Climate Change and India:
Stabilization, Technology and Development

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Agenda

Indian Emissions Scenarios

- Framework and Storylines
- Drivers
- Technologies in Scenarios (Short and Long-term)

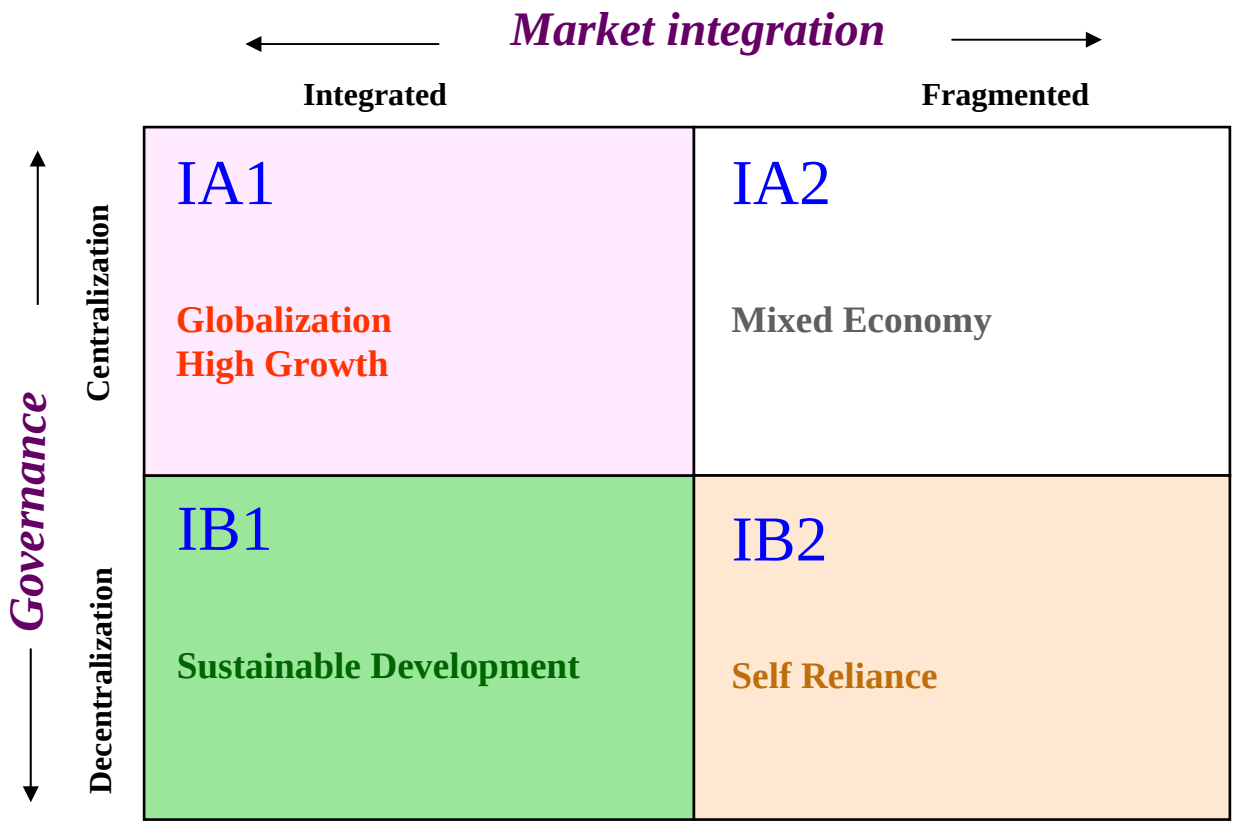
Stabilization Induced Technological Change (Analysis of A2 Scenario)

- Indian Emissions and Stabilization needs
- Implications of Stabilization for India

Aligning Development and Climate: Co-benefits, Transitions & Innovations

- South-Asia Regional Co-operation
- Conjoint Market for CO_2 and SO_2
- Changing Drivers of Technological Change
- Aligning Development and Climate

Indian Scenarios



Scenarios Storylines: Transitions

IA1

- Population: Low growth, specialized skills, high migration
- Urbanization: High, concentrated, vertical cities
- Economy: High growth, global market, competition
- Resources: Old and New Fossil, Biomass, Nuclear, efficient use
- Technologies: Centralized, Global R&D, private IPRs, rapid diffusion, supply-side push
- Environment: Market instruments, high-tech solutions

IA2

- Population: Medium, medium skills, restricted migration
- Urbanization: Medium, concentrated, unplanned
- Economy: Medium growth, regional market, uneven regional development
- Resources: Fossil, local, unsustainable use
- Technologies: Regional R&D, weak IPR regime, slow diffusion
- Environment: Mixed instruments, end-of-pipe solutions

IB1

- Population: Medium, diverse skills, two-way migration
- Urbanization: Medium, dispersed, planned
- Economy: Medium growth, diverse goods and services, global market, even development, sustainable consumption
- Resources: Local, renewable, sustainable use
- Technologies: Shared R&D, rapid diffusion, demand-side
- Environment: Mixed instruments, preventive approach, resource conservation, dematerialization, recycling

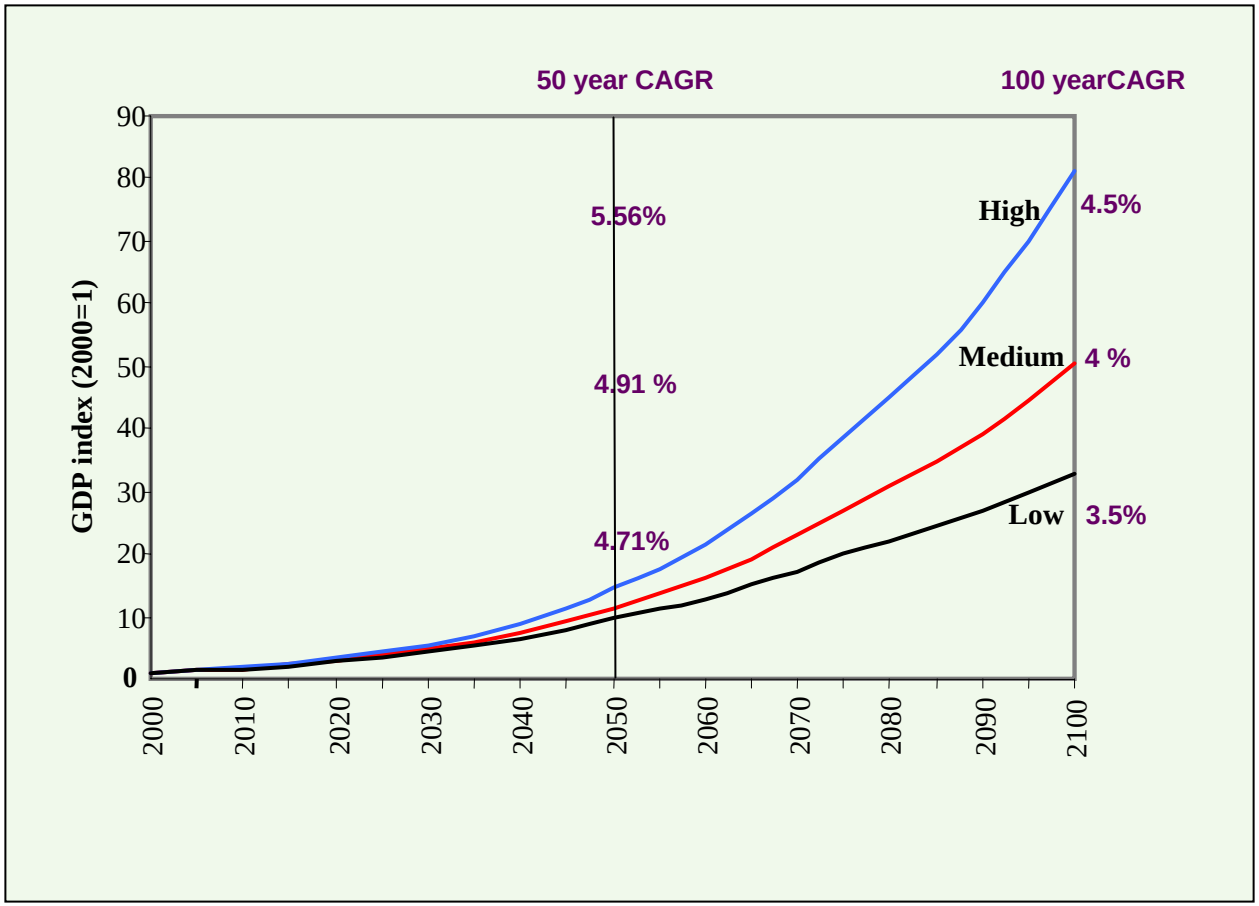
IB2

- Population: High, low skills, restricted migration
- Urbanization: Low, unplanned, dispersed
- Economy: Low growth, local market, control
- Resources: local, inefficient use
- Technologies: Local R&D, weak IPR regime, slow diffusion
- Environment: Command and control instruments, local approach and solutions

Energy Transition Drivers

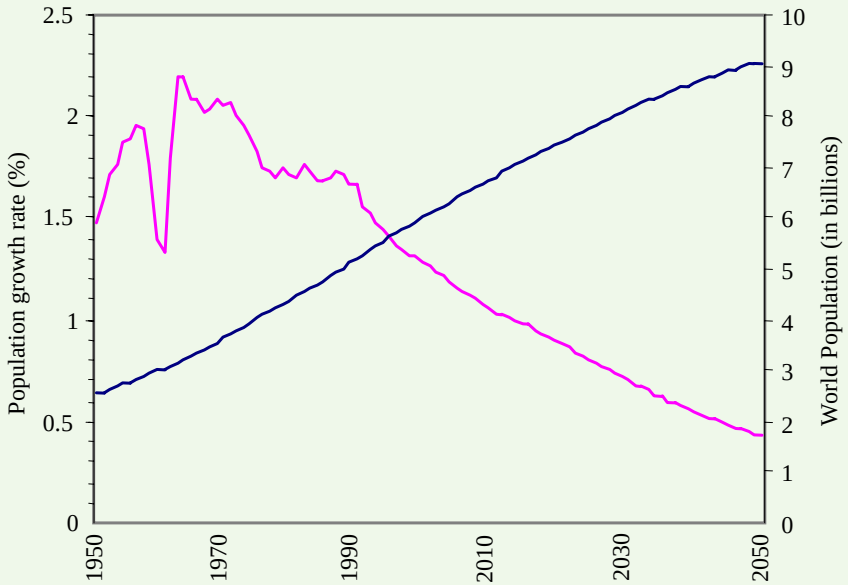
- **Population**
  - **Fertility and Mortality rates**
  - **Rural-Urban**
- **Economic growth**
  - **Economic structure changes**
  - **Globalization**
  - **Income distribution**
  - **Urbanization**
  - **Rural economic growth**
- **Energy supply security**
  - **Oil price stability**
  - **Energy geo-politics**
  - **Energy portfolio**
- **New Energy technologies**
  - **Capital costs,**
  - **Learning curve,**
  - **R&D vs. leapfrogging**
  - **Technology transfer**

