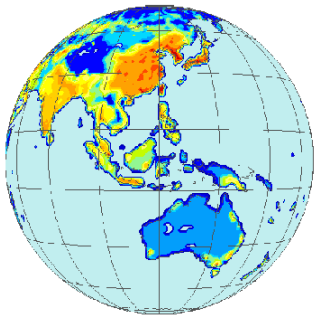


AIM Training Workshop 2008
Organized by NIES, October 2008, Tsukuba, Japan

Sustainable Low Carbon Society Scenarios and Modeling

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

AGENDA

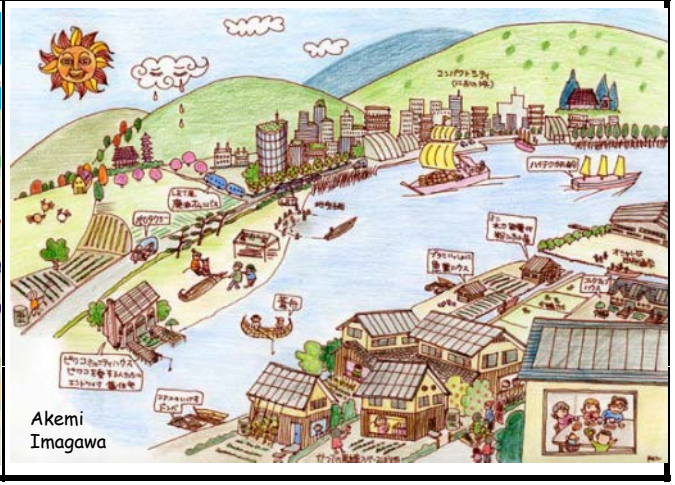
- Visions and Strategies: Japan and India
- What Drives Emissions?
- Alternate Strategies to Low Carbon Transition
- Emissions Reduction through Energy Supply Technologies
- Emissions Reduction Actions aligned to Development Choices
- Low Carbon Society: Integration, Adaptation and Cp-benefits
- Conclusions: Strategies for Low Carbon Transition

Visions and Strategies:

Japan and India

Slide: Courtesy Dr. Junichi Fujino, NIES, Tsukuba, Japan

As for LCS visions, we prepared two different but likely future societies

Vision A "Doraemon"	Vision B "Satsuki and Mei"
Vivid, Technology-driven	Slow, Natural-oriented
Urban/Personal	Decentralized/Community
Technology breakthrough Centralized production /recycle	Self-sufficient Produce locally, consume locally
Comfortable and Convenient	Social and Cultural Values
2%/yr GDP per capita growth	1%/yr GDP per capita growth
	

Doraemon is a Japanese comic series created by Fujiko F. Fujio. The series is about a robotic cat named Doraemon, who travels back in time from the 22nd century. He has a pocket, which connects to the fourth dimension and acts like a wormhole.

Satsuki and Mei's House reproduced in the 2005 World Expo. Satsuki and Mei are daughters in the film "My Neighbor Totoro". They lived an old house in rural Japan, near which many curious and magical creatures inhabited.

Slide: Courtesy Dr. Junichi Fujino, NIES, Tsukuba, Japan

LCS house in 2050 in Japan

Utilizing solar power

Photovoltaic

34-69MW
(25-47% house has PV on roof (now 1%)) and develop high efficiency (<30%) PV

Eco-life education

10-20% energy demand reduction

rooftop gardening

High efficiency lighting
【eg LED lighting】

Reduce 1/2 energy demand
Share 100%

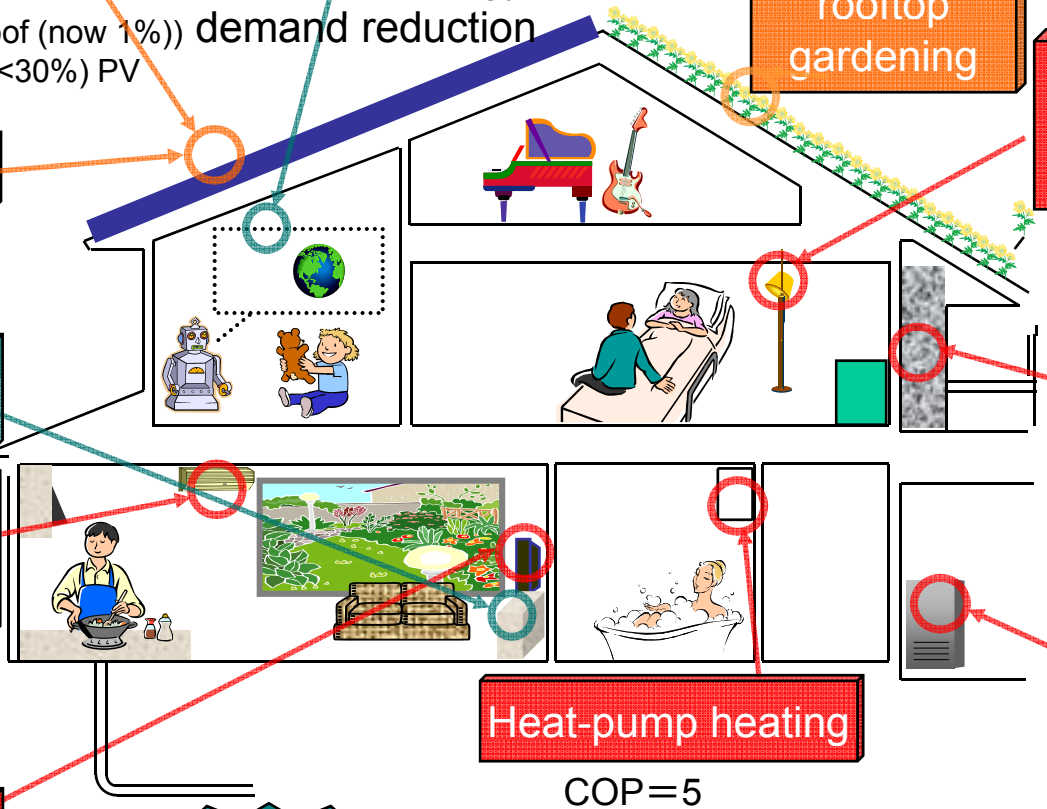
Solar heating

Diffusion rate: 20-60%
（currently 8%）

Monitoring system
equipped with appliances

High-insulation

Reduce 60% warming energy demand, share 100%



Super high efficiency air conditioner

COP (coefficients of performance=8), share 100%

Fuel cell

share 0-20%

Heat-pump heating

COP＝5
share 30-70%

Stand-by energy reduction

Reduce 1/3 energy demand, share 100%

Good information for economy and environment makes people's behavior low-carbon

High efficiency appliances reduce energy demand and support comfortable and safe lifestyle

India: Mainstreaming Climate Change in National Development

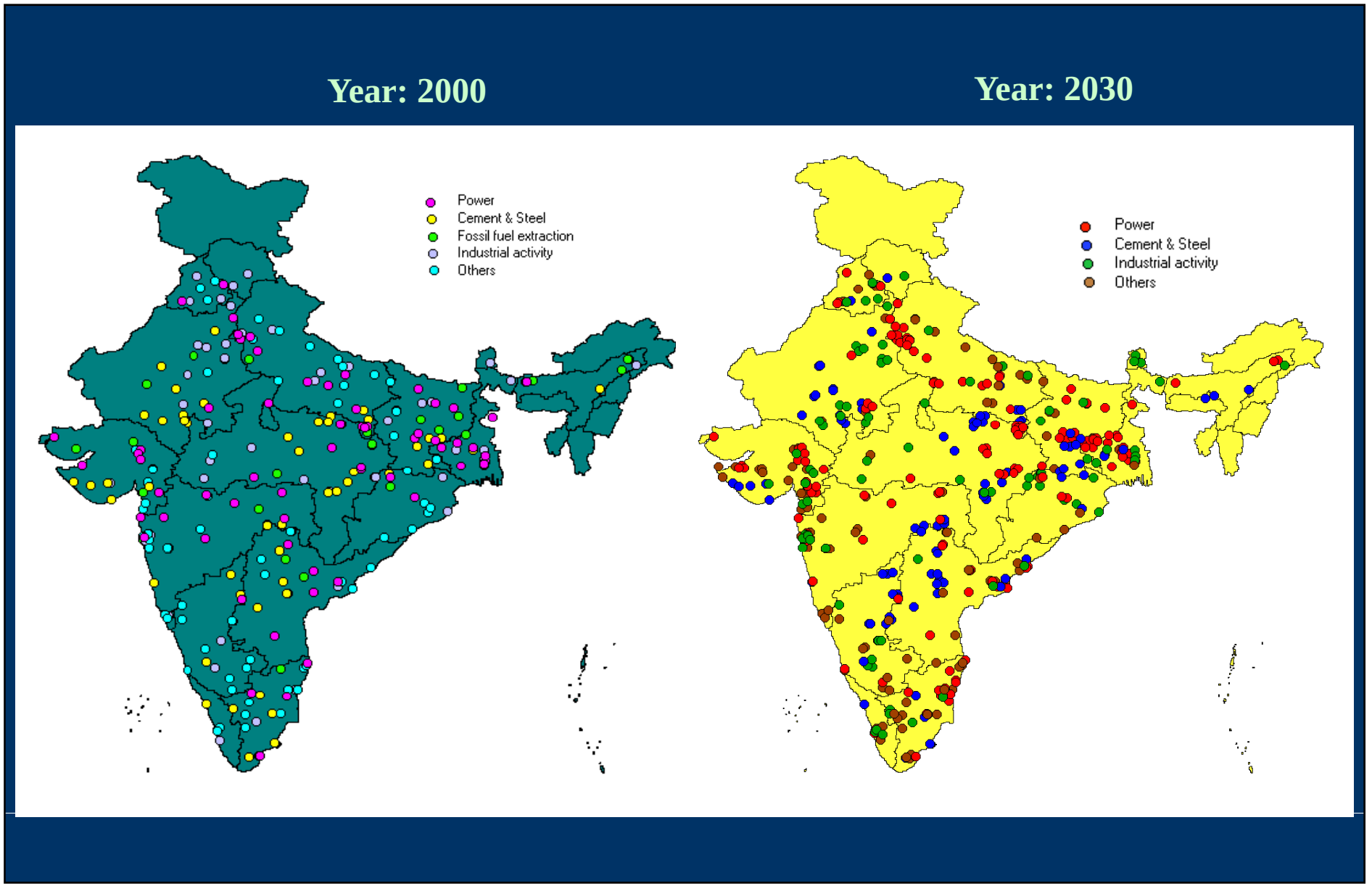
Aligning climate policies and actions with:

