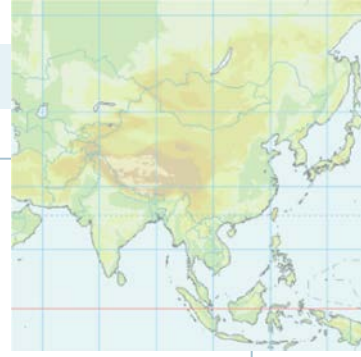


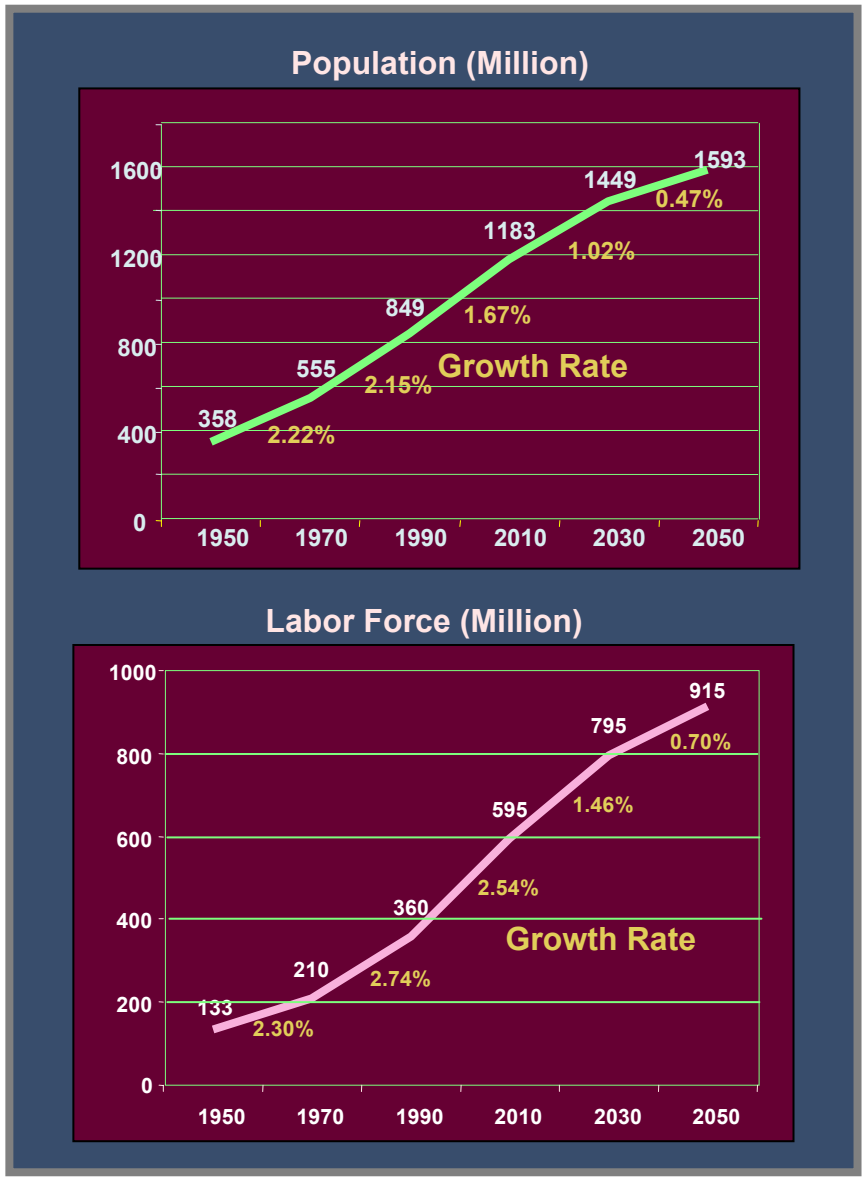
Scenarios, Modelling and Analysis of Low Carbon Society for India

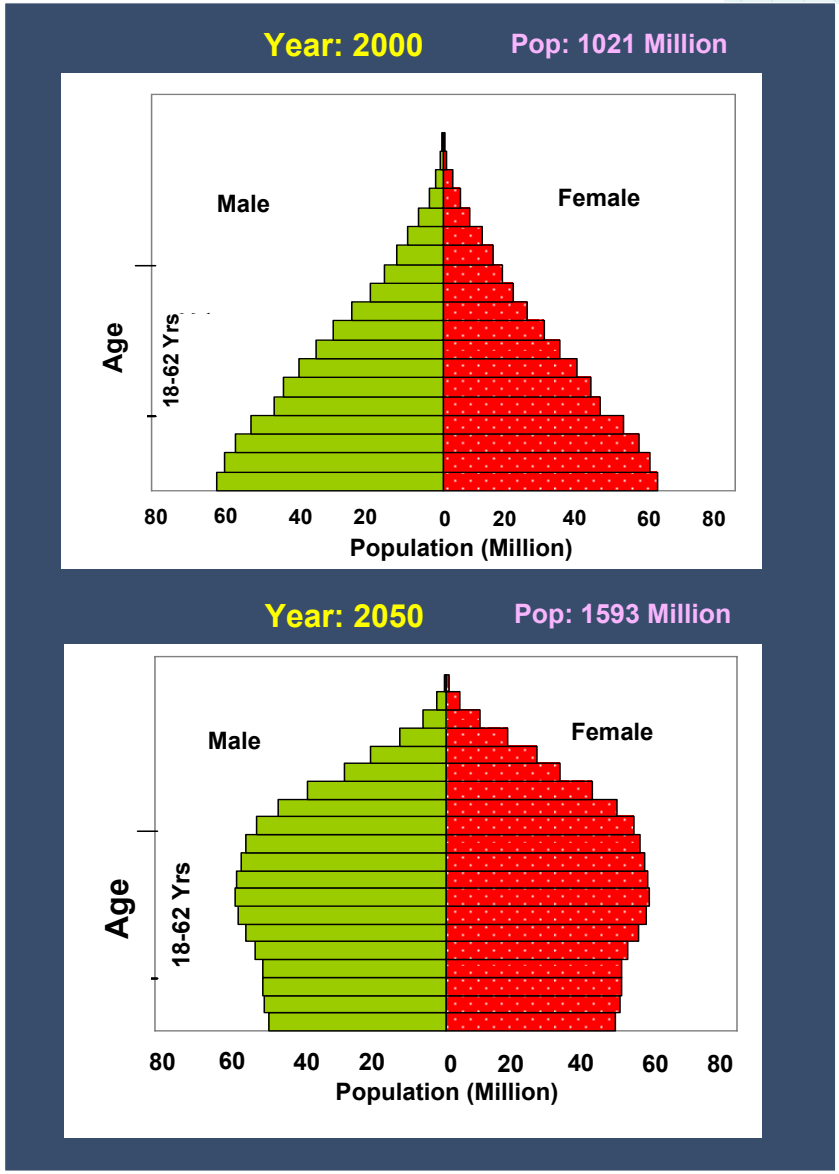
P.R. Shukla
Indian Institute of Management
Ahmedabad, India

Presented in the
'13th AIM International Workshop'
Tsukuba, Japan, February 17-18, 2008