Economic Growth

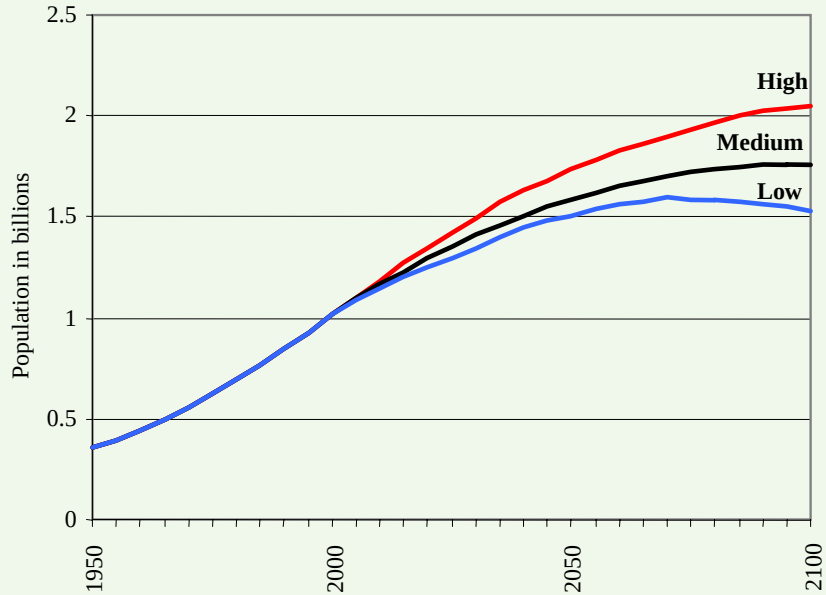


Population

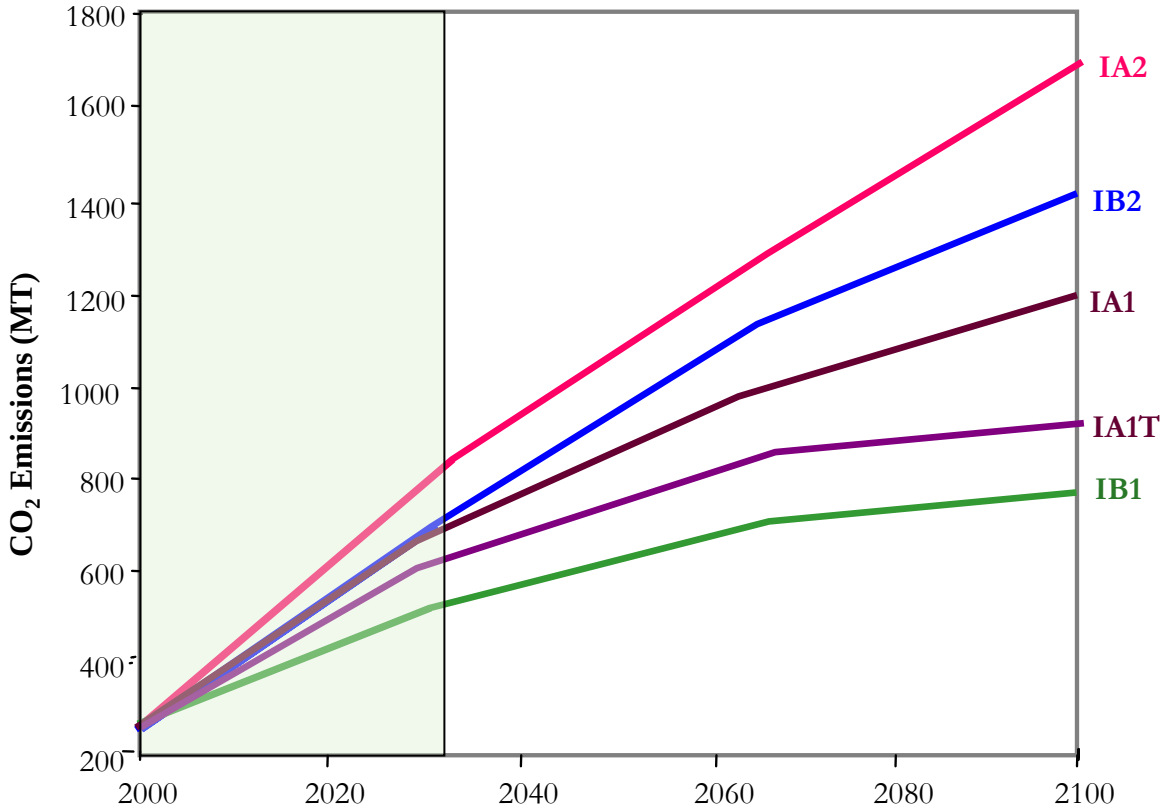
World Population (Median Scenario)



Indian Population Scenarios

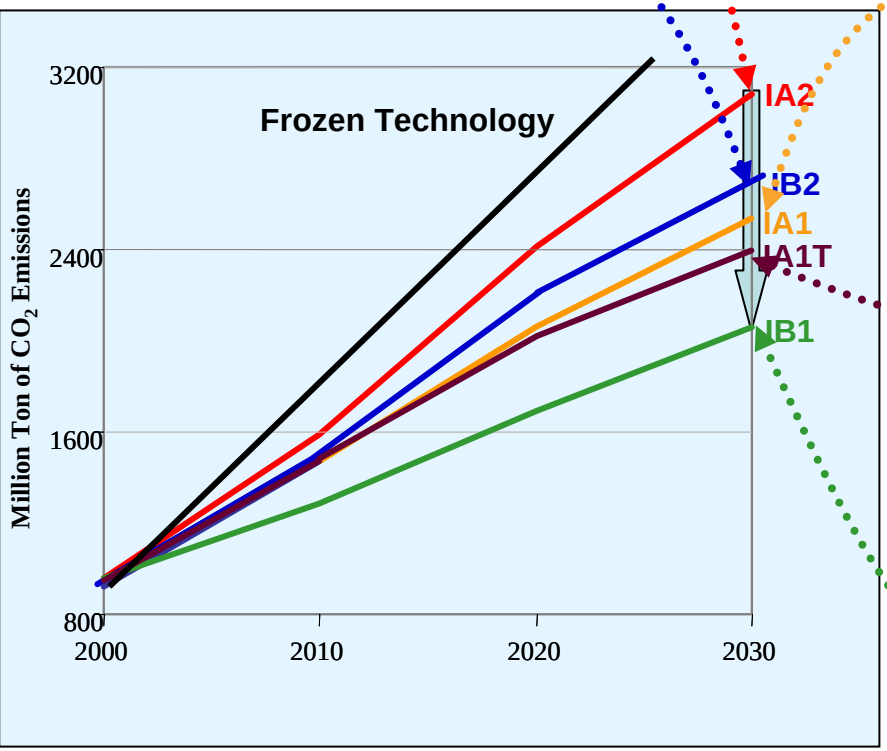


India: CO_2 Emissions



Technologies in Scenarios: Short-term

Conventional Technology Paths



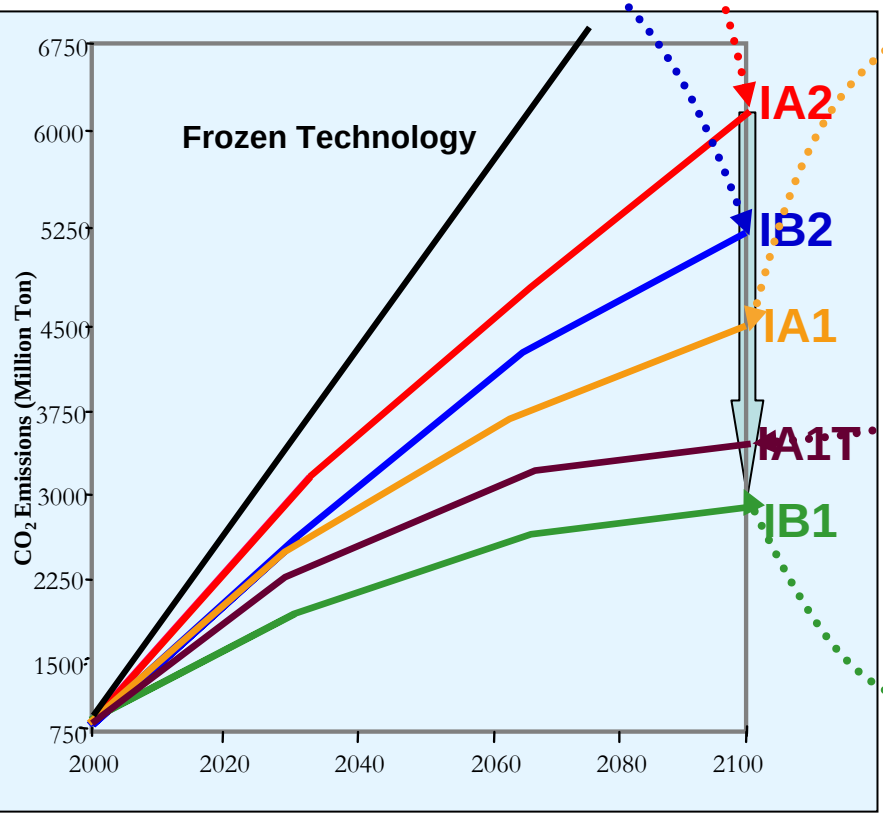
- Road infrastructures, Energy markets
- Gasoline hybrid vehicle, Bio-ethanol
- Ultra-critical boilers, IGCC
- Building insulations, Appliance standards

- Nuclear Fission, Information highways
- Fuel cell vehicle: H2 from natural gas
- Energy efficiency, Environment markets

- Bikeway, Advanced car sharing system
- Renewable energy technologies
- Waste recycling and reuse
- Virtual communication system
- Urban planning, Public transport

Technologies in Scenarios: Long-term

Conventional Technology Paths

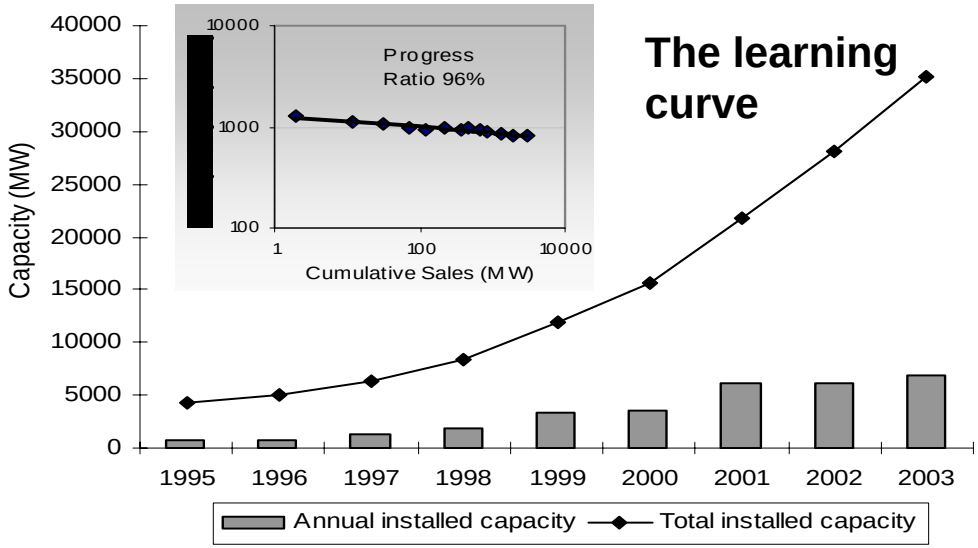


- Synfuels, Gas hydrates, Nuclear fission
- Fuel cell vehicle: Carbon-free hydrogen
- Energy efficient appliances/ infrastrucutre
- CO_2 Capture/ Storage, pipeline networks

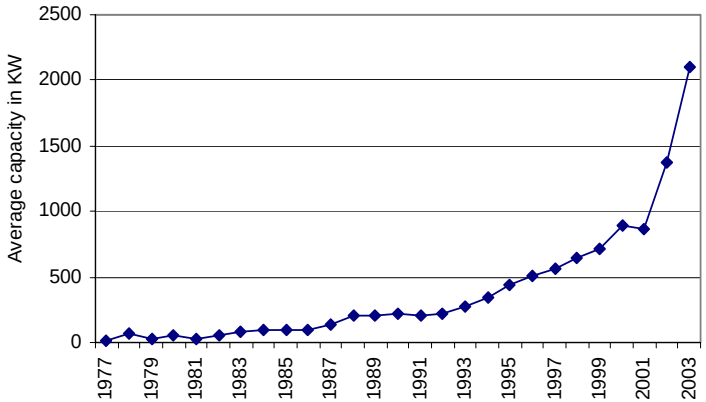
- Nuclear Fusion, Backstops
- Information highways, High speed trains
- Advanced materials, Nanotechnology

- High share of renewable Energy
- Lifestyle changes, Eco-friendly choices
- Substitution of transport by IT
- Dematerialization, material substitutions
- Sustainable habitats, Public amenities