- *MDGs / National development targets*
- *Agreed goals under extant international agreements*
- *Developing resilience to Vulnerabilities and Adapting to changing Climate Parameters*

MDG, India's National Targets and Climate Change

MDG and global targets	India's National plan targets	Interface with Climate Change
Goal 1: Eradicate extreme poverty and hunger Targets: Halve, between 1990 and 2015, the proportion of people with income below $1 a day and those who suffer from hunger	• Double the per capita income by 2012 • Reduce poverty ratio by 15% by 2012 • Contain population growth to 16.2% between 2001-2011	• Higher income enhances access to services, food, fuel, information, an enhances mitigative and adaptive capacity • Higher climate variability would enhance risks to meet the goal
Goal 7: Ensure environmental sustainability Targets: Integrate SD principles in country policies/ programs to reverse loss of environmental resources Target: Halve by 2015 the proportion of people without sustainable access to safe drinking water	• Increase in forest cover to 25% by 2007 and 33% by 2012 (from 23% in 2001) • Sustained access to potable drinking water to all villages by 2007 • Electrify 80,000 additional villages by 2012 via decentralized sources • Cleaning of all major polluted rivers by 2007 and other notified stretches by 2012	• Enhanced sink capacity, reduced GHG and local emissions; lower fossil imports; reduced pressure on land, resources and ecosystems • Higher adaptive capacity to from enhanced supply of water, health & education in rural areas

Implementing the Roadmap: Conjoint Market for CO2 & SO2



Bio-diesel: Multiple Dividends and Risks

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

Jatropha Plantation in India

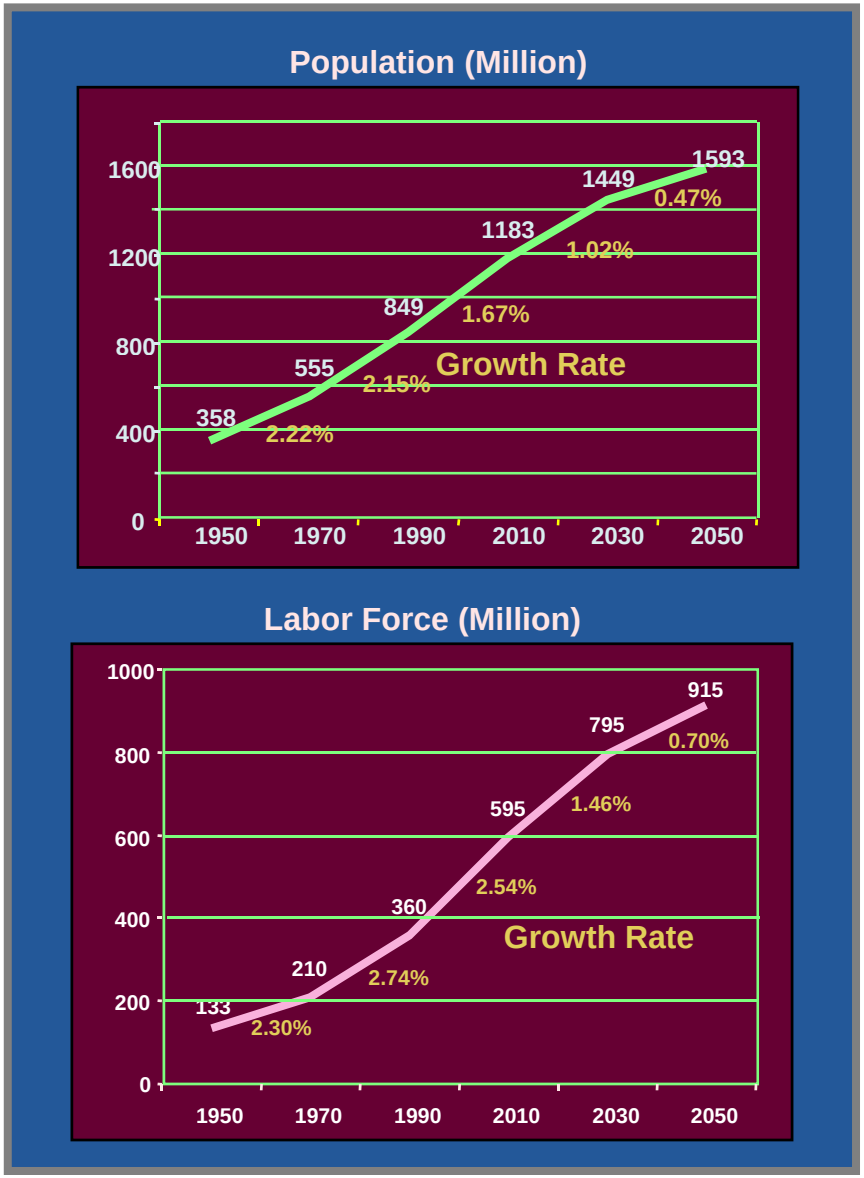
- **Rural Employment / Farm Income (from waste lands): :**
  Large scale employment potential in Jatropha plantation, seed collection and extraction
- **Energy Security**
  Imported fossil oil is replaced
- **Environment**
  Neutral carbon emissions, Rehabilitates waste land
- **Water and Food Security**
  Land and energy crop choices are vital to avoid conflicts with other sustainability goals

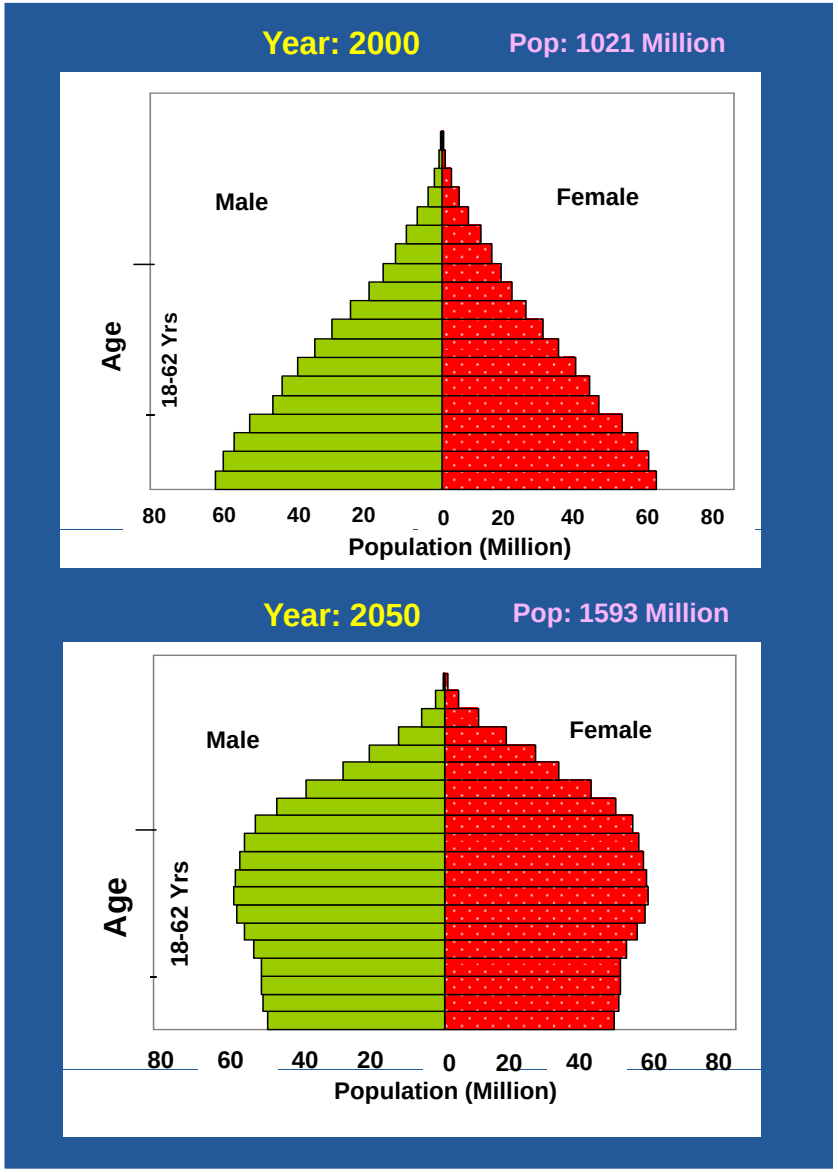
Oil Extraction Plant

Rural Employment

What drives Emissions?