Base Scenario

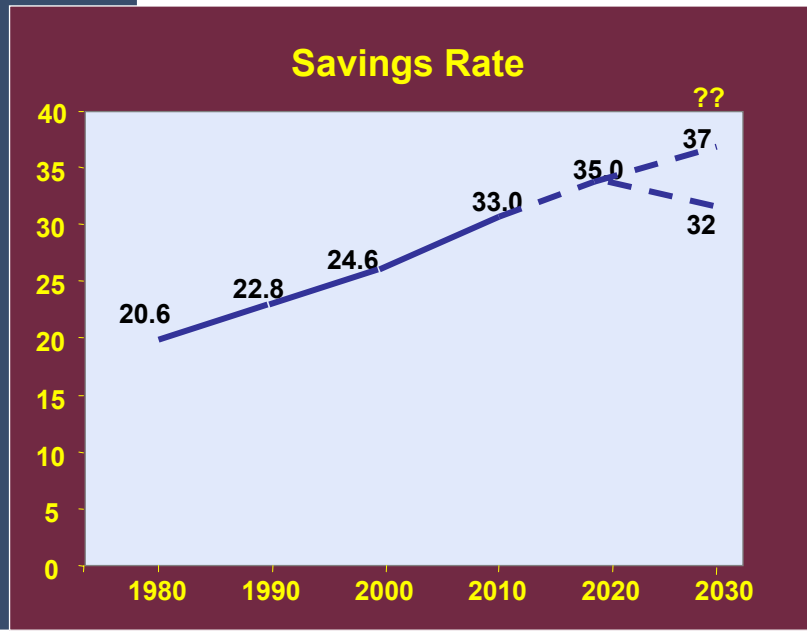
Demographic Drivers



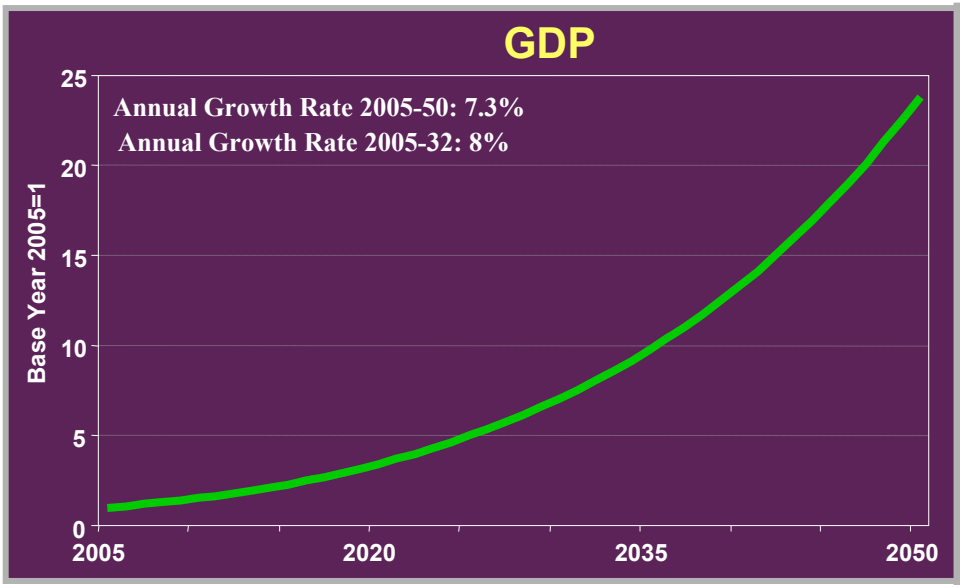


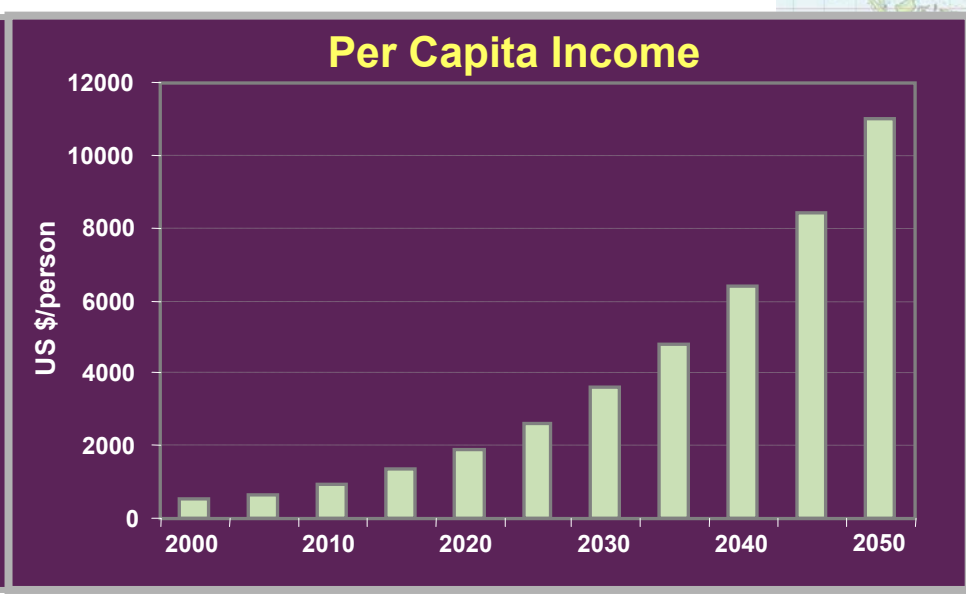
Drivers of Economic Growth

- **Human Capital**
  - High Labor Supply
  - Increasing Education
  - Migration (intra & inter county)
- **R&D**
  - Increasing Government/ Private Expenditure
  - International Knowledge Flows
  - R&D Collaborations
- **Technology**
  - Infrastructures
  - Learning, transfers, deployment
- **Behavioral Changes**
  - High Savings Rate
  - Changing Lifestyles
- **Governance**
  - Institutions
  - Laws
  - Policies



Base Scenario GDP





Base Case Assumptions: Summary

1. **GDP**
   - Ann. Growth Rate: 7.2% from 2005-50
   - 2050 Economy: 24 times larger than 2005
2. **Population**
   - 2000: 1021 Million
   - 2050: 1593 Million
3. **650 ppmv CO2e Concentration Stabilization (or 550 CO2)**
4. **Radiative Forcing: 4.7 W/m2**

LCS Scenarios: Alternate Paradigms

Scenarios: Two Visions of Low Carbon Society

Achieving Stabilization of GHG Concentration by:

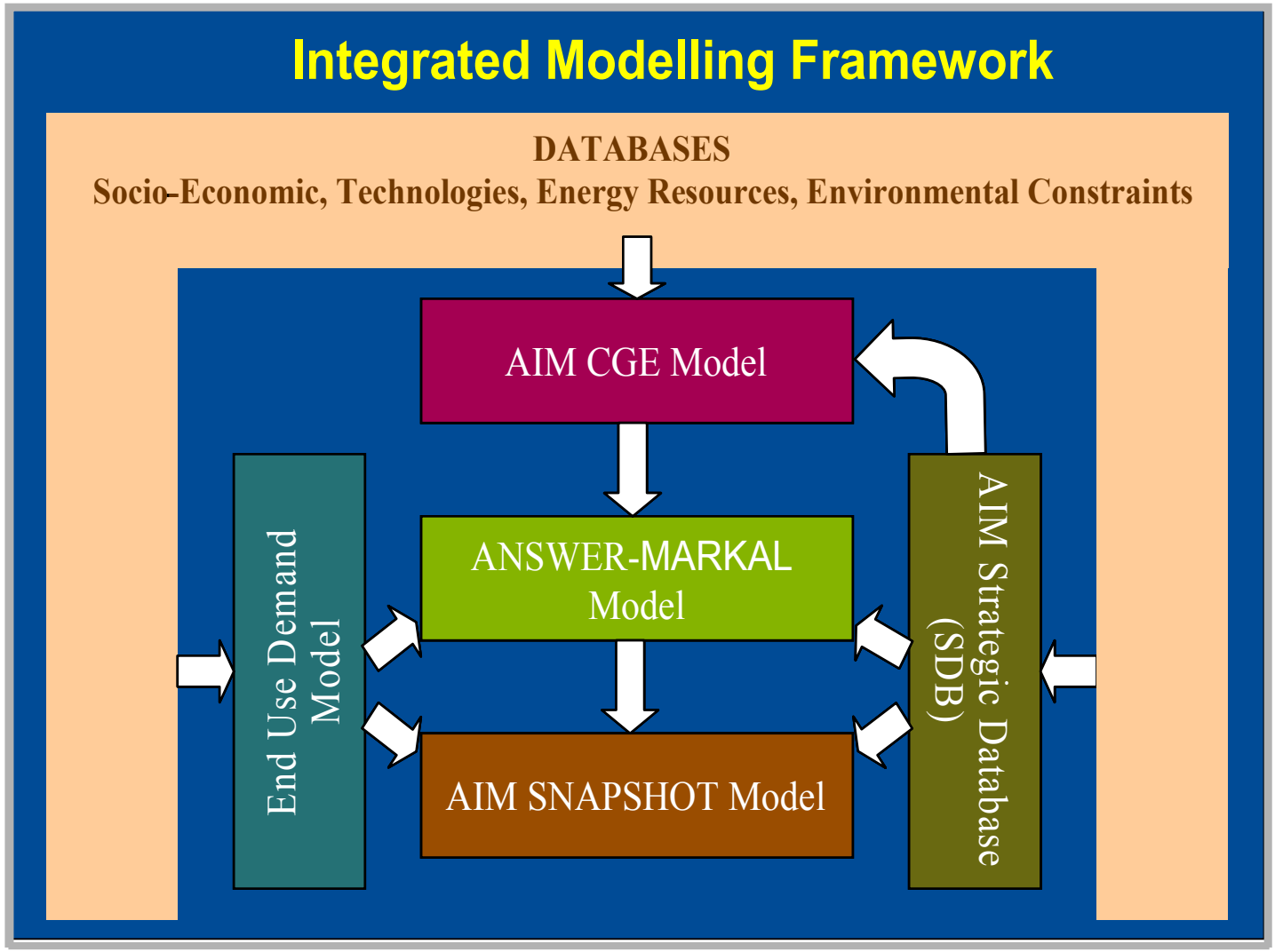
1. **Climate Centric Actions at the Margin of the Conventional Development Path**
   - **Policies: Global Carbon Price over Conventional Development Path**

2. **Aligning Climate Actions with the Mainstream Development Actions**
   - **Policies: Sustainable Development Path + Stabilization**

What path shall best deliver national development goals while fulfilling international commitments?