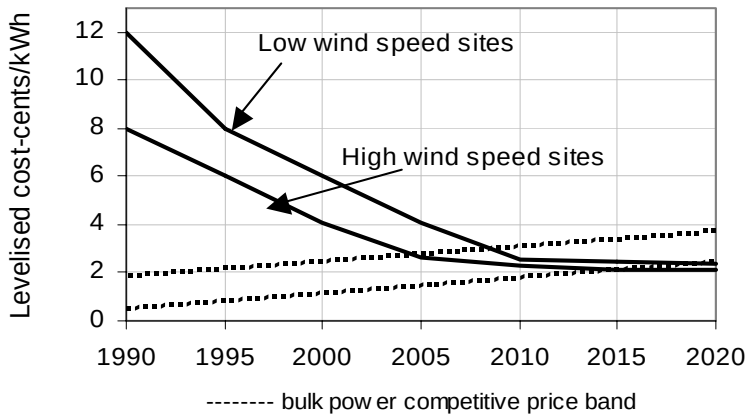
Wind Electricity



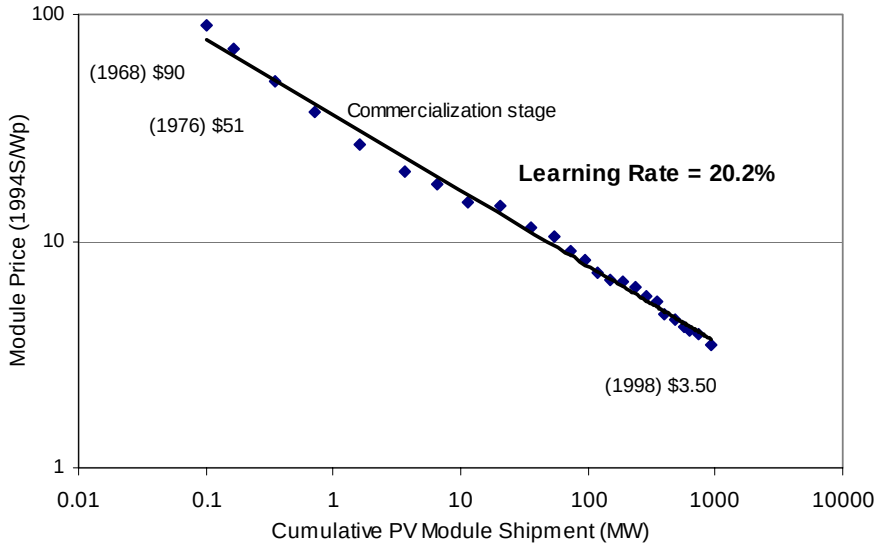
Turbine size



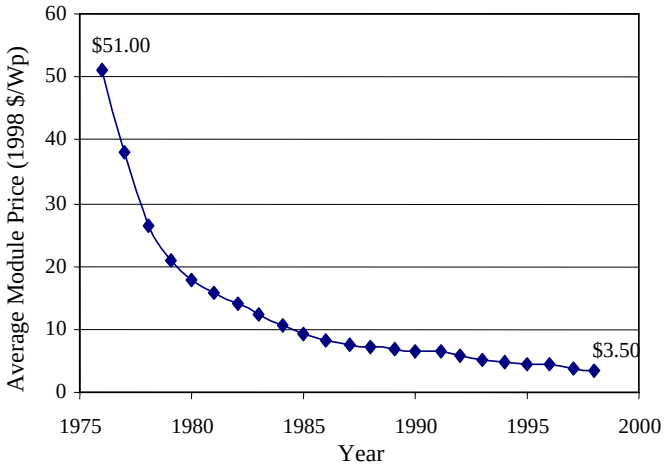
Projections



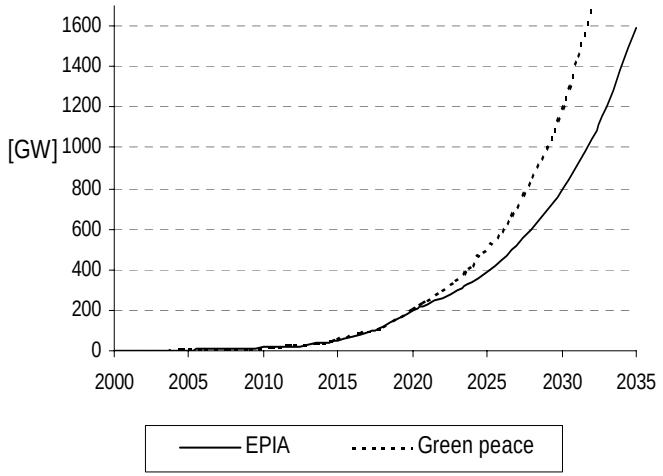
Solar Electricity



Cost History



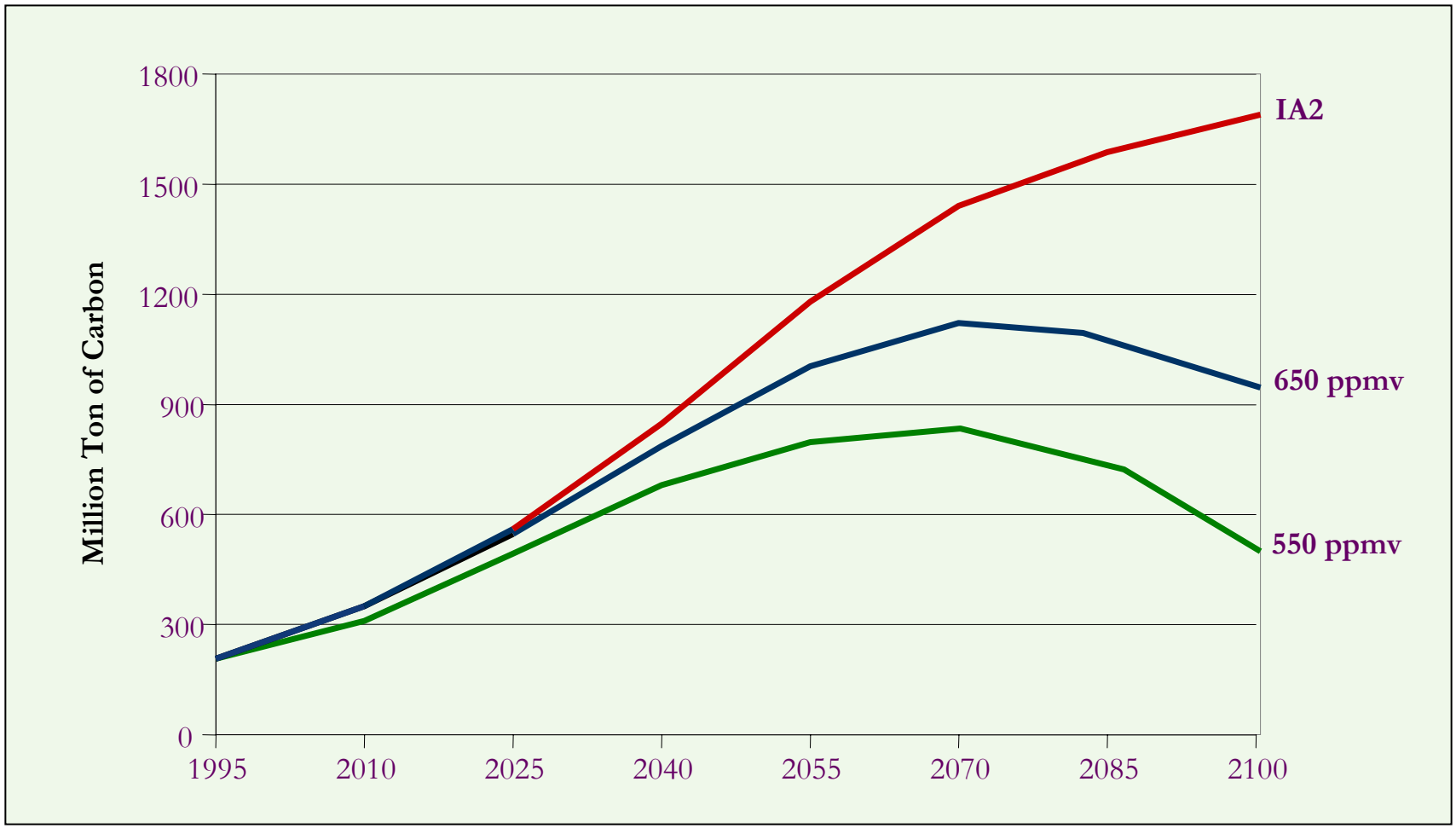
Cost Projections



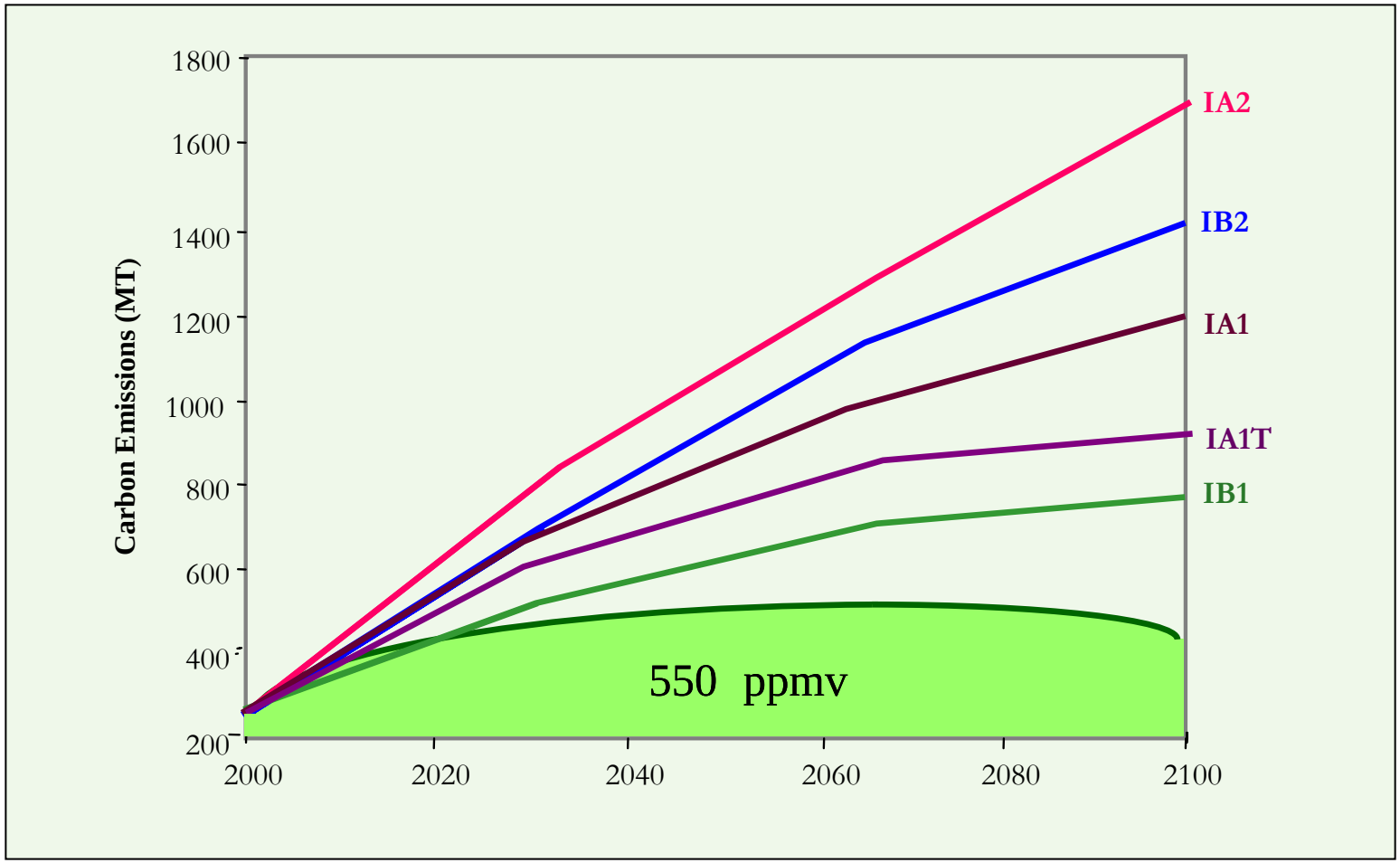
Stabilization Induced Technological Change