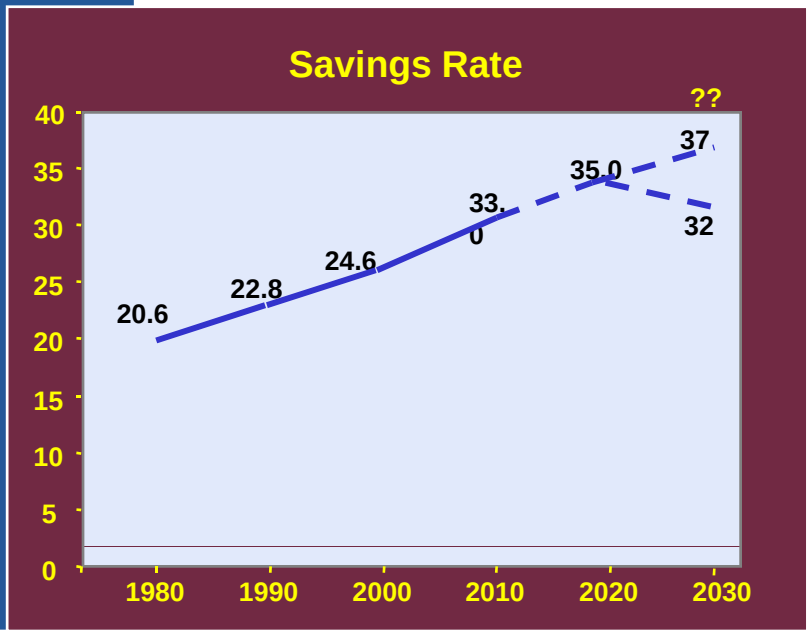
Demographic Drivers



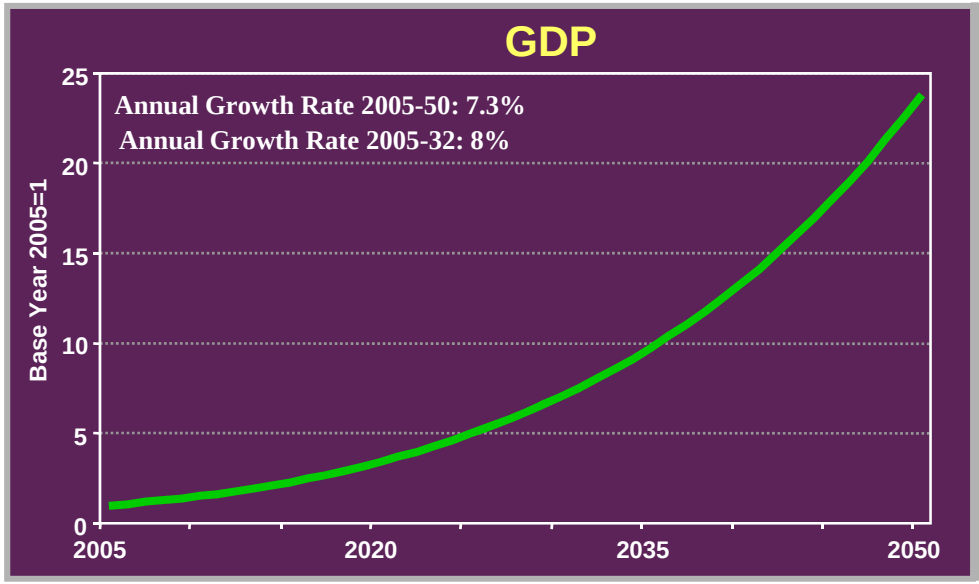


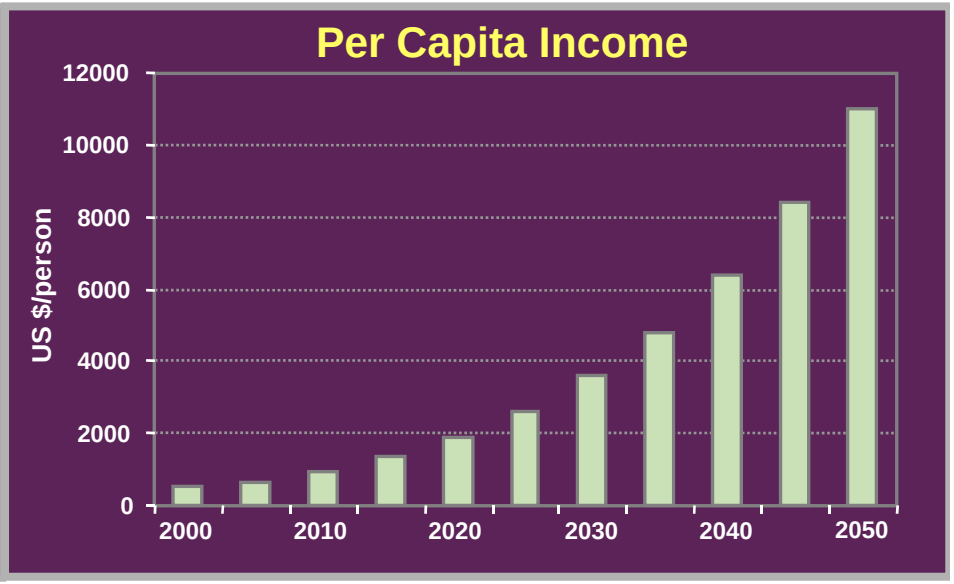
Drivers of Economic Growth

- **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



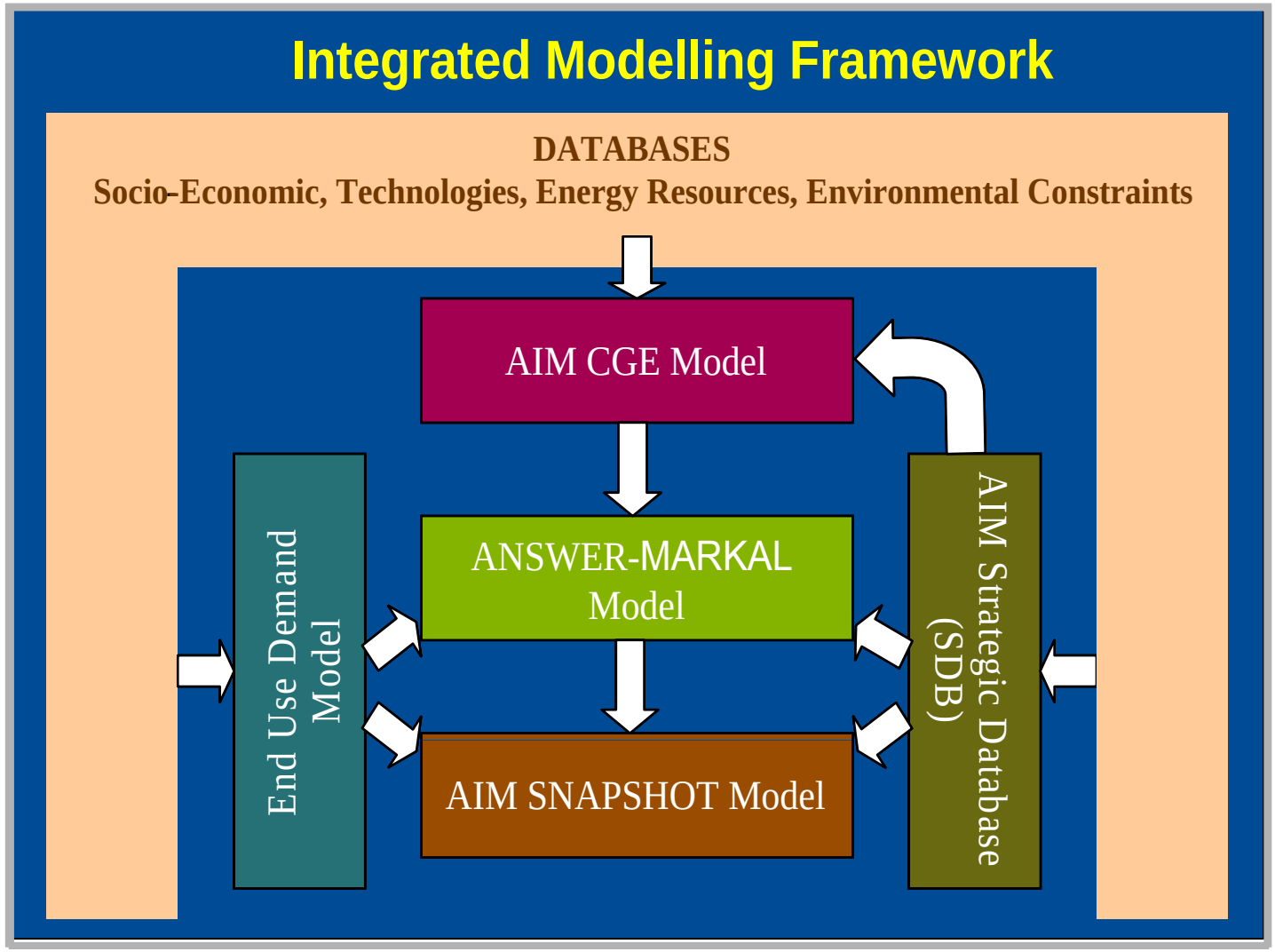


Base Case Assumptions: Summary

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**

Alternate Strategies to Low Carbon Transition

Integrated Modeling Framework

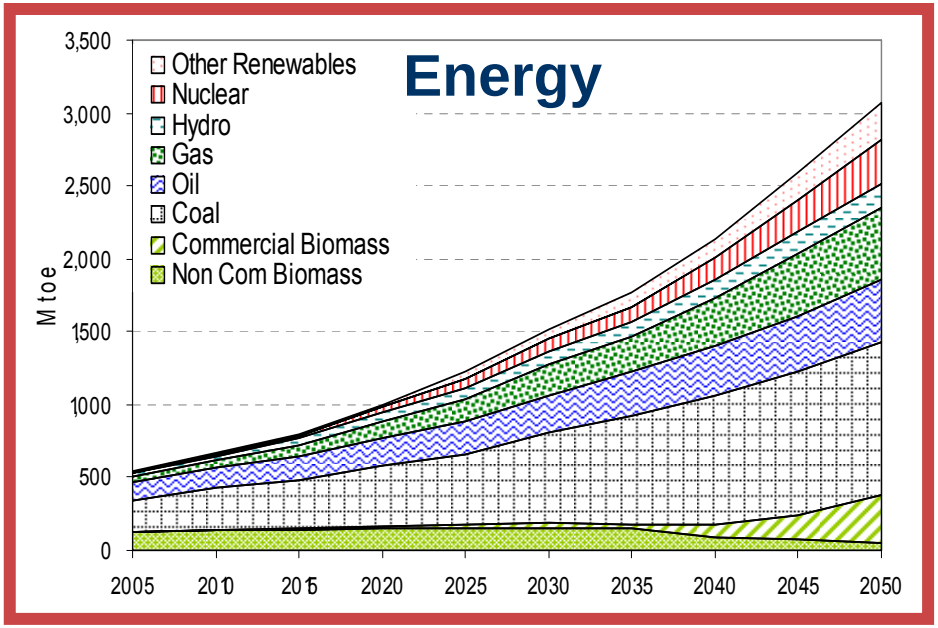


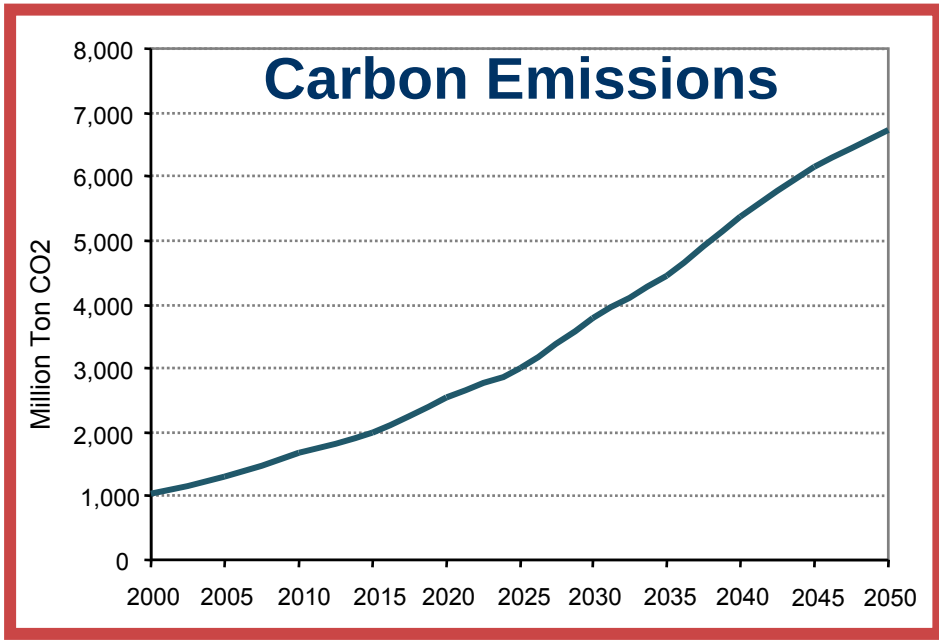
Energy and Carbon: Base Case

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





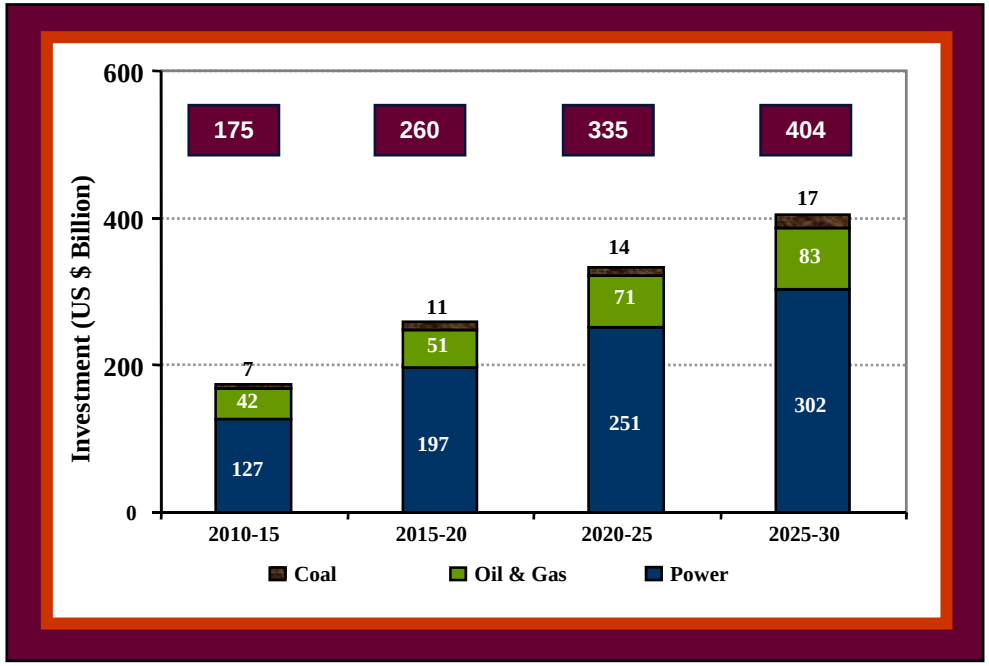
Results: Energy and Carbon Intensity

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

