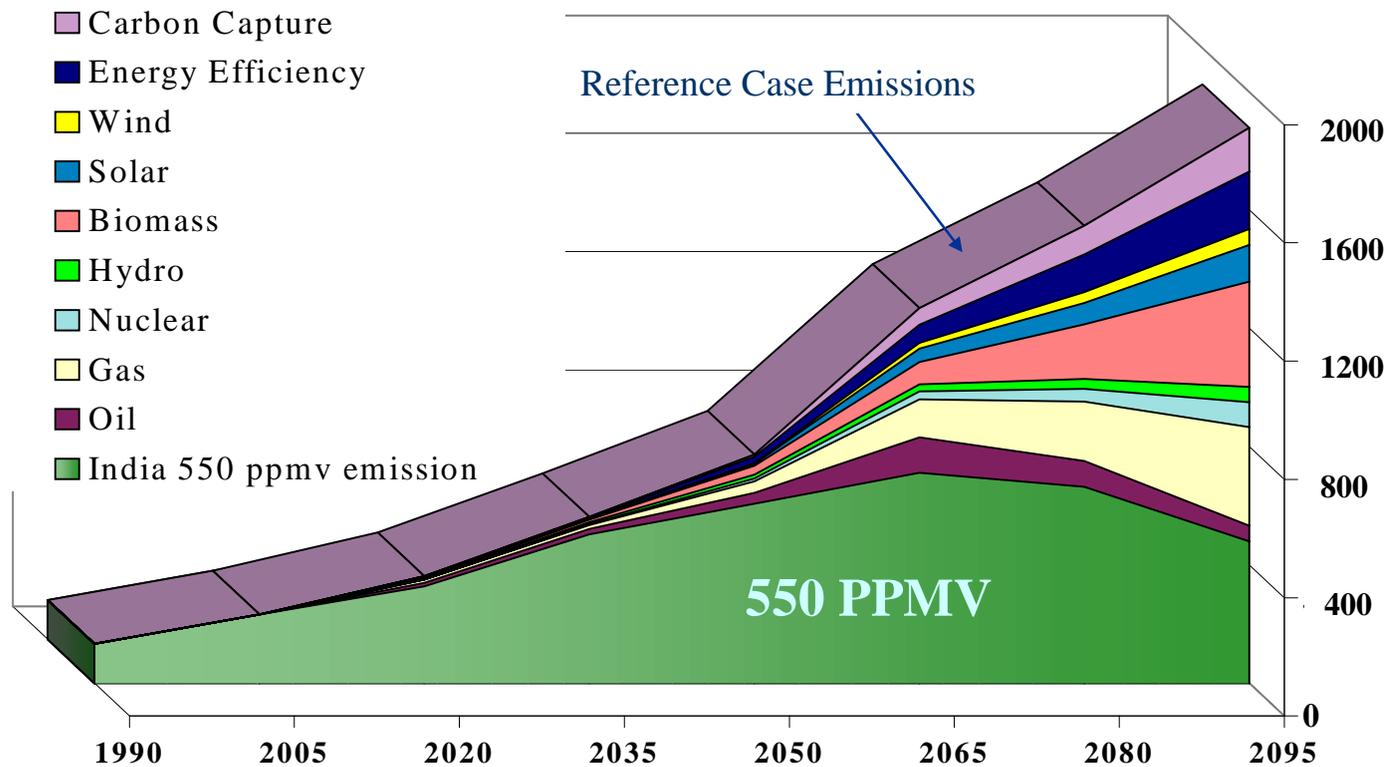
Primary Energy Trend



Long-term Carbon Emission Trend



Technological Change in India to Stabilize CO₂ at 550 ppmv

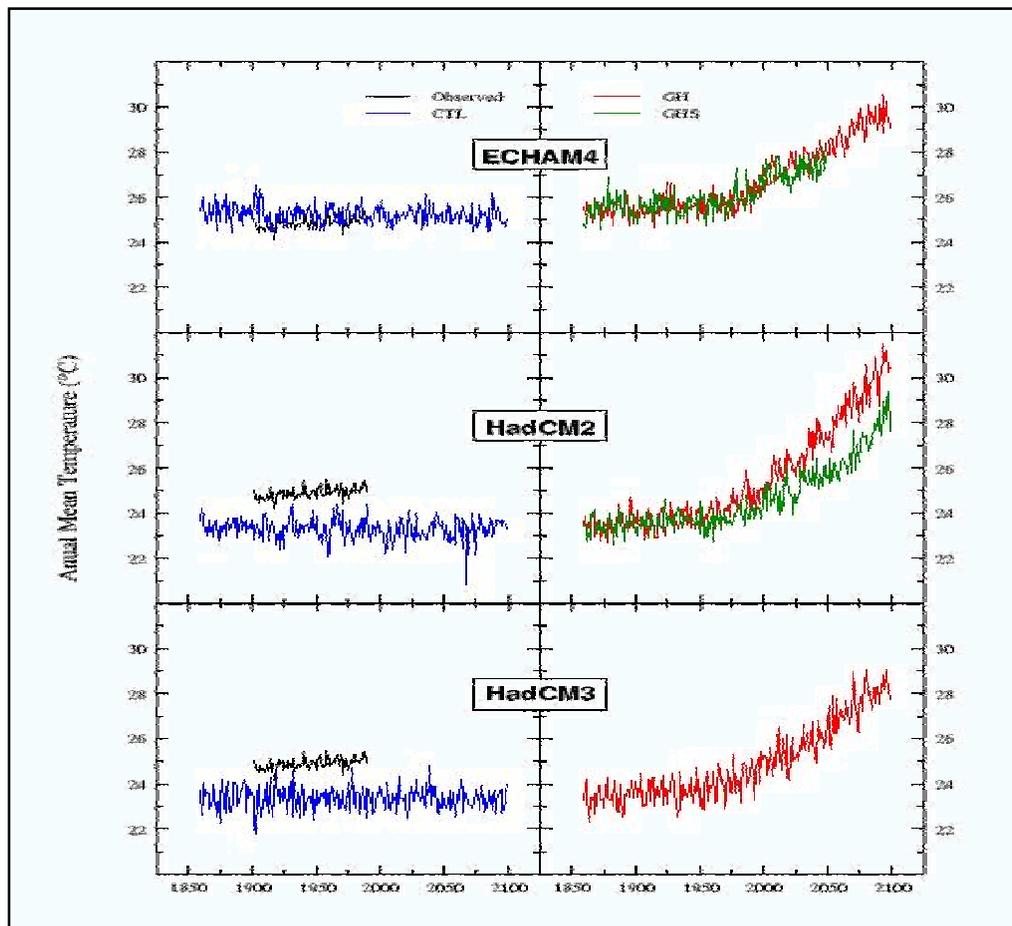




Impact of Climate Change on Energy Use

How temperature/rainfall shall affect on energy consumption?

Simulated Mean Annual Temp. India





Climate Change Impact on Energy