Assessment for IA2 Scenario

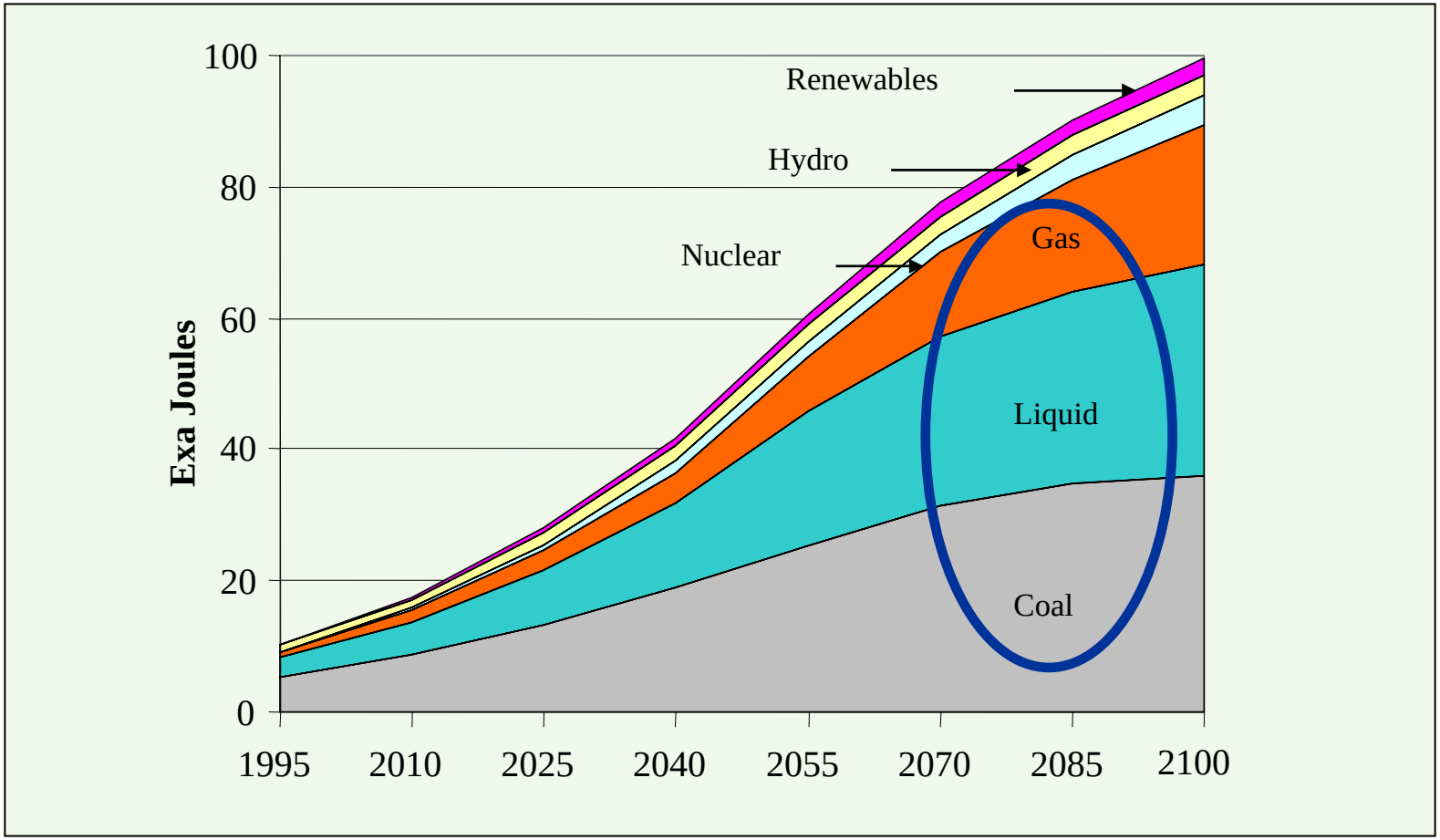
Stabilization: Optimal India Trajectories



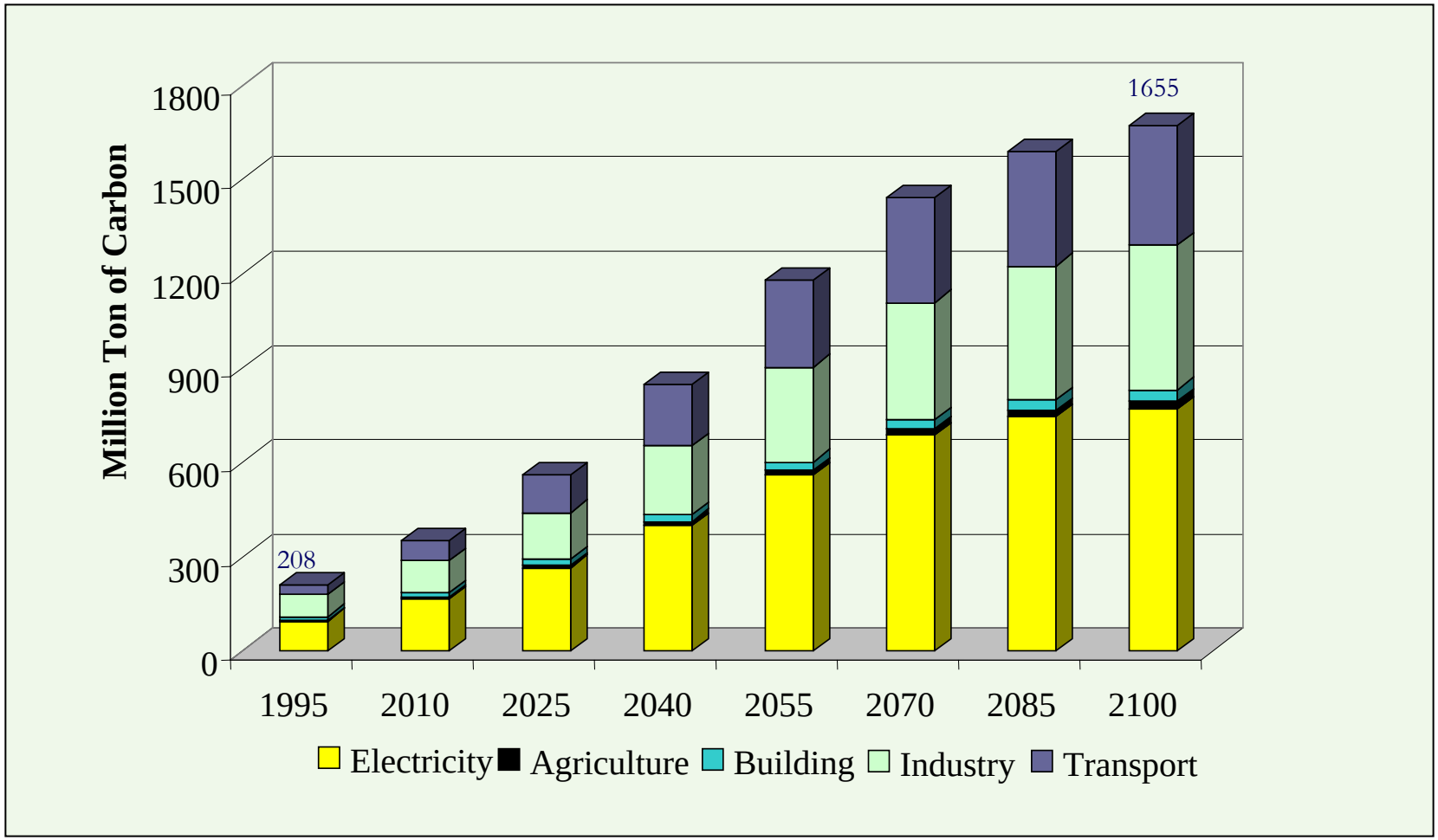
Indian Emission Scenarios and Stabilization



Primary Energy Projections (IA2 Scenario)



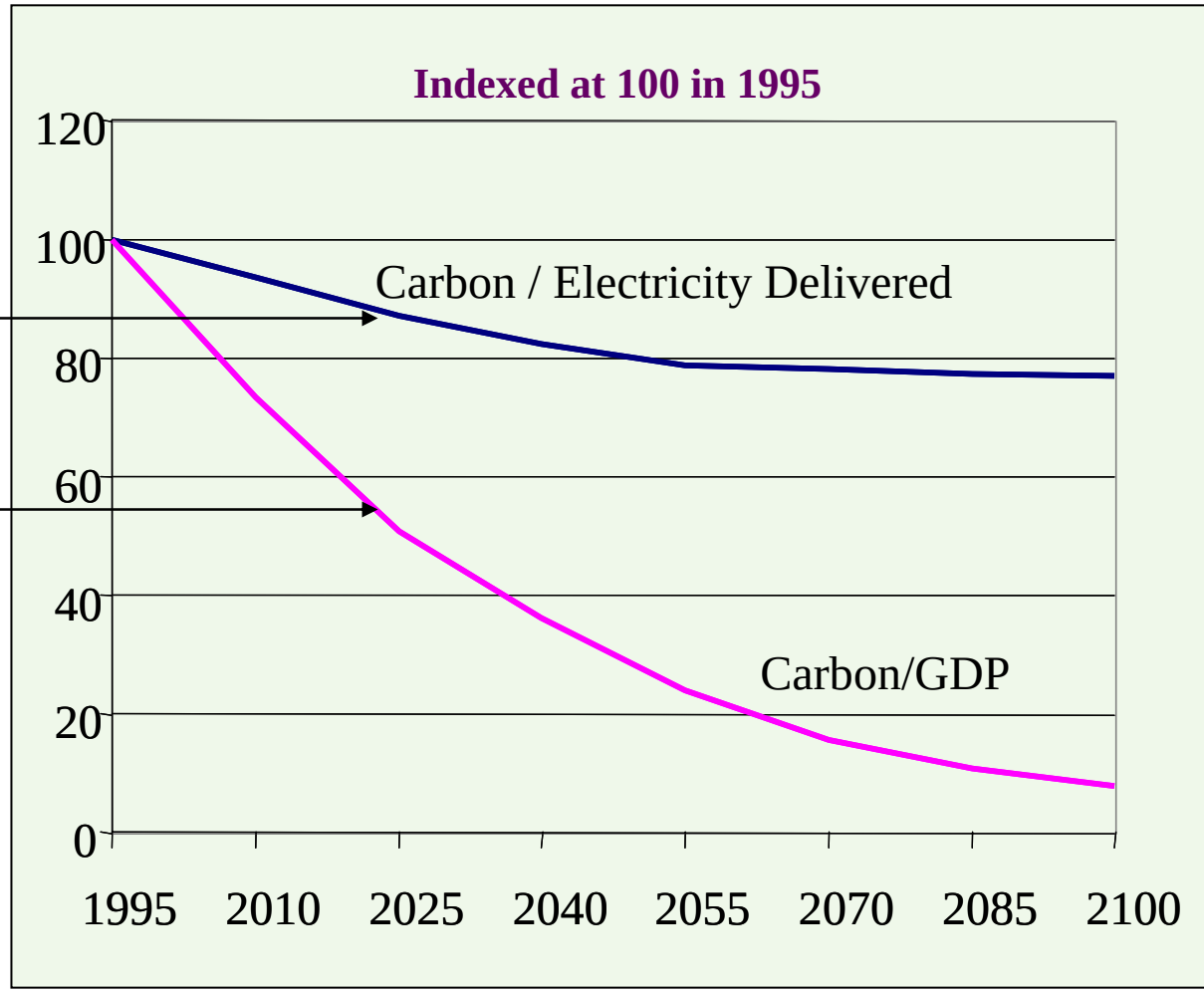
Carbon Emission Projections (IA2 Scenario)