Modeling

Integrated Modeling Framework



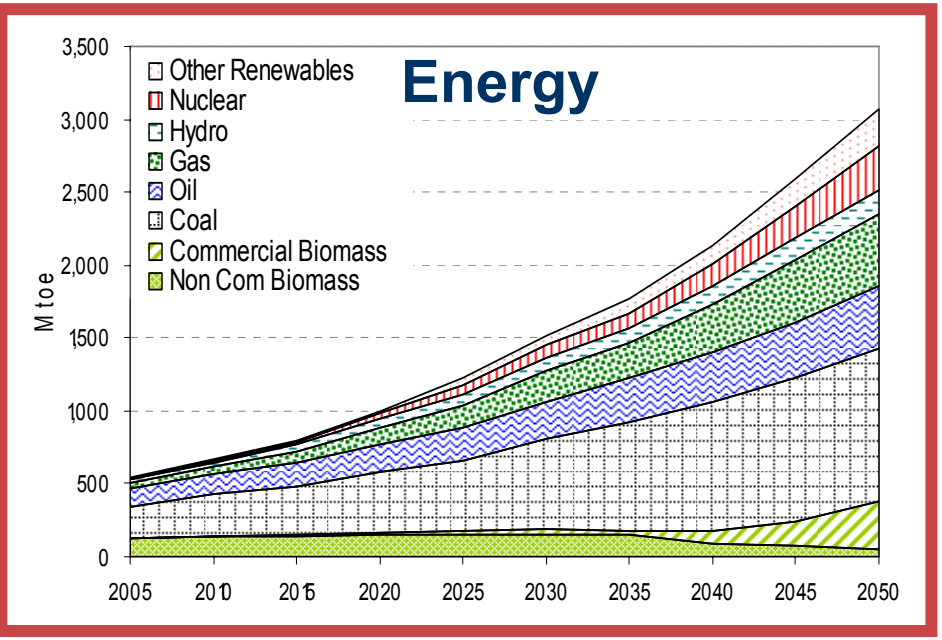
Base Scenario Analysis

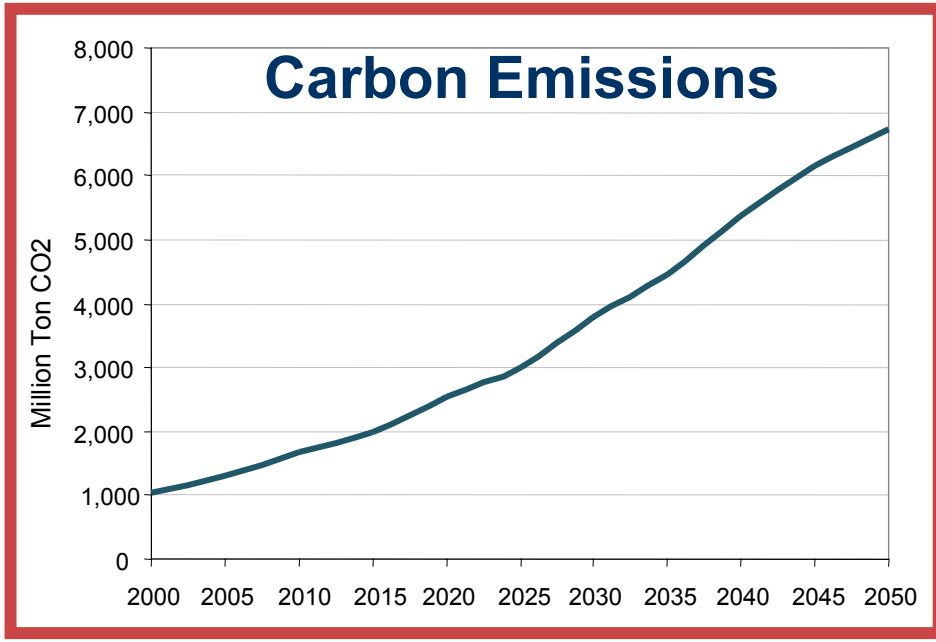
Energy and Carbon: Base Case

Assumptions

From 2005-2050:
Annual Economic Growth: 7.2%
Annual Population Growth: 0.9%

Absolute Growth in 2050 over 2005
Economy 23 times
Population 1.56 times





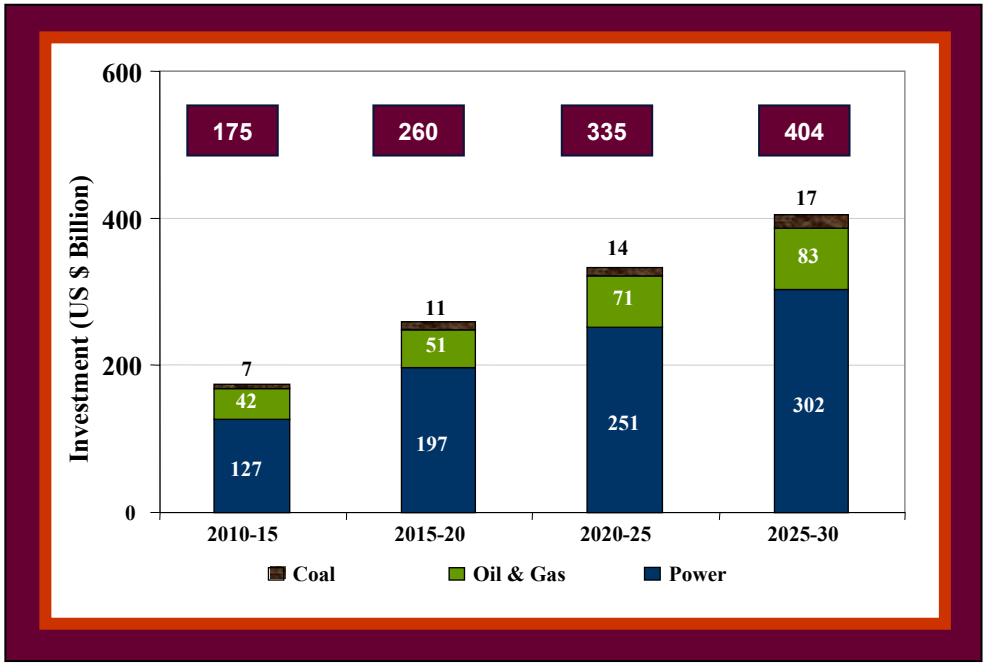
Results: Energy and Carbon Intensity

Annual Improvement From 2005-2050:
Energy Intensity: 3.14 (%)
Carbon Intensity: 3.07 (%)
Decarbonization of Energy: -0.07 (%)

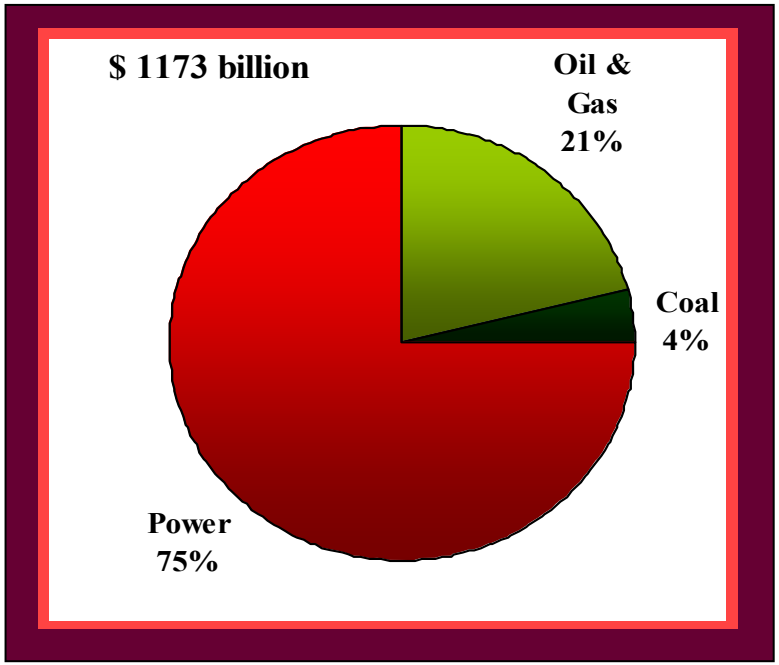
Ratios: 2050 over 2005
Energy Intensity: 0.249
Carbon Intensity: 0.257
Decarbonization of Energy: -3.1 (%)

Investment in Energy: Base Case

Energy Investments (2010-2030)



Share of Energy Investments (2010-2030)



LCS Scenario Analysis

LCS Scenarios: Alternate Paradigms

Scenarios: Two Visions of Low Carbon Society

Achieving Stabilization of GHG Concentration by:

1. **Climate Centric Actions at the Margin of the Conventional Development Path**
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What path shall best deliver national development goals while fulfilling international commitments?