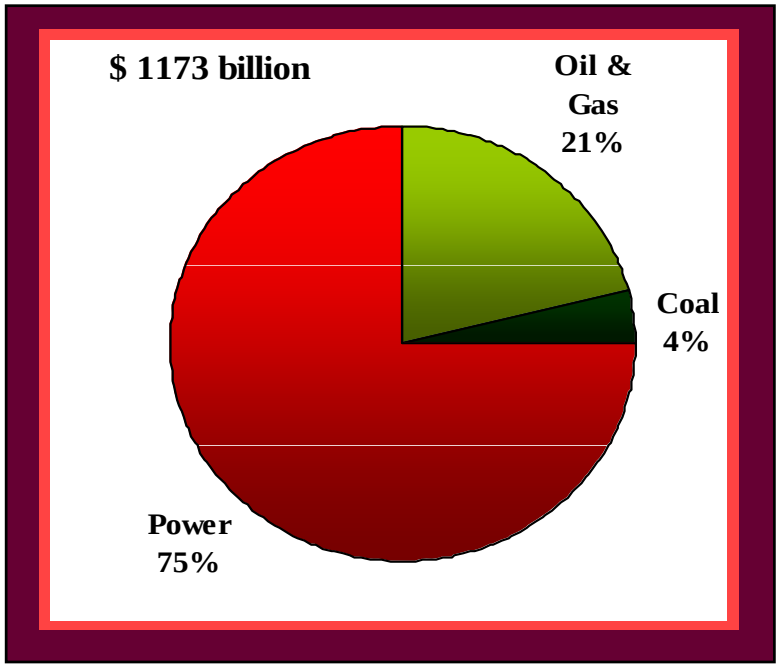
Ratios: 2050 over 2005
Energy Intensity: 0.249
Carbon Intensity: 0.257
Decarbonization of Energy: -3.1 (%)

Investment in Energy: Base Case

Energy Investments (2010-2030)



Share of Energy Investments (2010-2030)



Alternate Emissions Reduction Strategies

Alternate Development Visions

Assumptions

1. Global Stabilization Target Assumption:

- 550 ppmv CO2e Concentration (OR)
- 3.4 W/m2 (OR)
- @ 3^{o} centigrade temperature increase

2. Two Development Pathways for India:

(with same total CO2 emissions from 2005 to 2050)

1. Vision 1: **Conventional Development path**
2. Vision 2: **'Sustainability' scenario**

What path shall best deliver national development goals while fulfilling Climate Commitments?