Intensities: IA2 Scenario

Electricity remains carbon intensive

Strong decoupling between GDP growth and carbon emissions

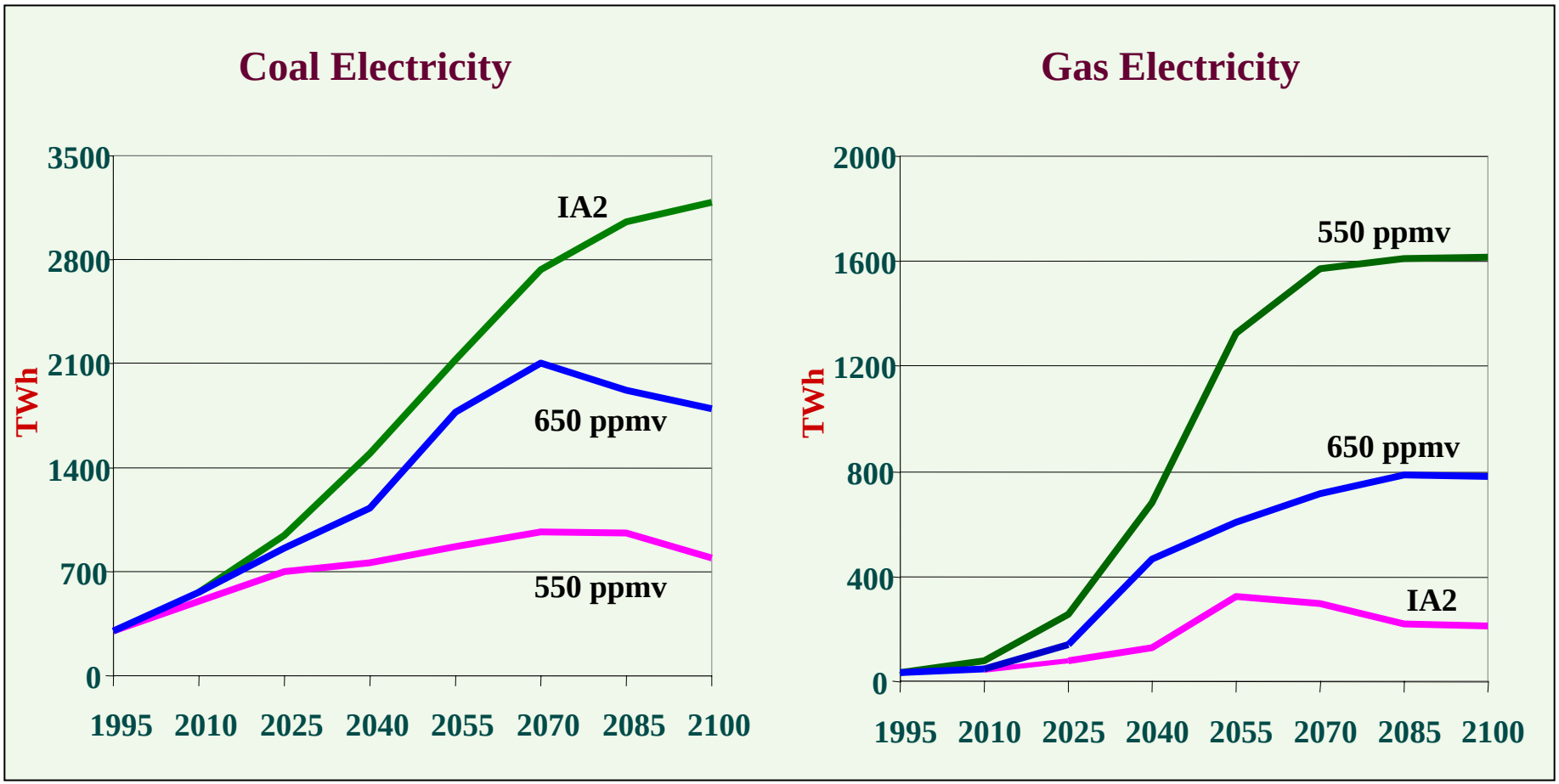


Stabilization, Technology and Development

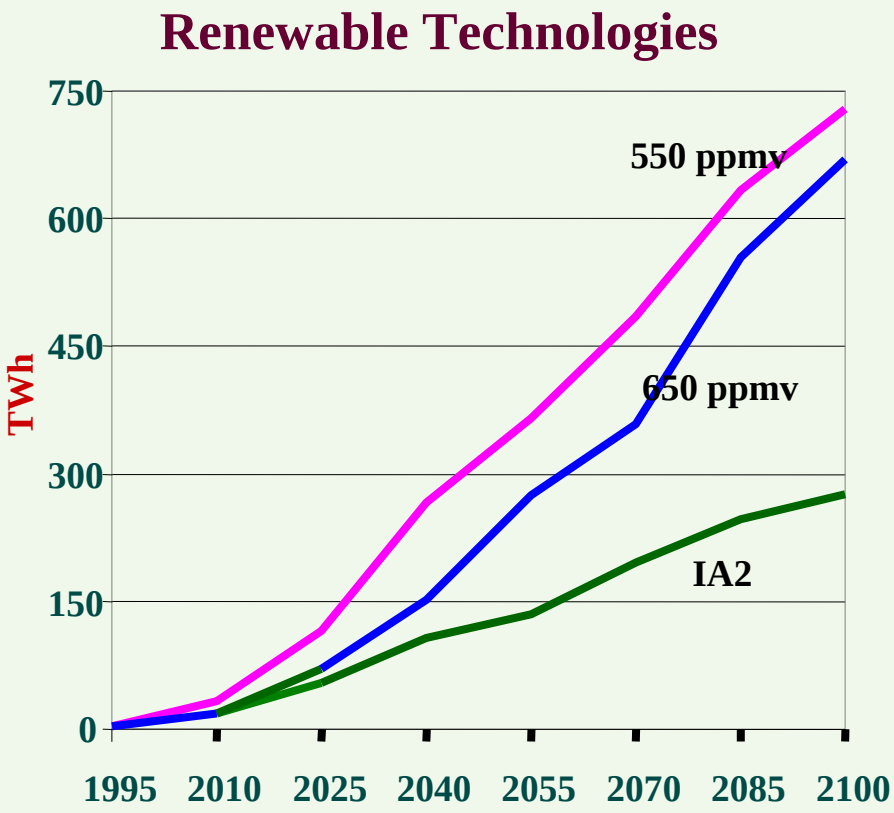
What would stabilization do to:

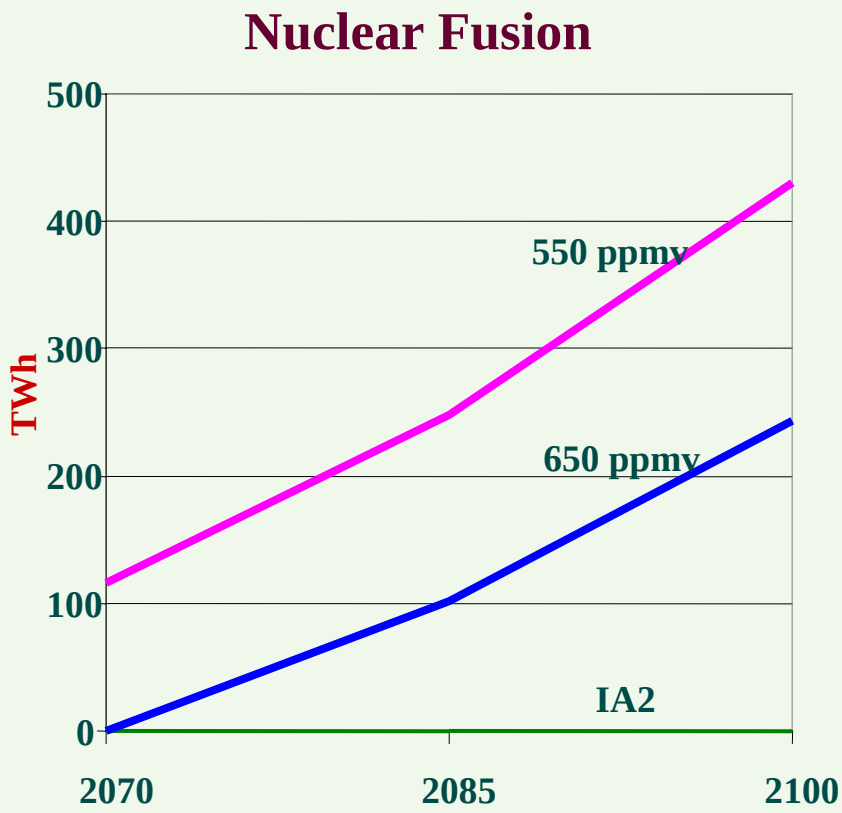
- Domestic coal supply
- Renewable Energy
- Competitiveness (cost of energy/ electricity)
- Structural changes (energy, economy)
- Local Air Quality
- Mitigation burden