Direct Impacts

- Space cooling and heating in residential, commercial and industrial buildings
- Air-conditioning in transport vehicles
- Time of use and cooling load

Indirect Impacts

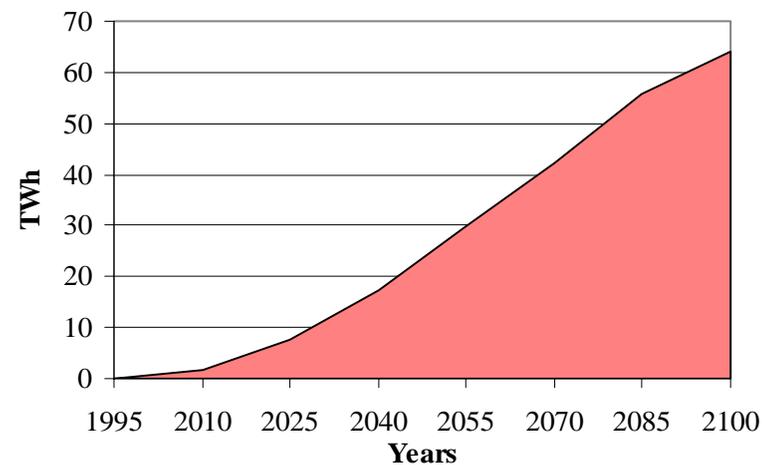
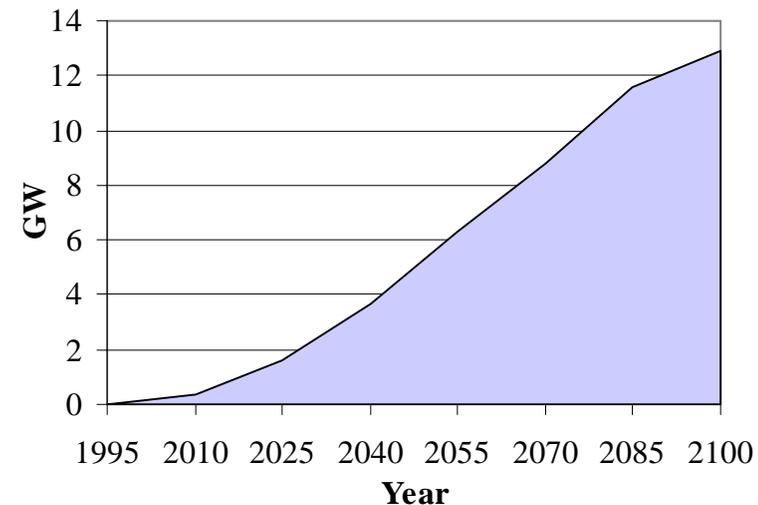
- Increased water requirement for irrigation
- Increased residential water requirement
- Water availability