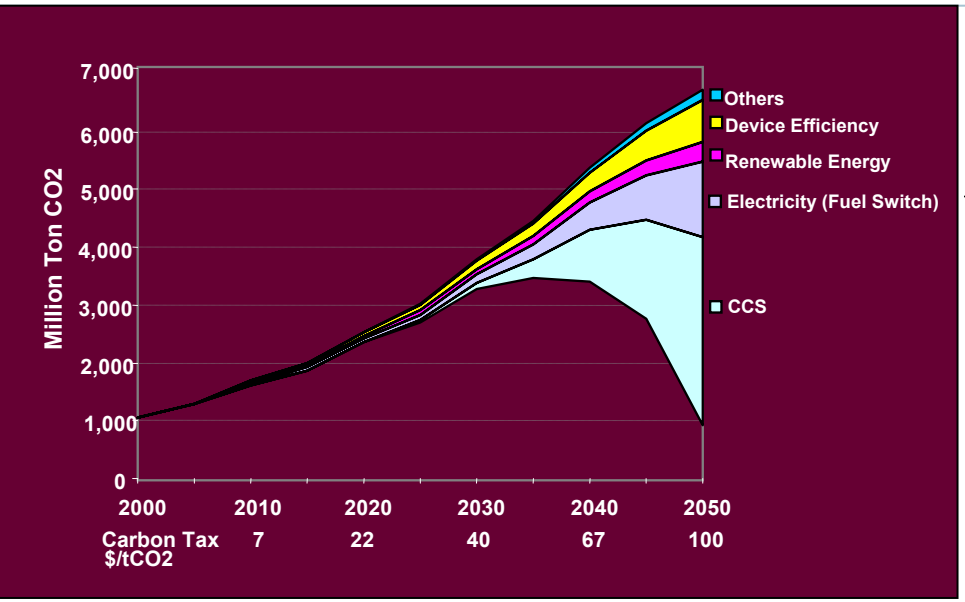
Indian LCS Scenario Assumptions

- LCS Scenarios assume 550 ppmv CO2e Concentration (or 470 CO2 Concentration)
- 3.4 W/m2 (or @ 3°C temperature increase)
- Two pathways of LCS produce identical cumulative CO2 emissions from 2005 to 2050
- LCS Vision 1 scenario has same GDP and Population as in Base Case (7.2% from 2005 to 50)
- LCS Vision 2 is a 'Sustainability' driven scenario with population & GDP lower than in Base Case (6.9% from 2005 to 50) but include variety of interventions in line with sustainable development paradigm

LCS Dimensions: Objectives/Interventions

- **Economic Development** (Quantity and Quality of Growth)
- Enhanced **Investment** in climate actions
  - Mitigation
  - Adaptation
- Climate change **Technologies**
  - R&D/ IPR
  - Technology transfer
- Climate change **Risks**
  - Adaptation costs
  - Climate Goals (e.g. Stabilization @ 450 ppmv CO_2e or 2^{O} C)
- **Equity/ Fairness** of global climate regime
- **Mechanisms/ Instruments** to manage climate change
  - Direct (Climate) vs. Indirect (Development)
  - Market vs. CC + Non-Market

Low Carbon Society Transitions

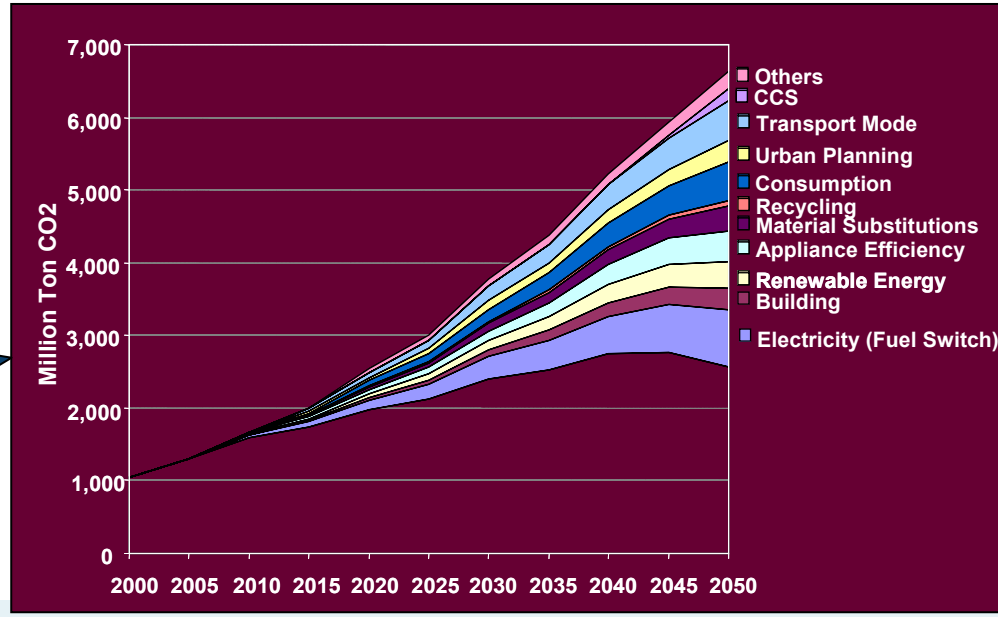


LCS Vision 1: transition with conventional path and carbon price

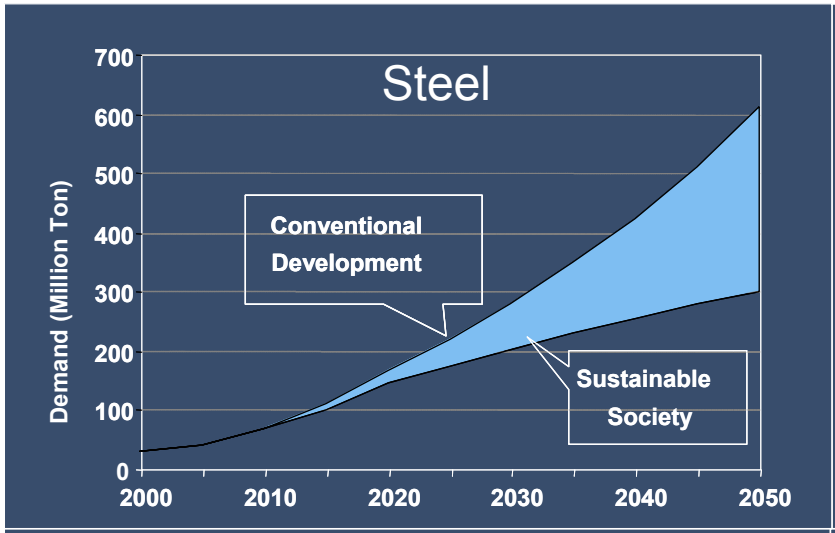
- High Carbon Price
- Climate Focused Technology Push
- Top-down/Supply-side actions

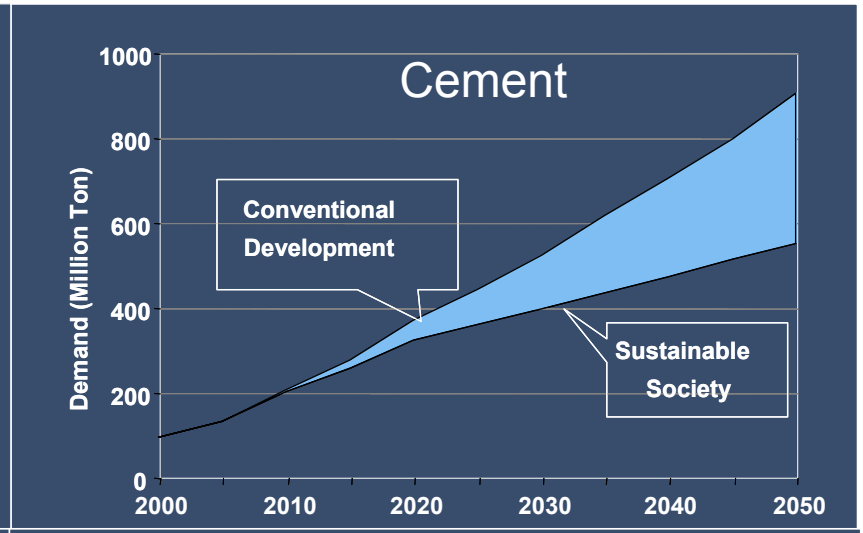
LCS Vision 2: aligning climate actions with sustainable development actions