Stabilization: Fossil Electricity Technologies

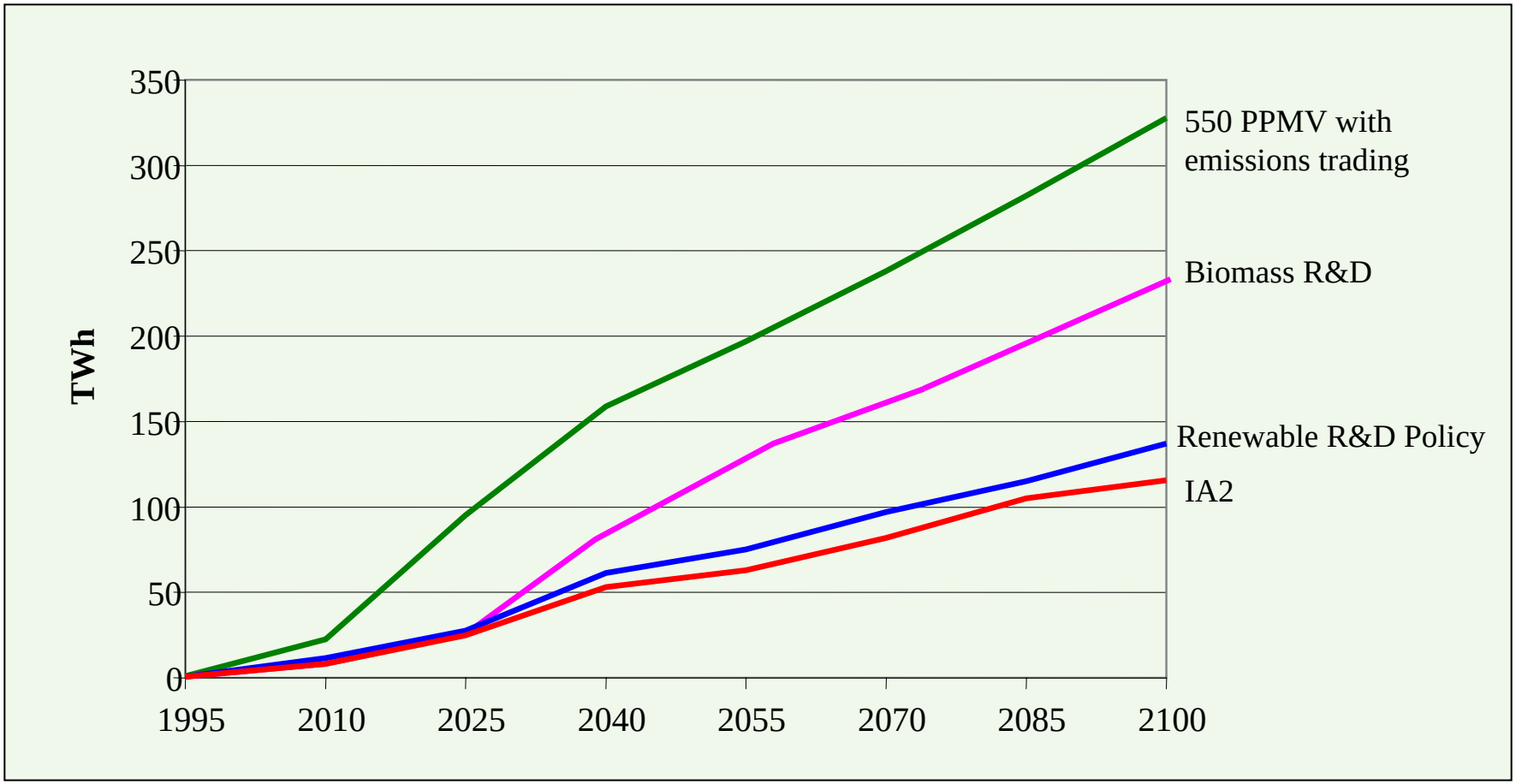


Stabilization: New/ Renewable Technologies



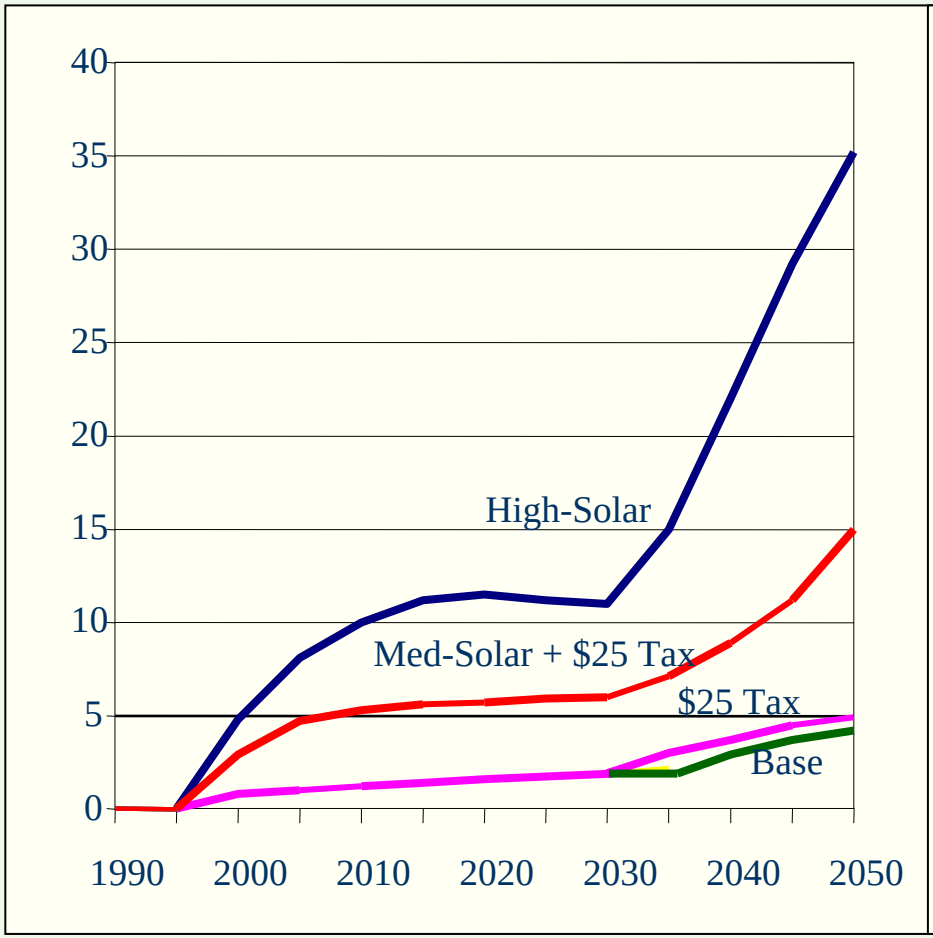


Biomass Electricity Penetration

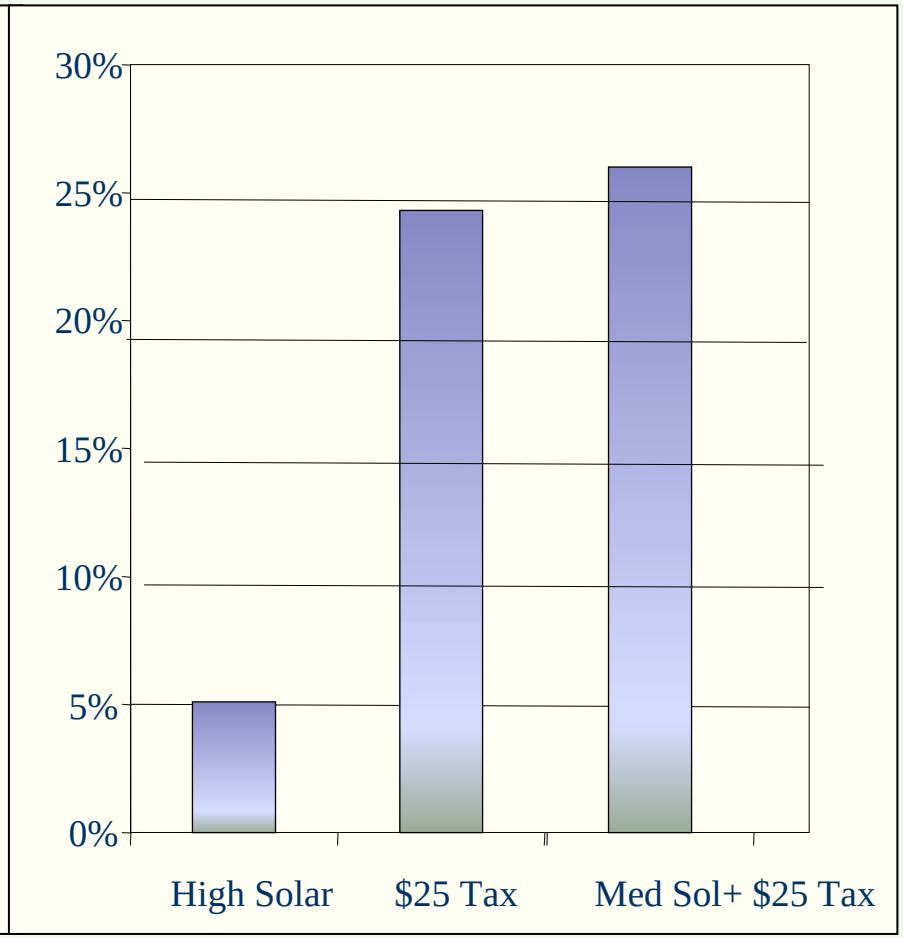


Technology Competition

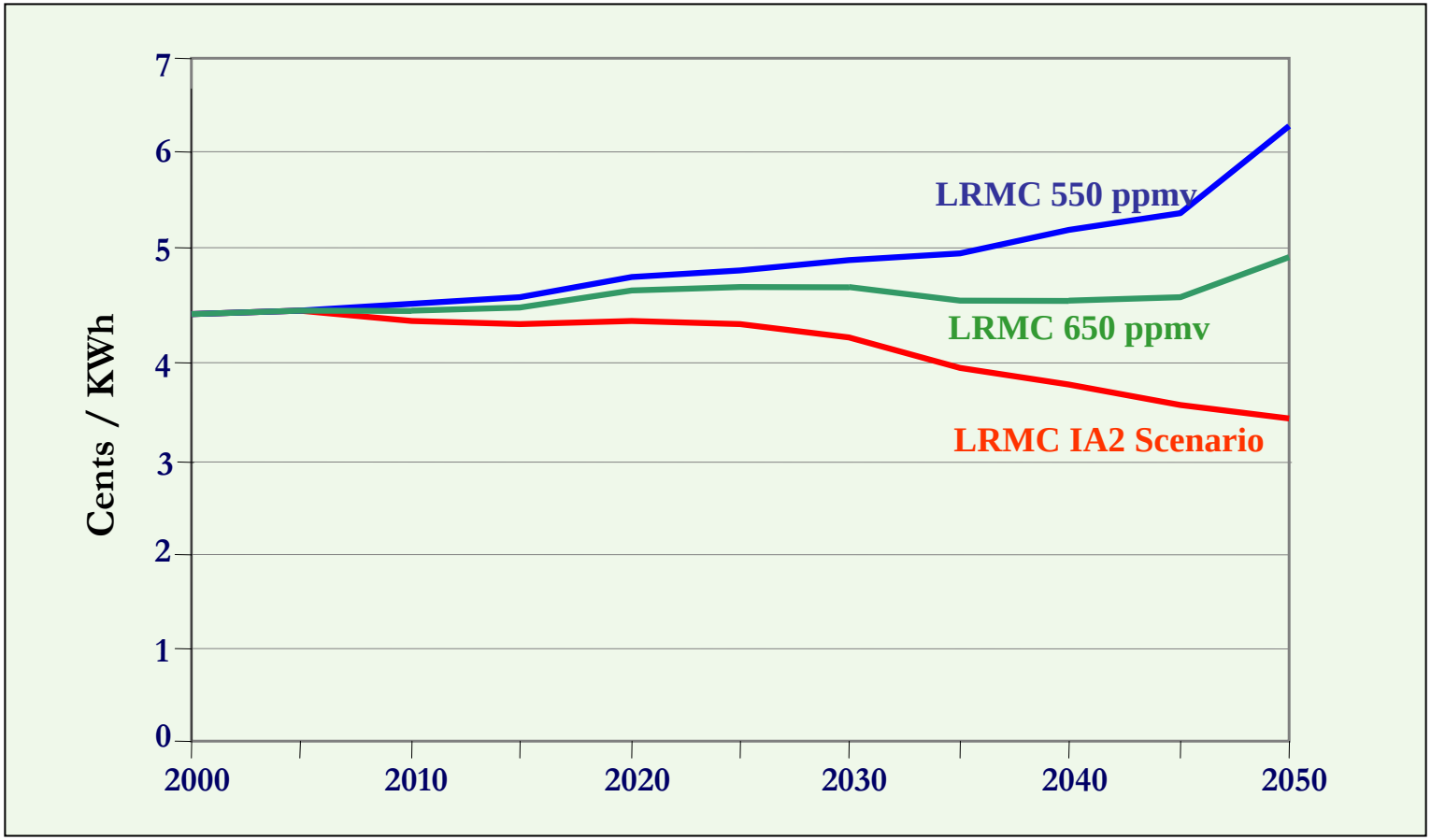
Solar PV Penetration



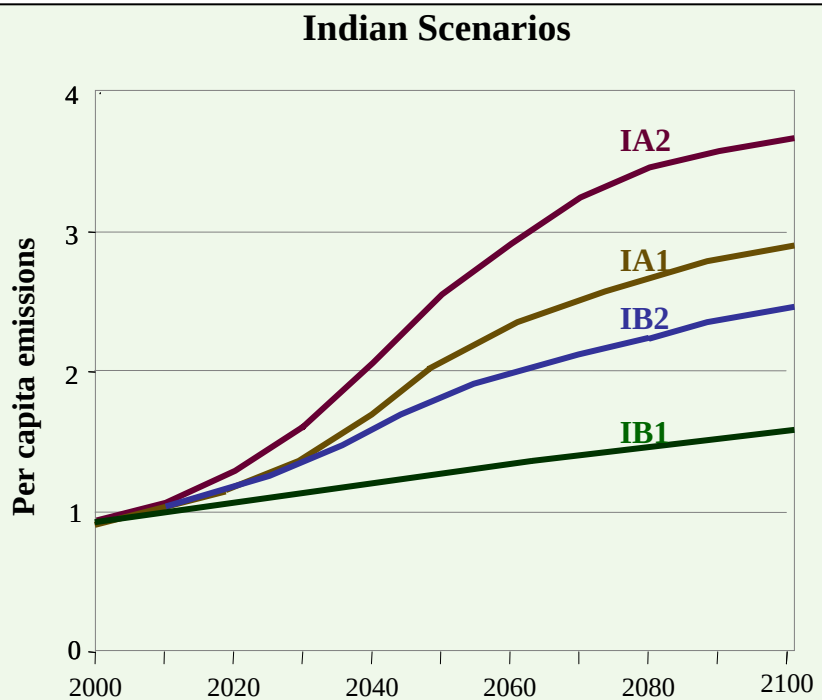
Carbon Mitigation

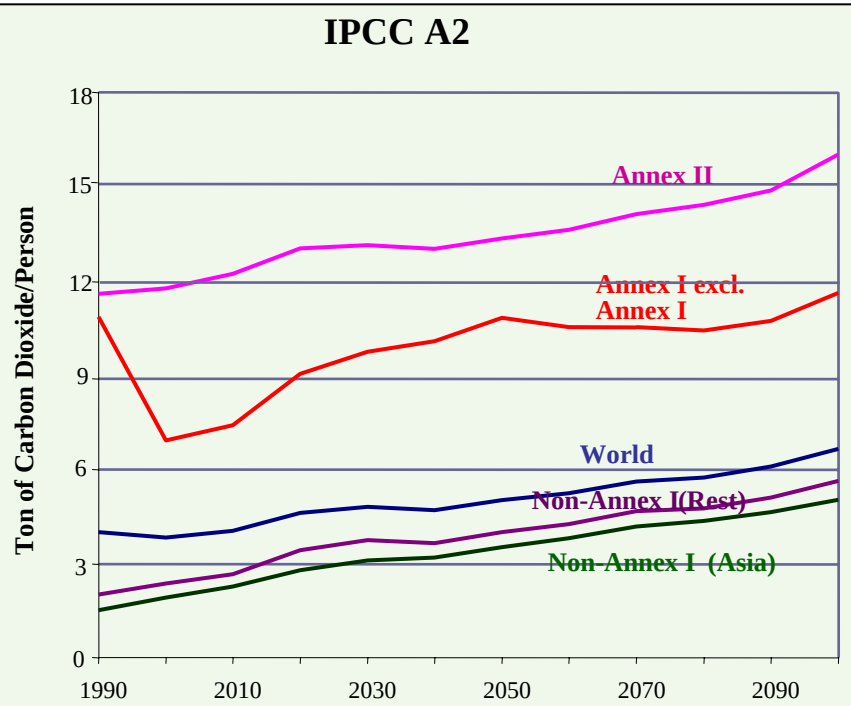