Strategies for Emissions Reduction

Alternate Pathways to Emissions Reduction

Achieving Stabilization of GHG Concentration by:

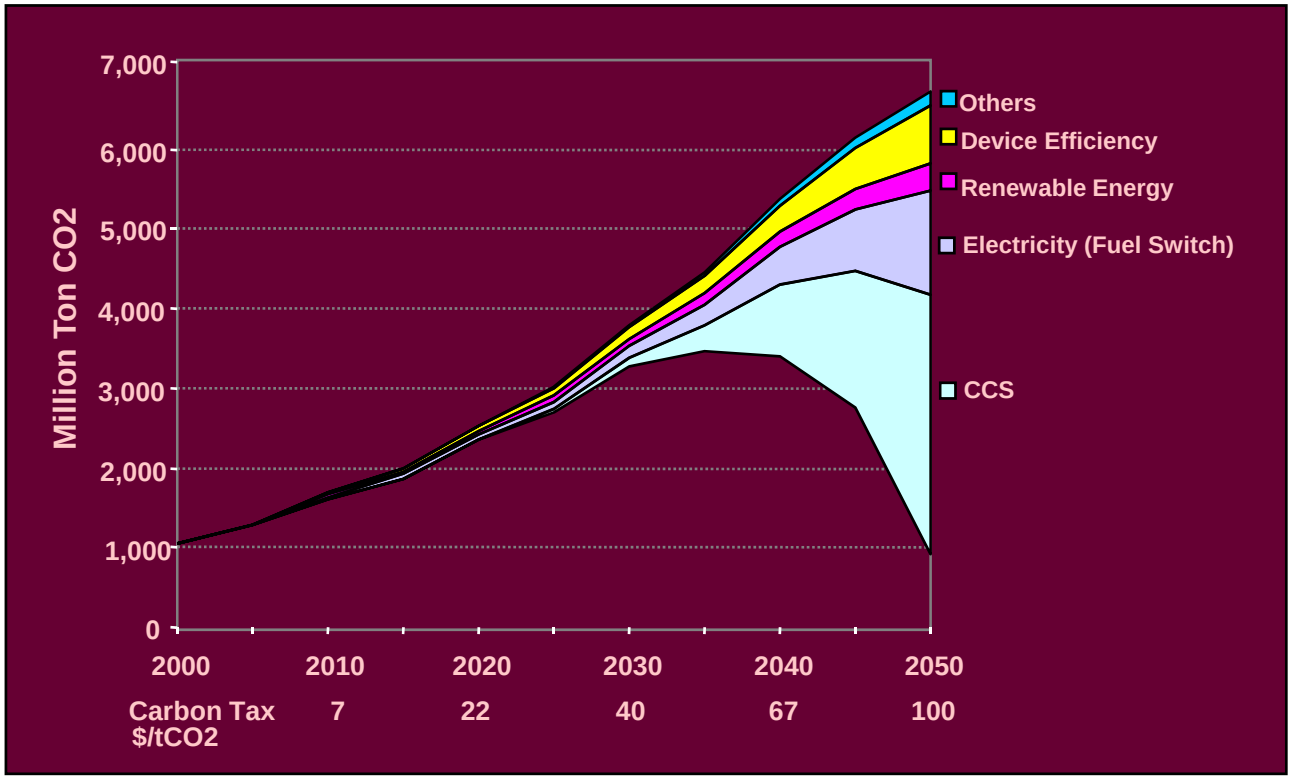
1. **Climate Centric Actions at the Margin of the Conventional Development Path**
   - **Policies: Global Carbon Price over Conventional Development Path**
2. **Aligning Climate Actions with Mainstream Development Actions**
   - **Policies: Sustainable Development Path + Stabilization**