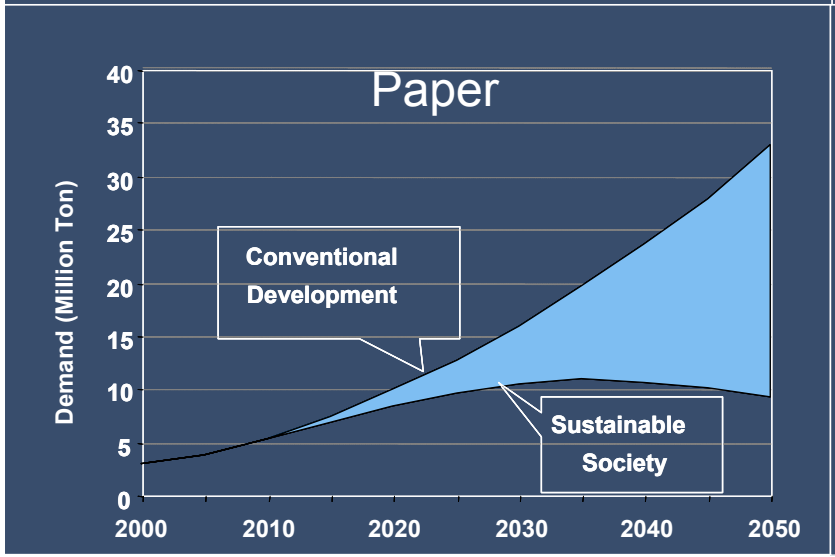
- Low Carbon Price
- Bottom-up/Demand-side actions
- Behavioural change
- Demand-side technology pull
- Diverse Technology portfolio