Stabilization & Electricity Cost: Competitiveness



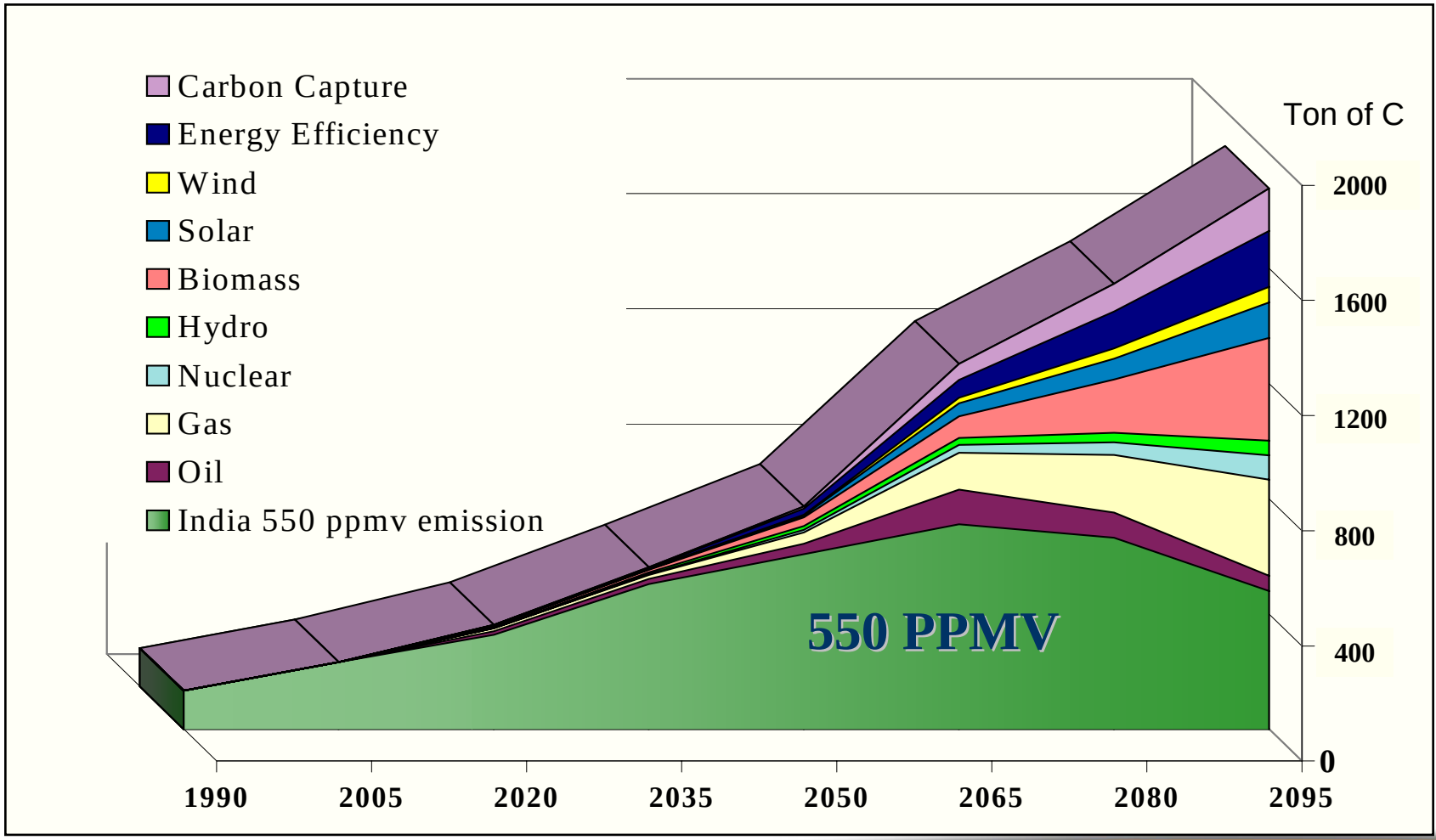
Per capita CO_2 emissions: Burden Sharing Issues





Induced Technological Change – IA2 Scenario:

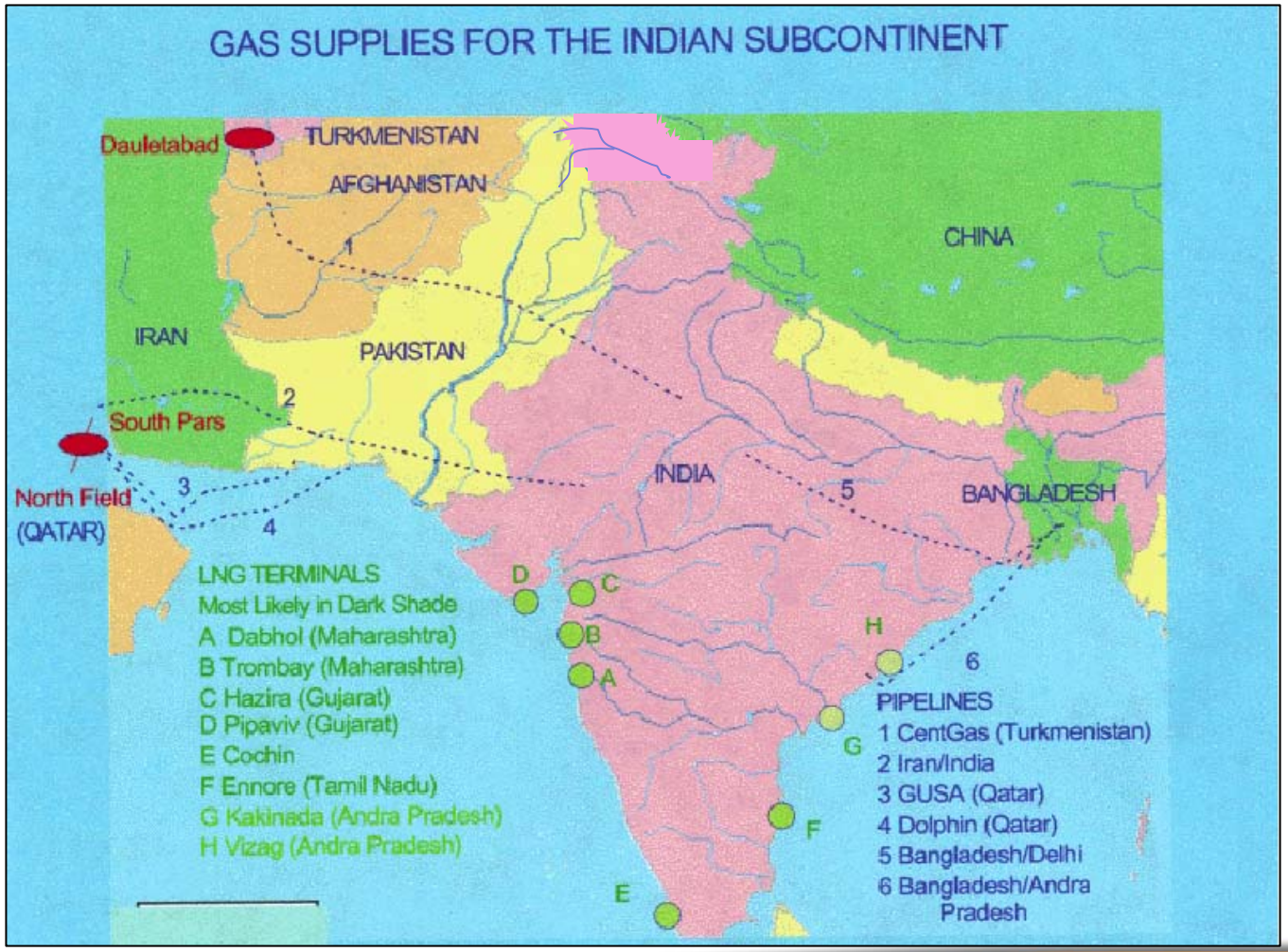
550 ppmv CO_2 Stabilization in India



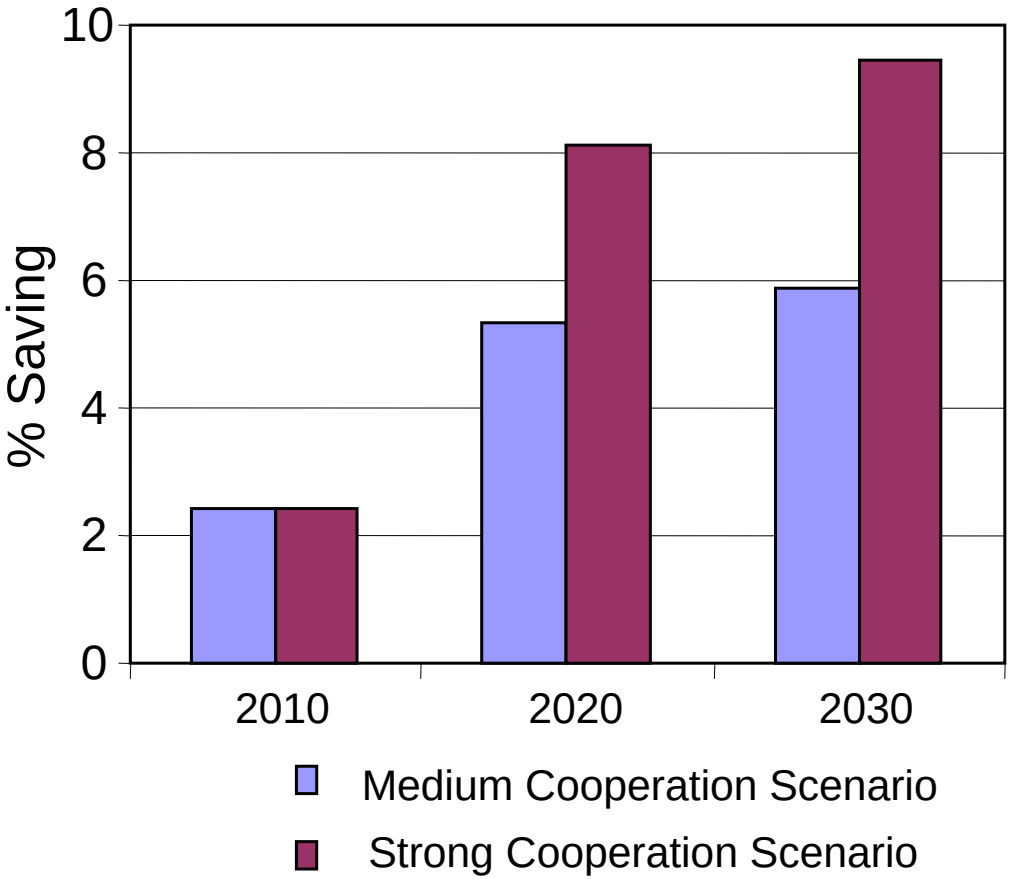
Aligning Development and Climate:
Co-benefits, Transitions & Innovations

- South-Asia Regional Cooperation
- Conjoint CO_2 and SO_2 Market
- Drivers of Technological Change