Supply Side Impacts

- Hydroelectricity potential
- Activities of petroleum companies

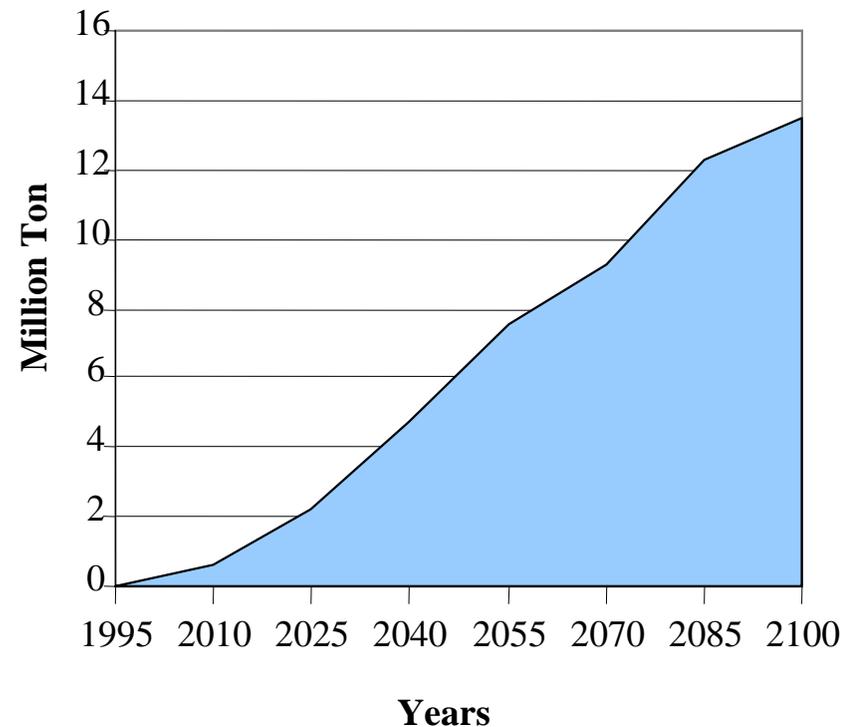
Impact on Energy

- Capacity for additional demand: 13 GW in 2100, i.e. 1.5% of reference case
- Electricity demand increased by 64 TWh in 2100
- Energy and electricity demand rise from building, irrigation and transport
- Energy mix is unaltered.



Impact on Emissions

- In 2100, carbon emissions increases by 13.5 million ton, i.e. 1% rise over reference case
- Emissions increase in power and transport sectors
- Cumulative increase 710 MT





Integrated Economic and Environment Assessment:

Adapting to Developing Country Dynamics

Integrated Environment Assessment & Developing Countries

- Inadequate database
- Assessment and modeling capabilities
- Model Assumptions
- Structural changes in the economy
- Myriad and conflicting developmental concerns
- Weak regional and international linkages
- Lack of sustained funding



Limitations of Present Approaches

- Limited capability to characterize and parameterize long term interactions between the economy, society, and environment
- Assumptions derived from developed world perspective
- Inability to characterize discontinuities and extreme events
- Weak behavioral interfaces
- Distance between analysts and policy makers

Capacity Building Needs for Developing Countries

- Inventorize existing best competence, data and experiences
- Networking and cooperation with regional and global teams
- Promote integrated assessment modeling under developing country expert leadership in cooperation with global experts
- Sustained funding
- Institutionalize integrated assessment activities