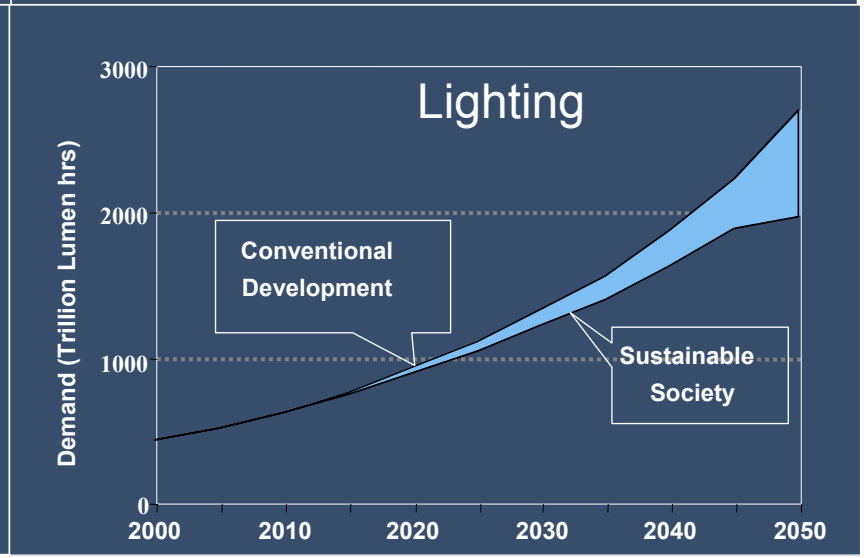


Demand Reduction & Substitution

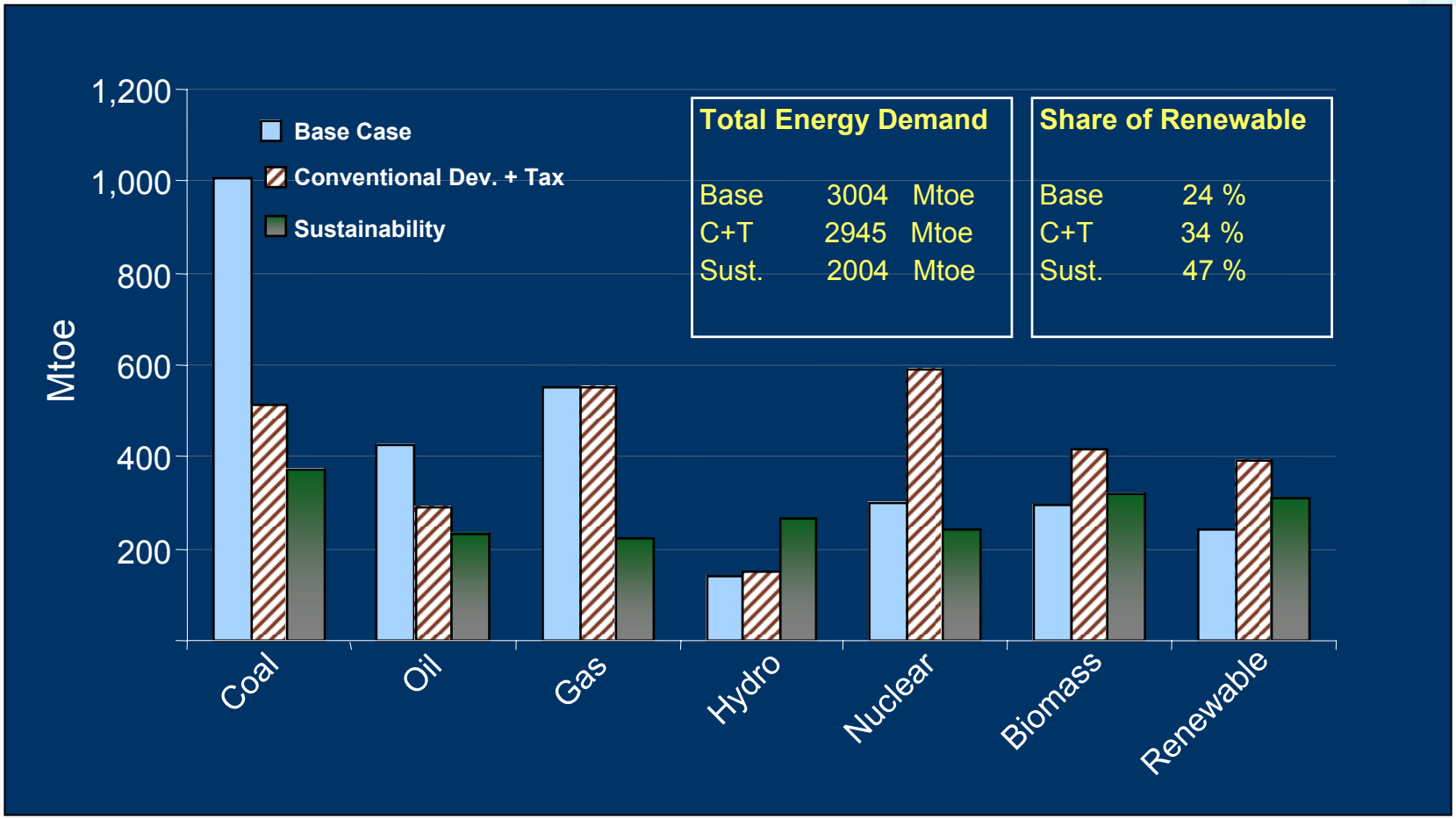






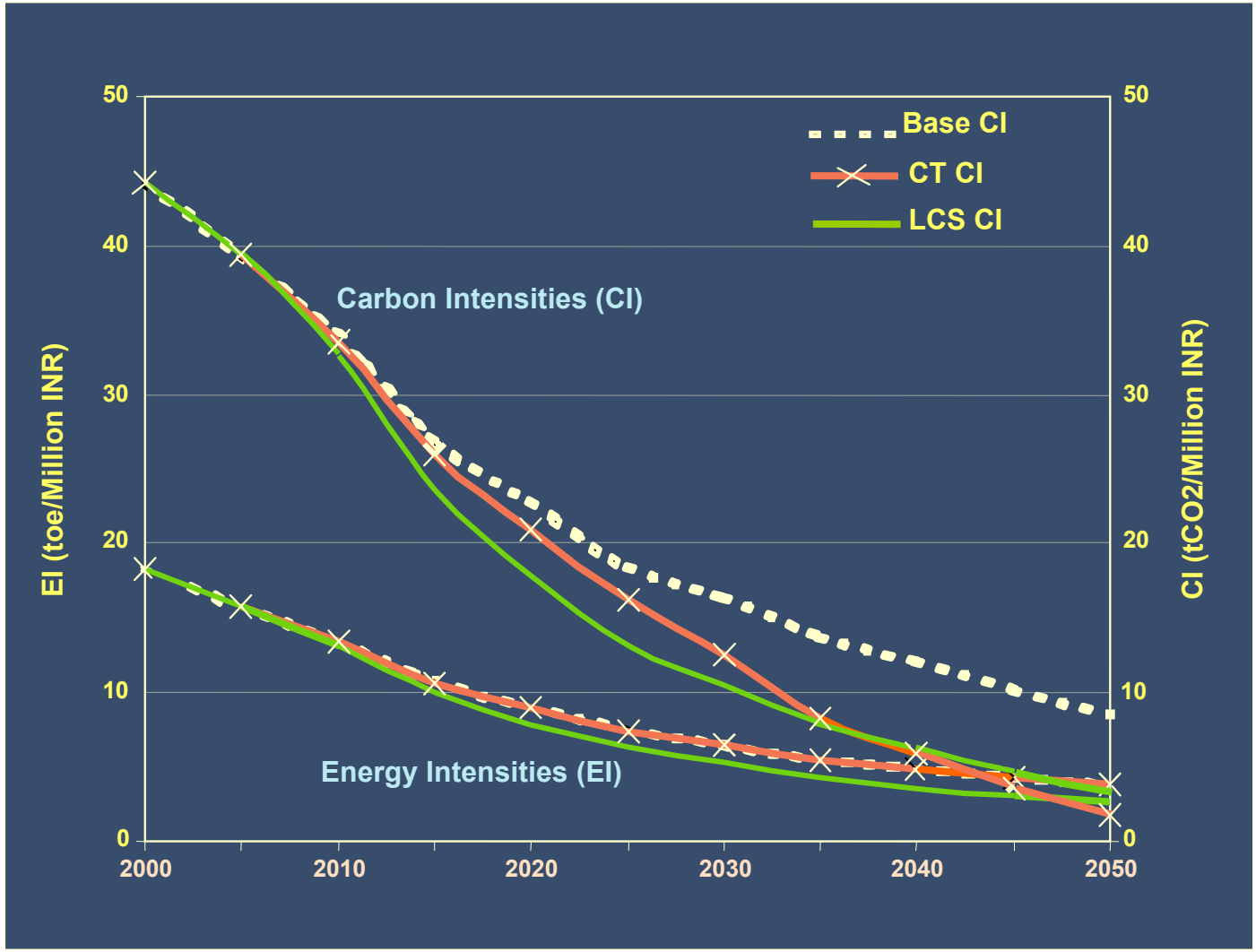


Energy Mix in 2050



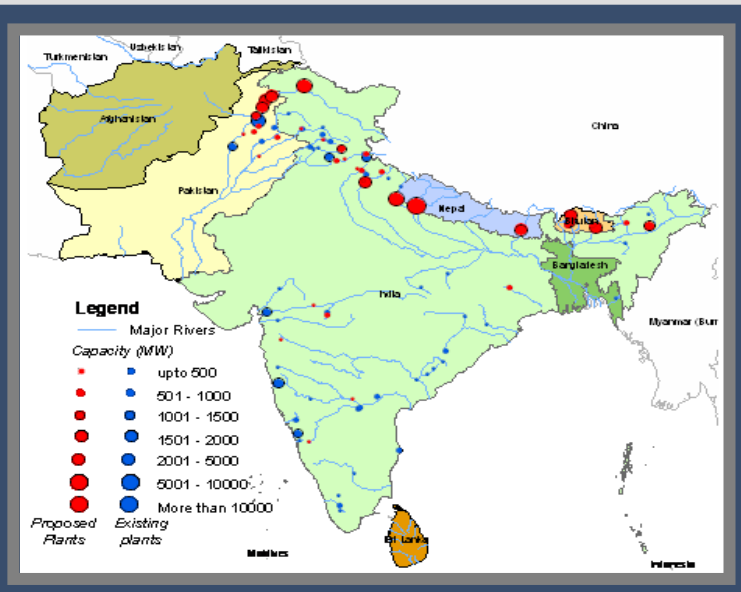
Sustainable LCS would reduce competition & conflicts for energy resources; thus contributing to peaceful transition to prosperous global socio-economic order in the 21st Century

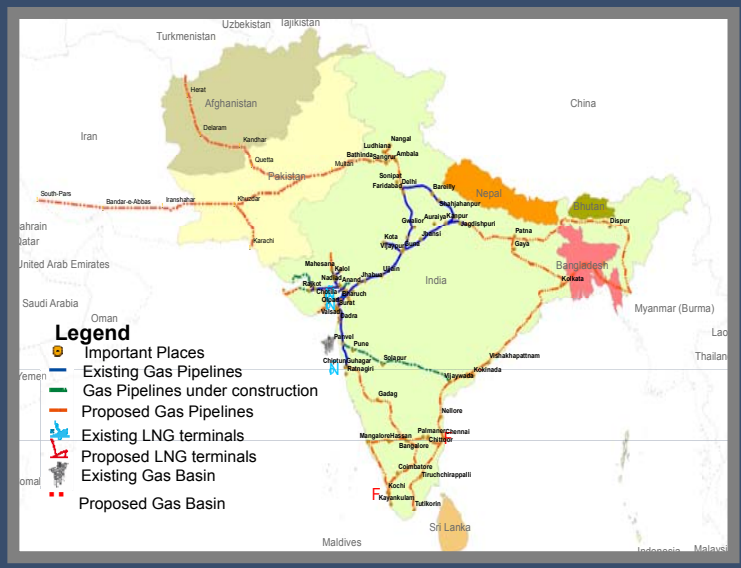
Energy and Carbon Intensities



Co-benefits of Regional Co-operation

MDG 1: Eradicate extreme poverty and hunger, MDG 7: Environmental Sustainability





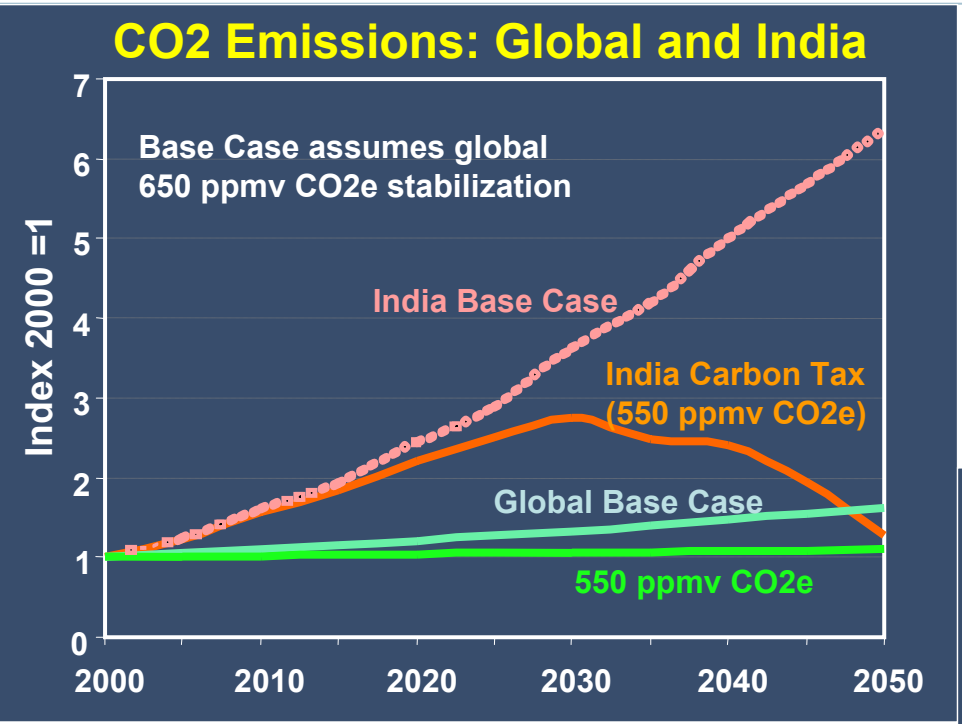
Co-benefits of South-Asia Integrated Energy-Water Market