Regional Energy Market Development

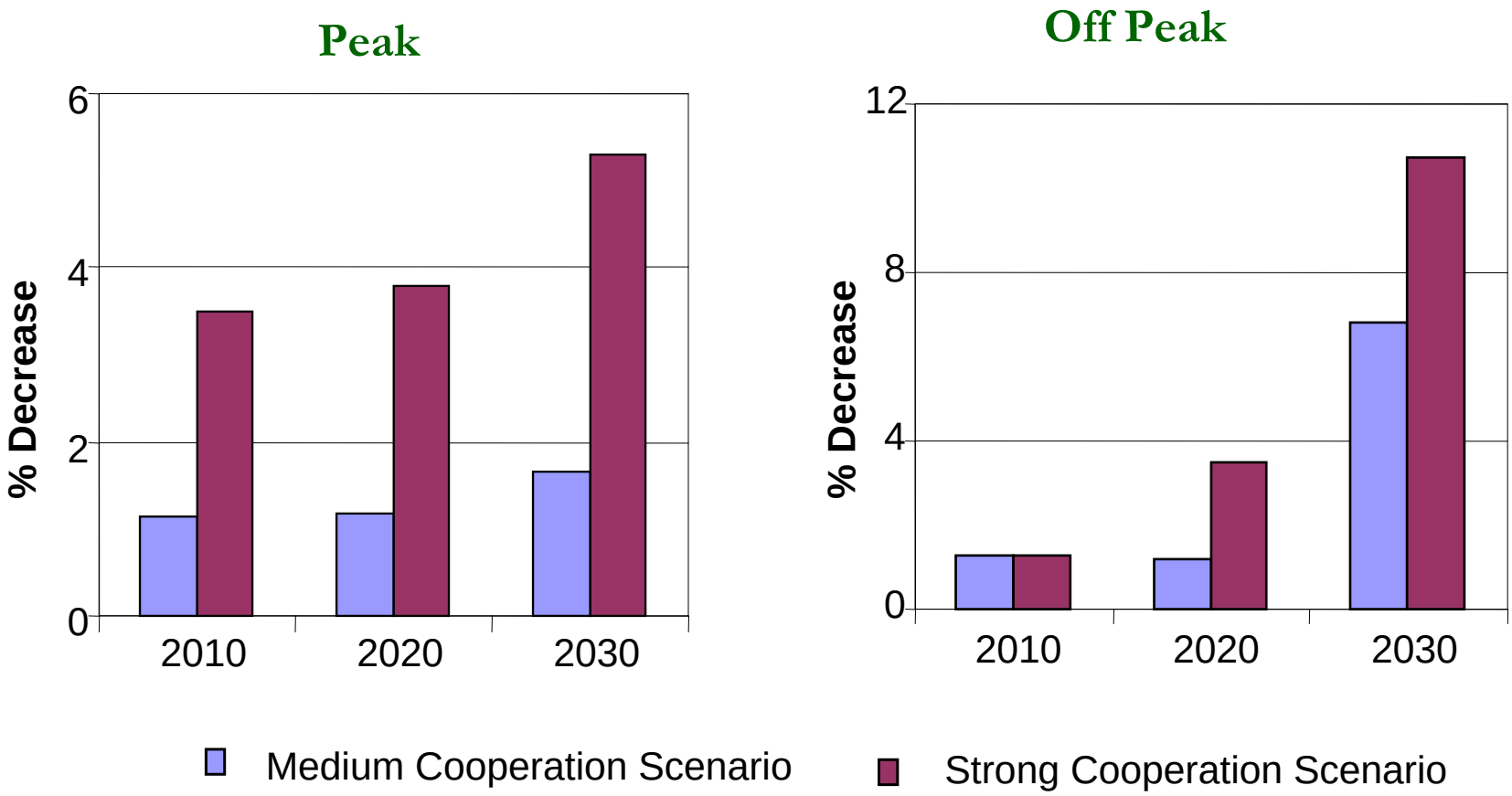


Total Primary Energy Supply Saving



- Cumulative Saving in Strong Cooperation: 60 EJ in 20 years (2010-2030)
- This is equivalent to $180 billion cumulative

Reduced Electricity Costs

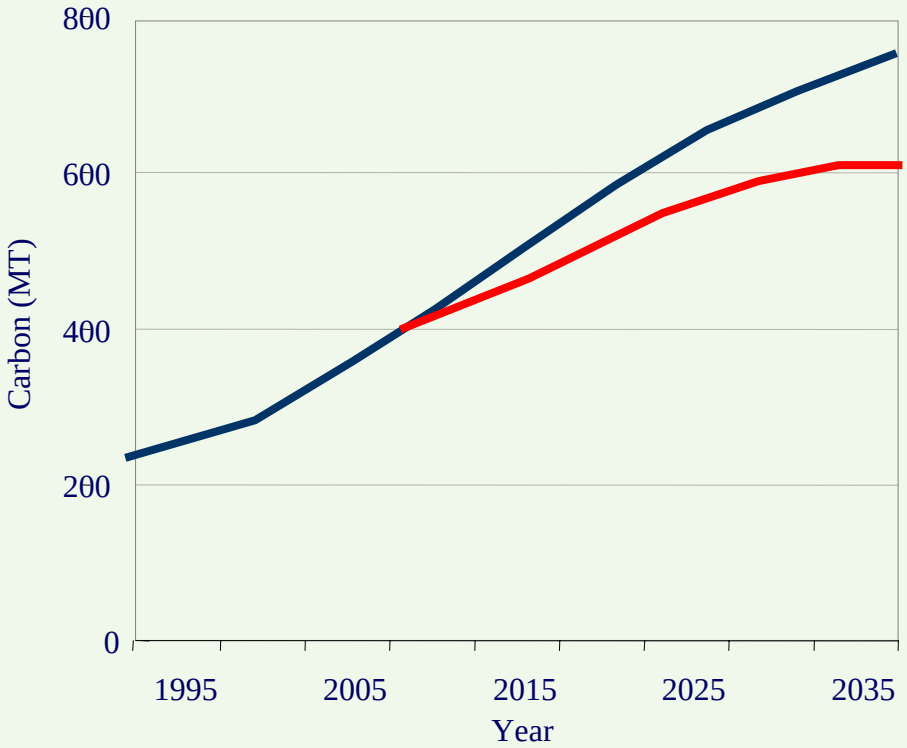


Benefits from South-Asia Energy Cooperation
(2010-2030)

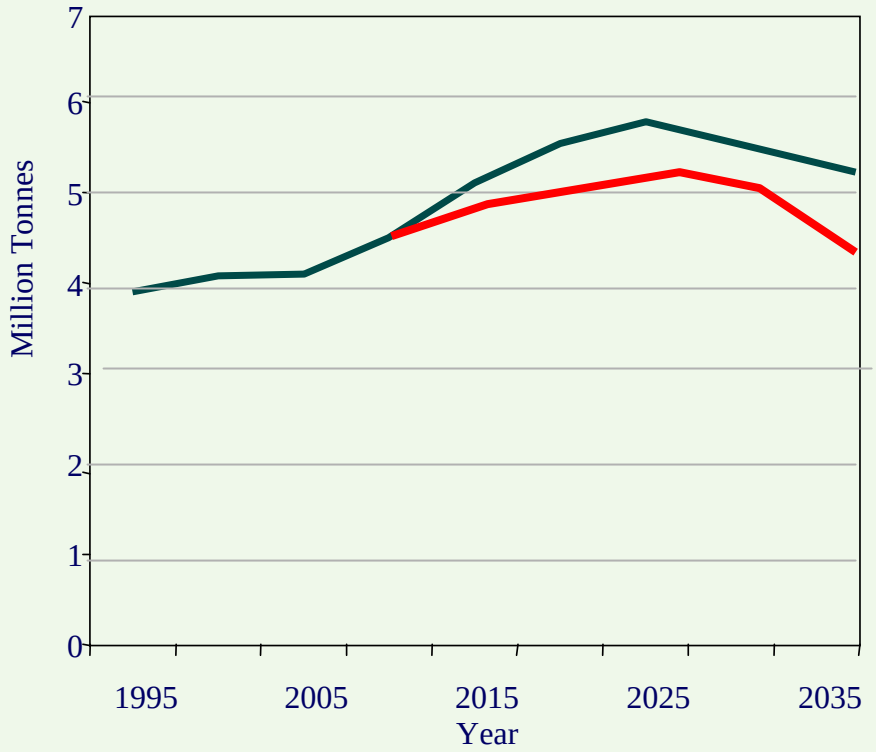
Benefit (Saving)		$ Billion	% of Region's GDP
Energy (Direct Benefits)			
Energy	60 Exa Joule	180	0.48
Investment in Energy Supply Technologies		72	0.19
Investment in Energy Demand Technologies		69	0.18
Environment (Indirect Benefits)			
Carbon	1.4 Billion Ton	28	0.08
Sulfur Dioxide (SO_2)	50 Million Ton	10	0.03
Total Direct and Indirect Benefits		359	0.98
Spillover Benefits			
Water	16 GW additional hydro capacity		
Flood Control	From additional dams		
Competitiveness	Reduced unit energy/electricity cost		

Co-benefits of CO_2 & SO_2 Mitigation?: India A2 Scenario

Carbon Emissions



SO_2 Emissions



Drivers of technological change

Transitions in Developing Countries

- Demographic
- Energy
- Incomes
- Infrastructures
- Institutions

International Labor market

- Wage differential
- Income gaps
- Migration

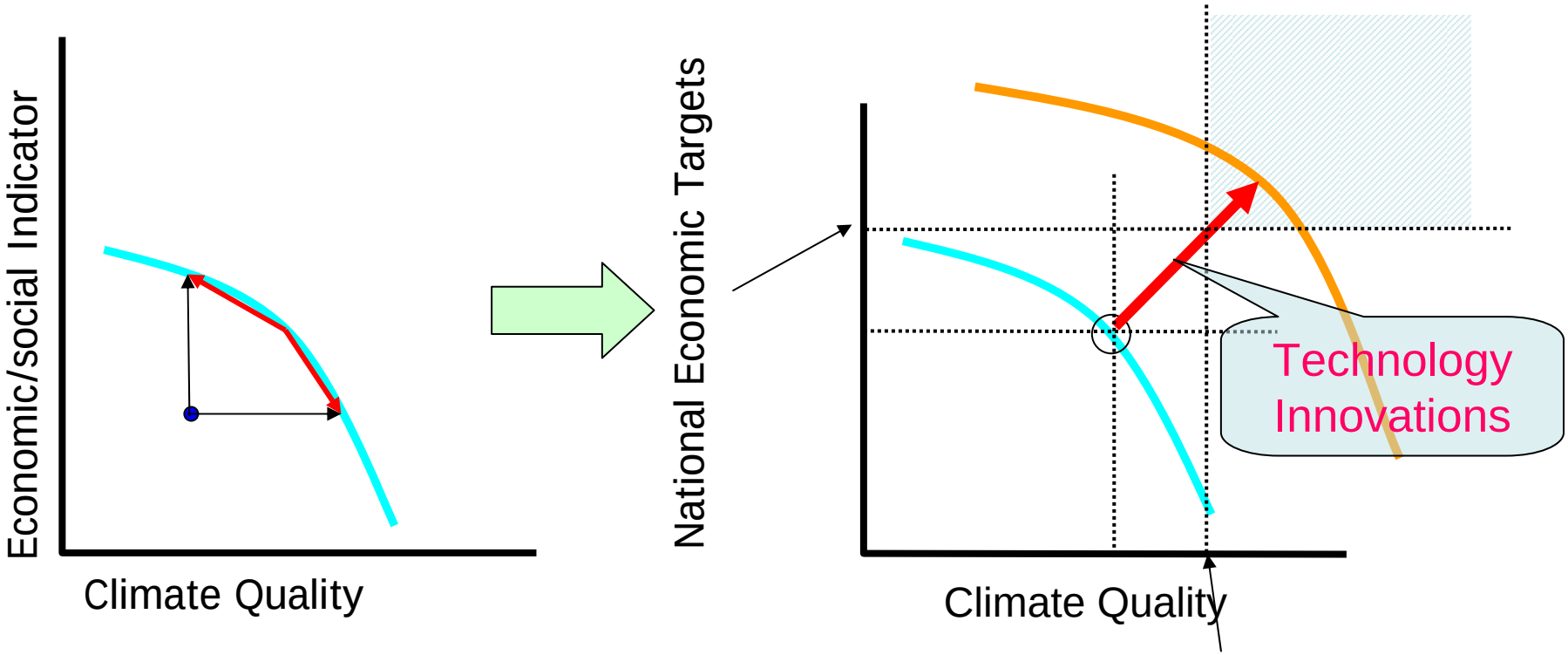
Human Capital

Knowledge flows

- Diasporas and social networks
- Shifting comparative advantage in knowledge services
- Role of local and contextual knowledge

Governance, risks and investment flows

Aligning Development and Climate: Technology Innovations



Thank you