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

Objectives and Interventions

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

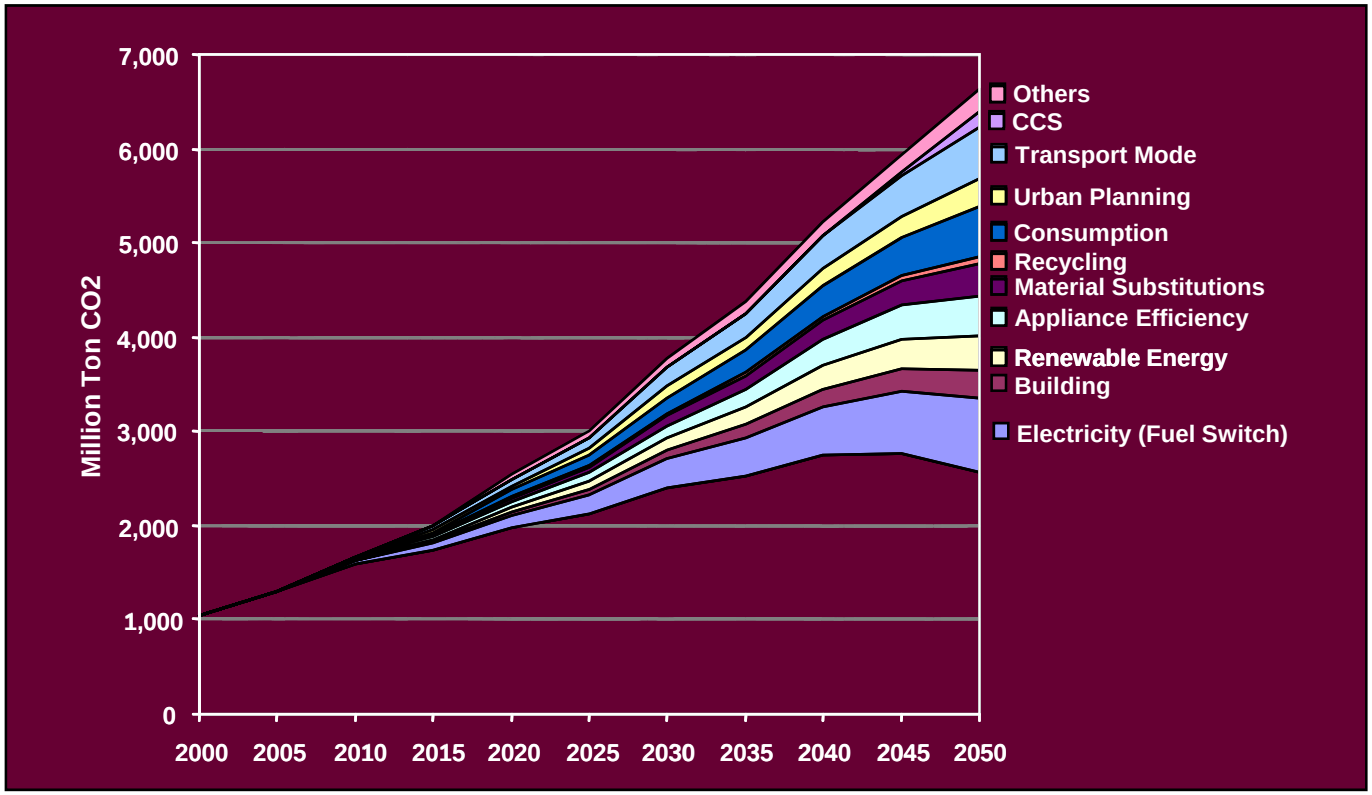
Emissions Reduction Strategy - 1



Emissions Reduction with Supply-side technologies

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

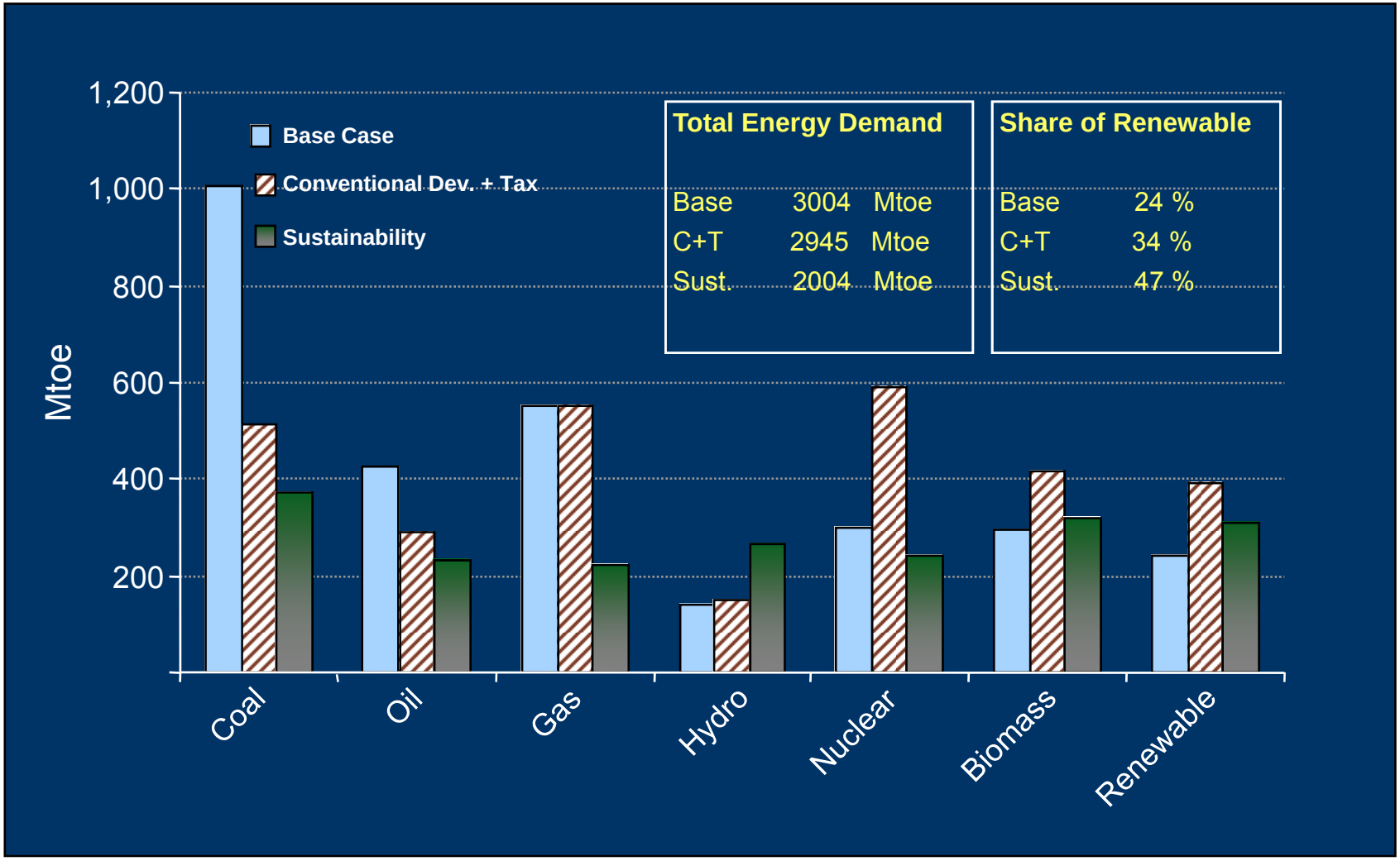
Emissions Reduction Strategy - 2



Emissions reduction with Demand-side Technologies

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

Energy Technology Mix in 2050



Emissions Reduction through Energy Supply Technologies ('Deep Dive Technologies)

Carbon Capture and Storage

Technology Cooperation Tasks

- **Short-term:** Geological Mapping, Pilot Investment
- **Medium-term:** Technology and Knowledge transfer
- **Long-term:** Development of National Industry, Costs

Policy Instruments for Cooperation

- **Government Agreements:** UNFCCC, APP, Bilateral
- **Carbon Price**
- **Energy Security/ Local Emissions**

Rong Dong Oilfield Project (approved under CDM) in Vietnam by Nippon Oil Corporation reduces 0.68 Million Ton CO_2 per year.

CO_2 Post-Combustion Capture from flue gas stream of a gas fired power plant for urea production in Malaysia using chemical Absorption Process Technology from Mitsubishi Heavy Industries. 0.2 million ton CO_2 Capture per year

Coal Gasification Plant producing Synthetic Gas in North Dakota, USA capturing 3.3. $MtCO_2$ per year during Pre-combustion.

Nuclear Technology

Technology Cooperation Tasks

- Technology Supply (e.g. Gen III, Gen IV)
- Fuel Access

Policy Instruments for Cooperation

- Government Initiative/ Agreements
- International Supervision: e.g. IAEA
- National Energy Mix (Targets): Energy Security

Inside view of Kamini reactor, 100 MW
Went critical in Sept 96, using U-233 fuel

India's First 540 MWe Nuclear Power Plant (Started 09/2005)

2X1000MWe VVER reactors under construction at Koodankulam (Going Critical in 2008)

Wind Power

Technology Cooperation Tasks

- Wind Potential Mapping
- Turbine Technology Transfer
- Private-Private Technology Collaboration
- National Industry / Scale Economy
- Technology Export

Policy Instruments for Cooperation

- National Subsidies
- Renewable Targets / Commitments
- Carbon Price

Bio-Energy

Technology Cooperation Tasks

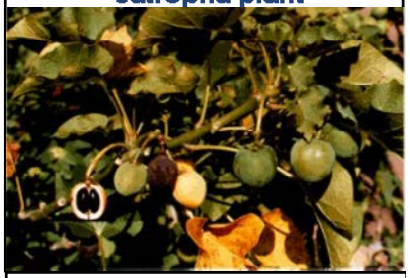
- Choice of Biomass and Production Methods
- Private-Private Technology Collaboration
- National Industry / Scale Economy

Policy Instruments for Cooperation

- Fuel-Mix Norms
- Renewable Energy Targets
- Energy Security / Local Co-benefits
- Food Security (Barrier)

Jatropha Plantation in India

Jatropha plant



Bio-diesel Extraction Plant

Sugarcane Plantation

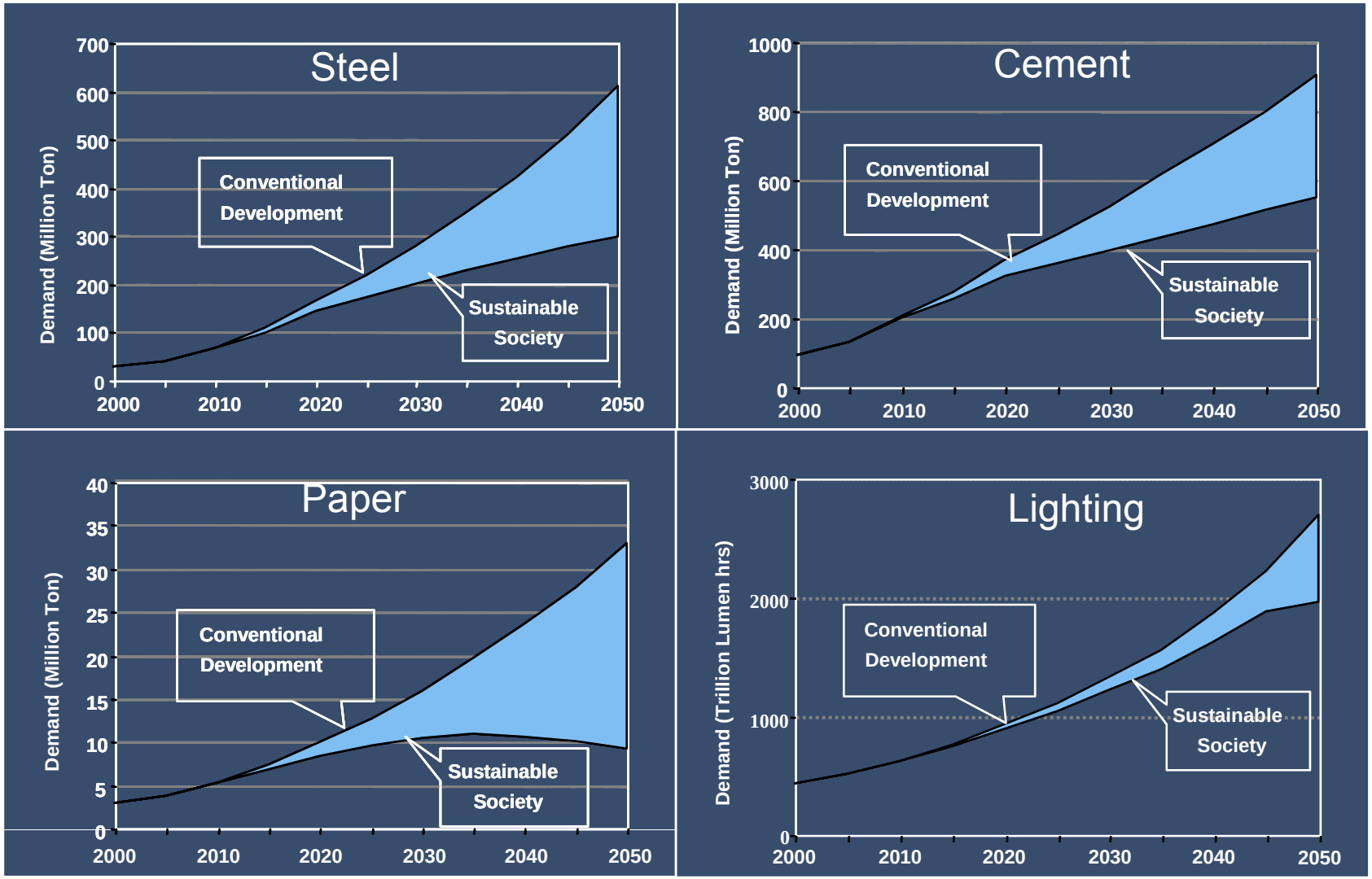
Corn Field

Switch Grass

Poplar Trees

Emissions Reduction Actions aligned to Development Choices

Demand Reduction & Substitution



Urban Design and Climate

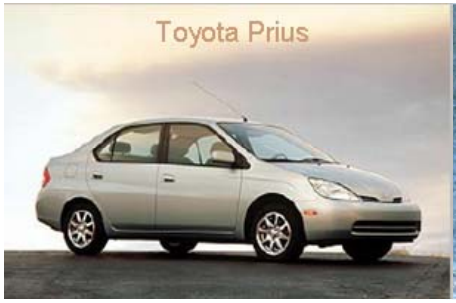
- Land-use Planning
- Building Choices
- Infrastructures
- Service Networks