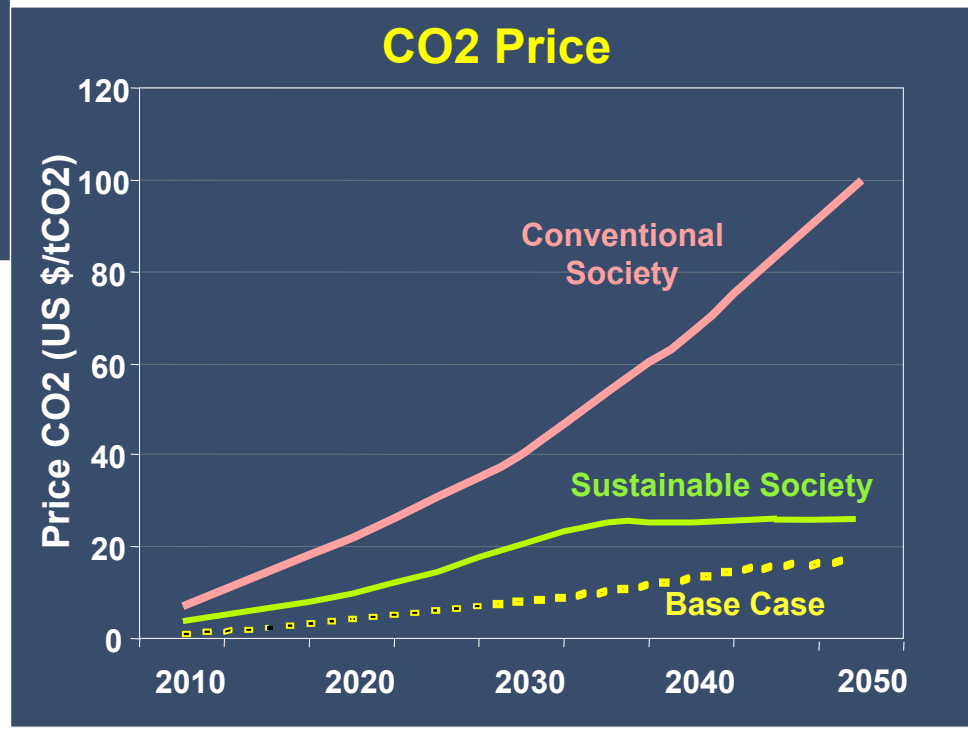
Benefit (Saving) Cumulative from 2010 to 2030		$ Billion	% GDP
Energy	60 Exa Joule	321	0.87
CO_2 Equiv.	5.1 Billion Ton	28	0.08
SO_2	50 Million Ton	10	0.03
	Total	359	0.98

Spill-over Benefits / Co-Benefits

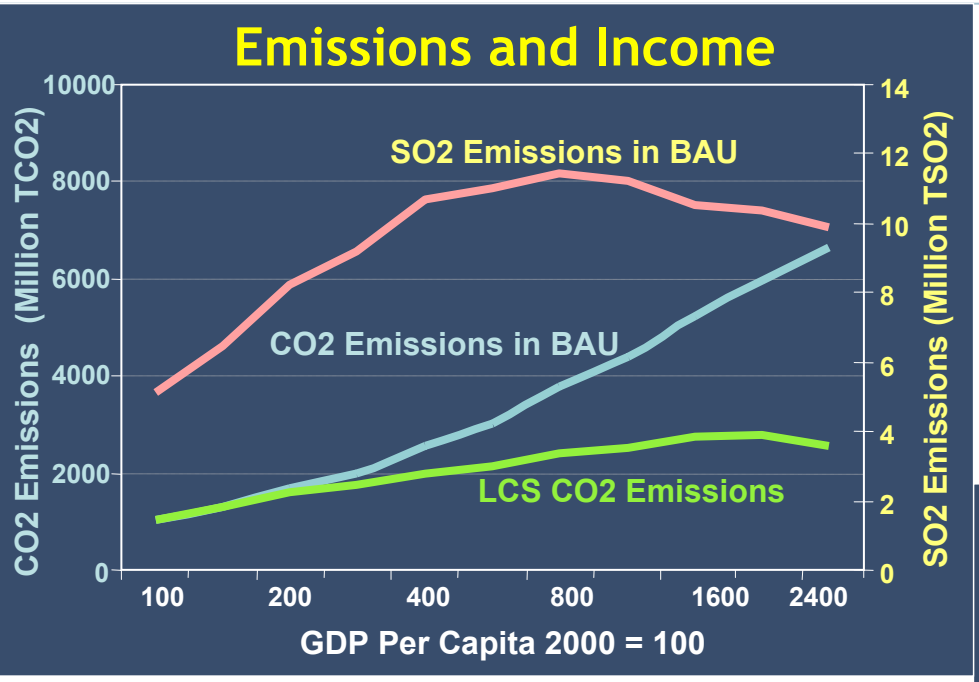
- More Water for Food Production (MDG1)
- 16 GW additional Hydropower (MDG1&7)
- Flood control (MDG1&7)
- Lower energy prices would enhance competitiveness of regional industries (MDG1)

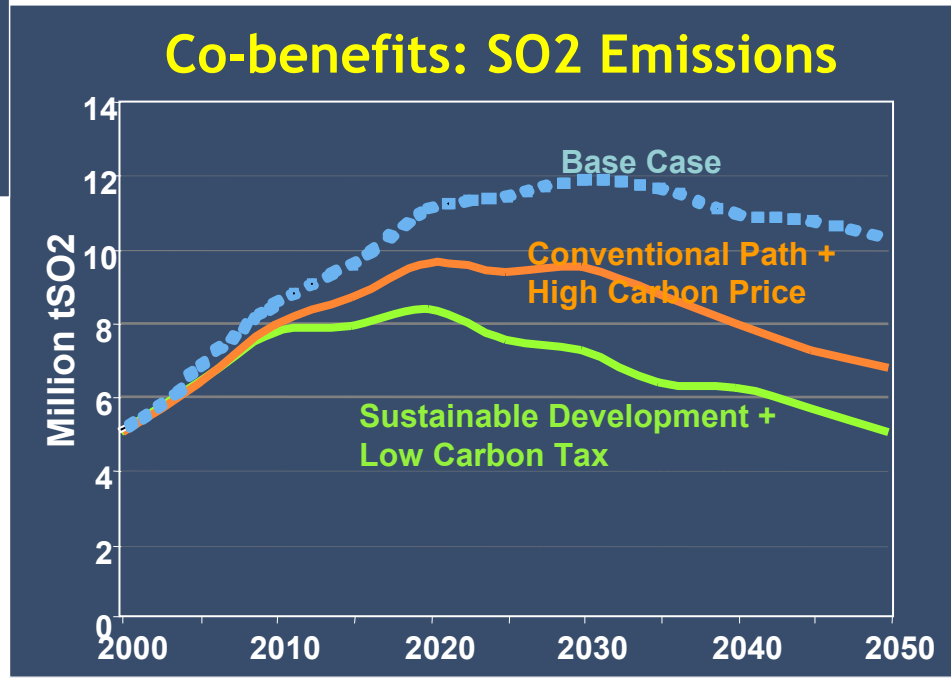
CO2 Emissions & Price Trajectories



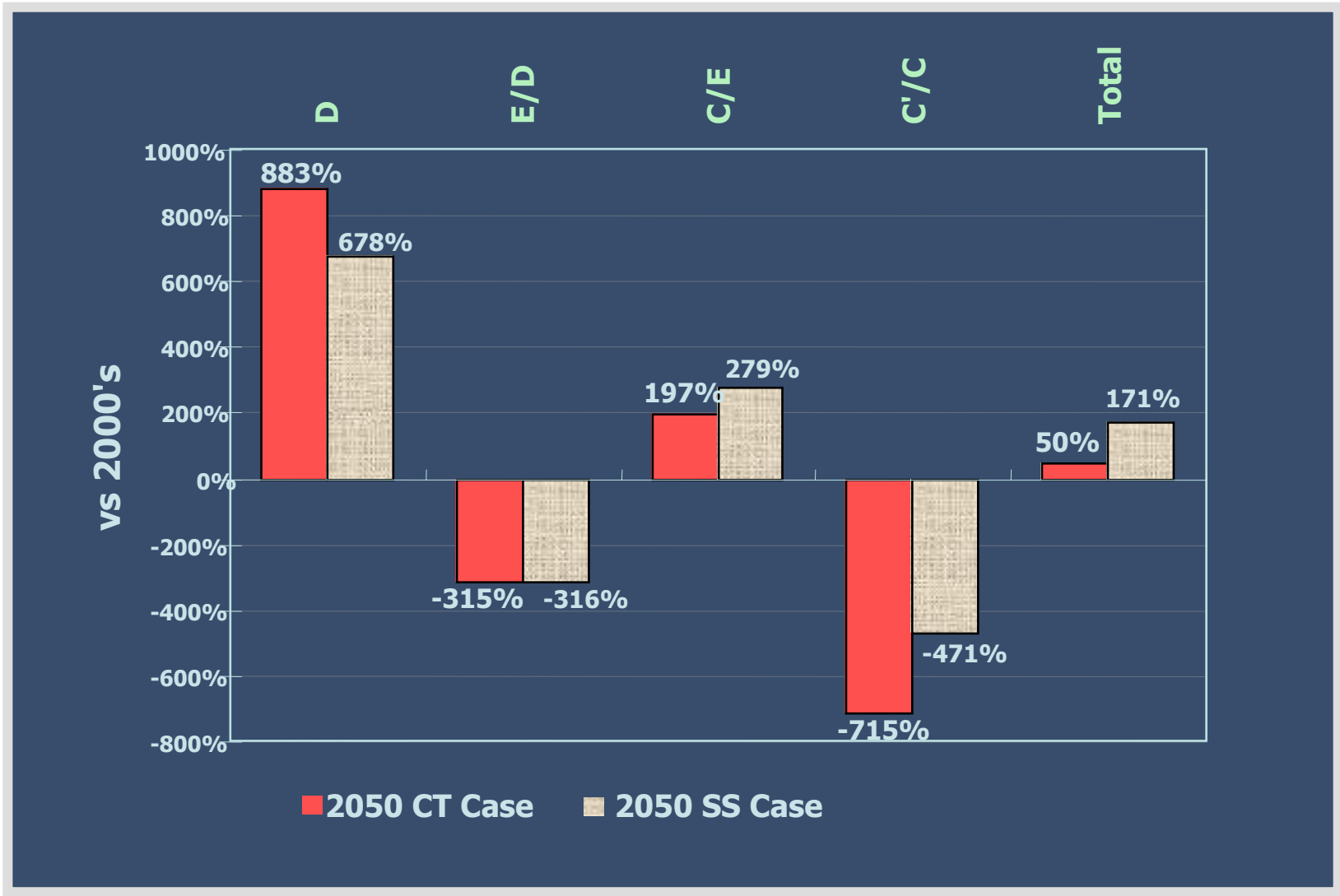


Income Effect and Co-benefits

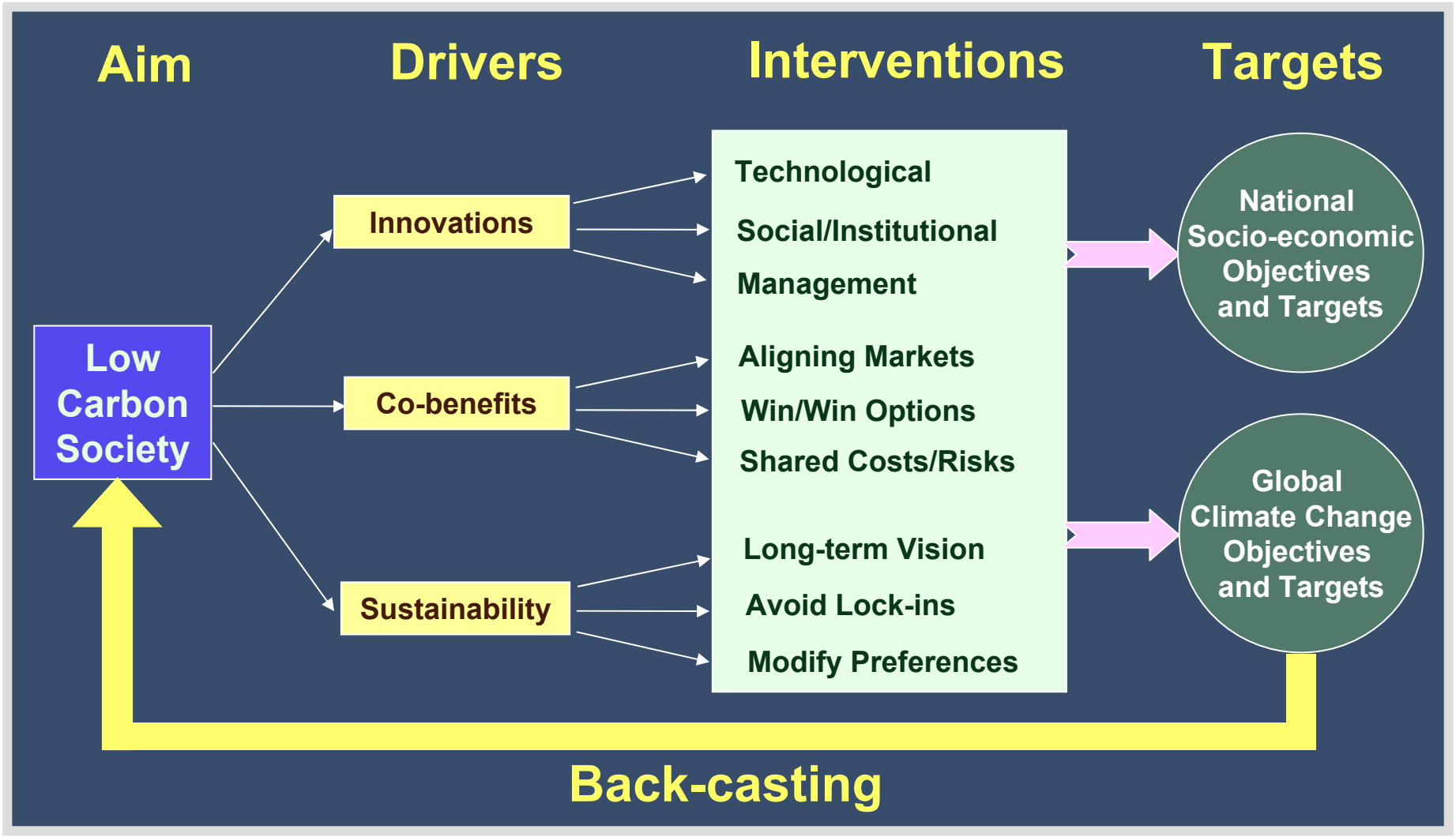




Kaya Analysis of LCS Scenarios

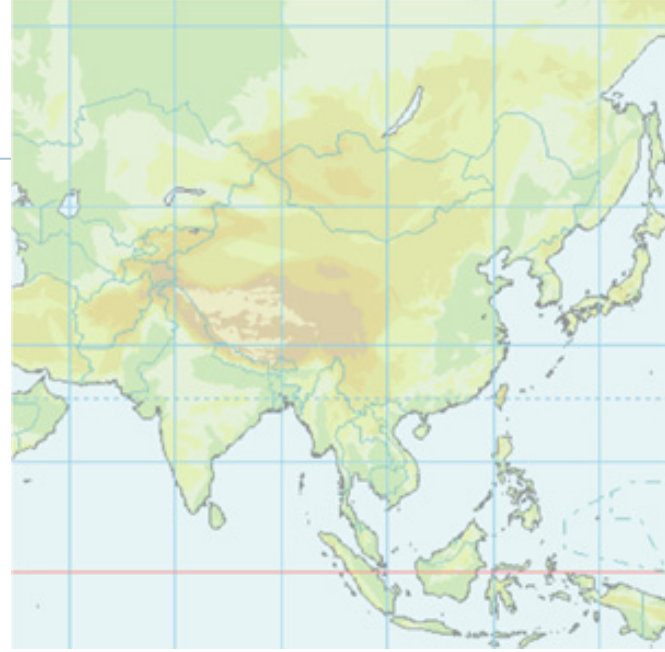


Sustainable Low Carbon Development



Conclusions

- **Modeling**
  - **Integrated Modeling System** with AIM/CGE, MARKAL & SNAPSHOT models
- **Scenarios**
  - Climate Change at **Margin** versus **Mainstream**
  - **High Carbon Tax** versus **Sustainable Development Policies**
- **Analysis**
  - **Kaya Identity Factors**
  - **Technology roadmap to LCS**
  - Incentives and Infrastructures for **Behavioral Changes**
  - **Sustainability** policies for altering **development pathway**
  - **Climate-centric policies** to contribute to cost-effective global stabilization pathway and adaptation



Thank you