Transport Vehicles & Mitigation

Rush Hour Traffic in India

Rising Incomes and Small Cars

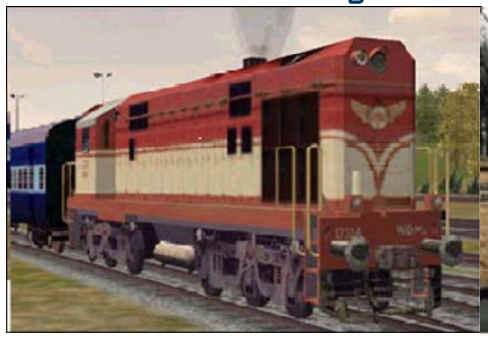
Tata Nano: $2500 QQ: $4000



Electric Car: Reva

CNG Three-Wheeler

10% Bio-diesel Engine



Bio-diesel Bus

Transport Modal Shift Technologies

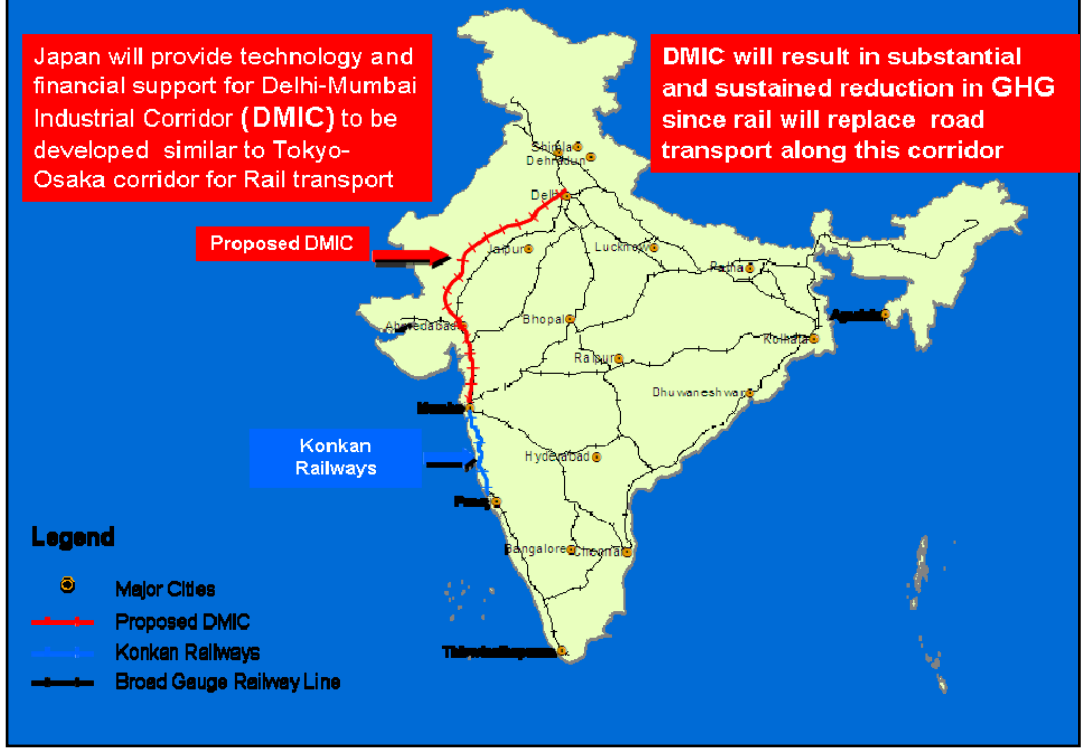
Bus Rapid Transport System

Public Transport: Metro Rail

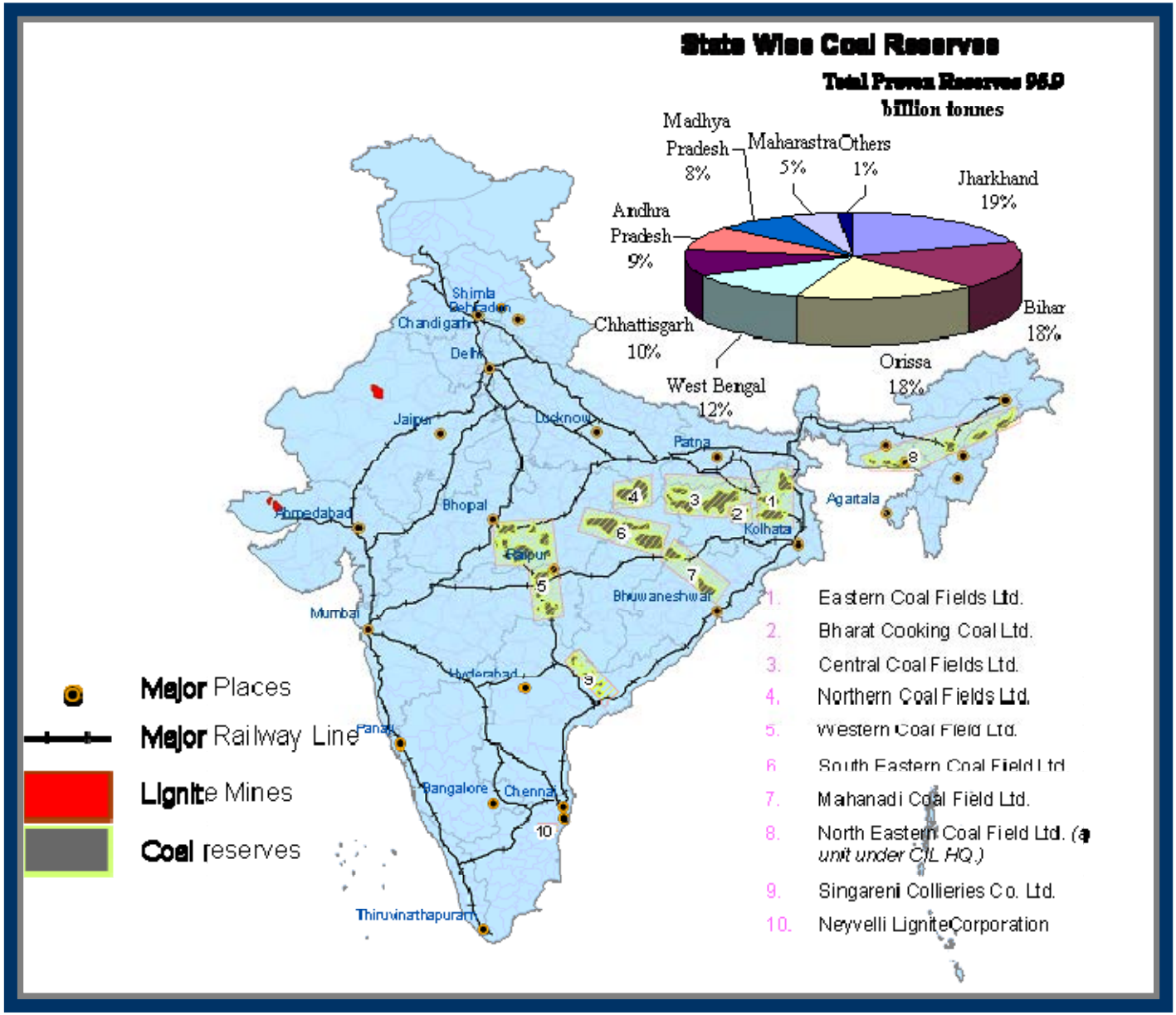
Technologies for Train Corridors

Japan will provide technology and financial support for Delhi-Mumbai Industrial Corridor (DMIC) to be developed similar to Tokyo-Osaka corridor for Rail transport

DMIC will result in substantial and sustained reduction in GHG since rail will replace road transport along this corridor

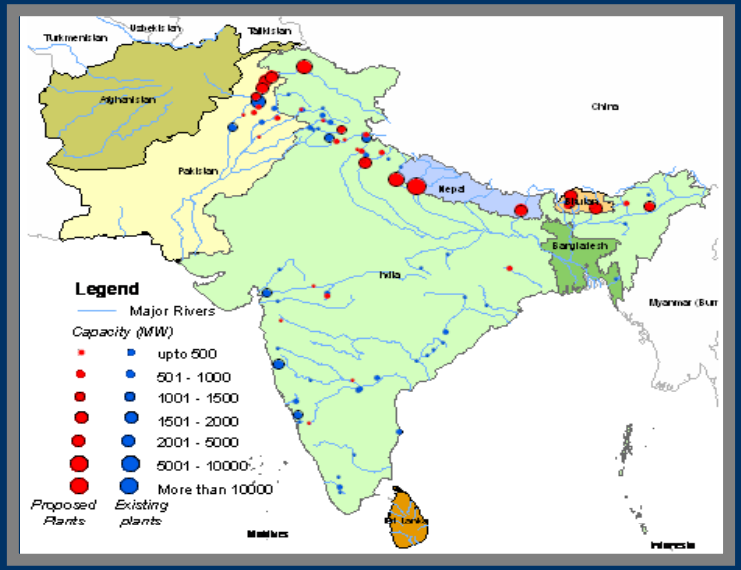


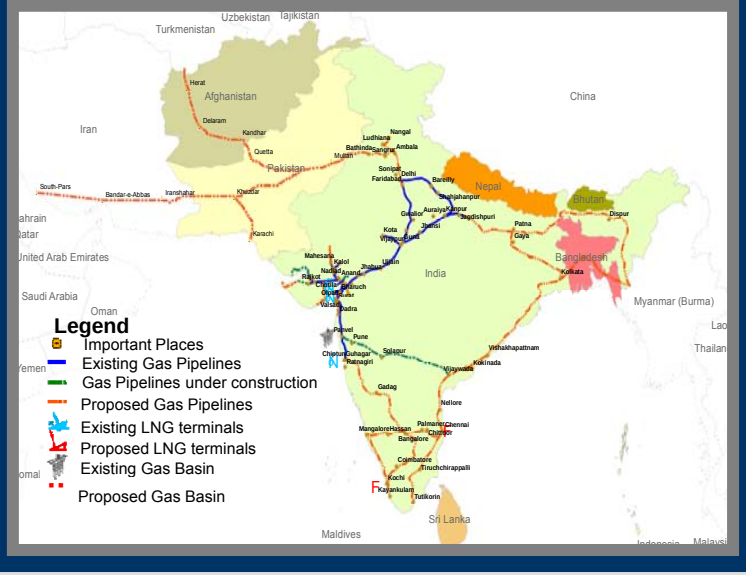
Transport: Coal by Wire



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

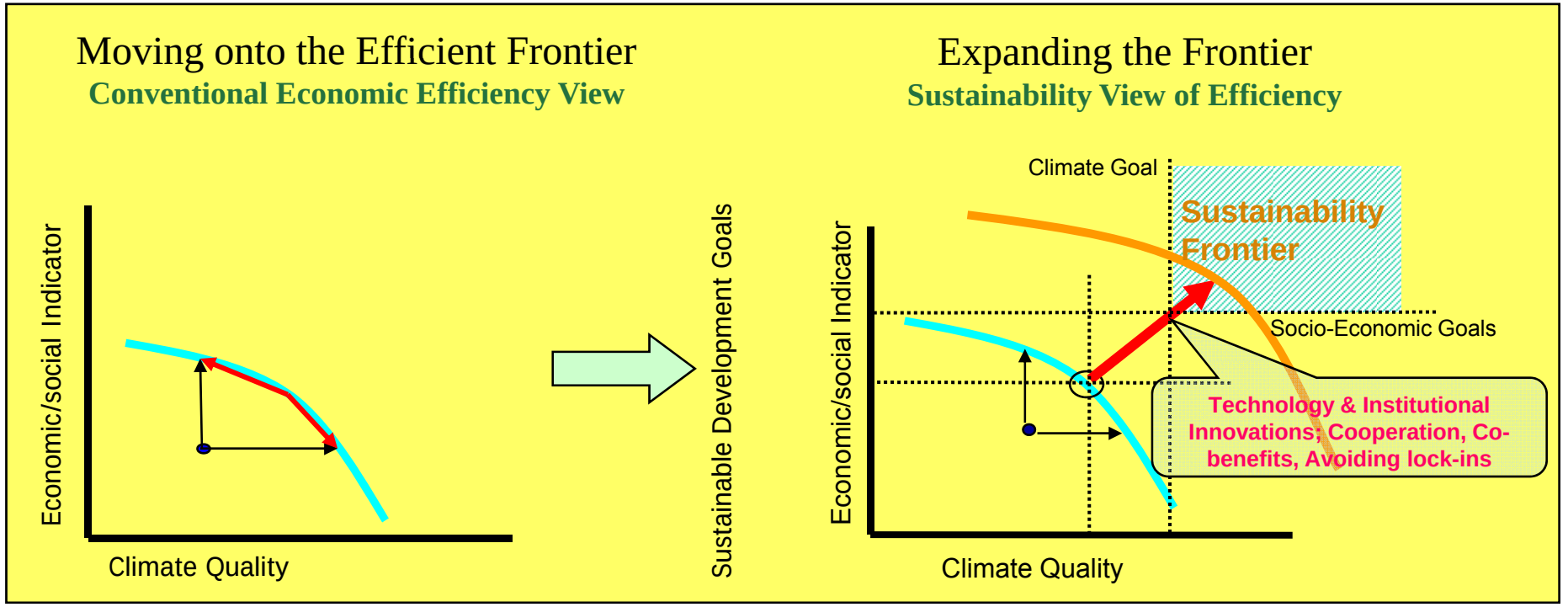
Benefit (Saving) Cumulative from 2010 to 2030		**$ Billion**	**% GDP**
Energy	**60 Exa Joule**	**321**	**0.87**
CO_2 Equiv.	**5.1 Billion Ton**	**28**	**0.08**
SO_2	**50 Million Ton**	**10**	**0.03**
	Total	**359**	**0.98**

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)

Sustainability and Low Carbon Society

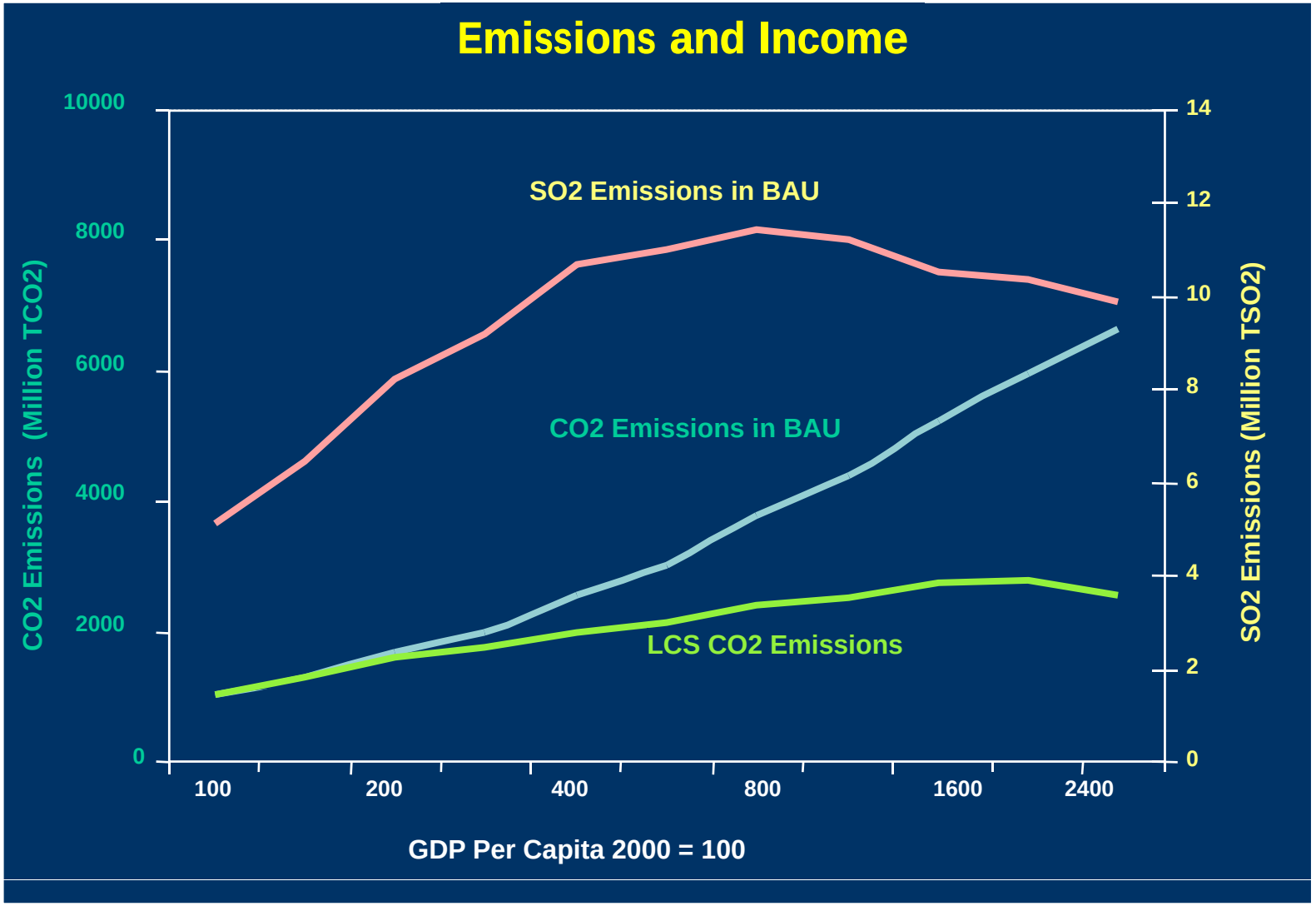
Sustainable Low Carbon Society: Concept



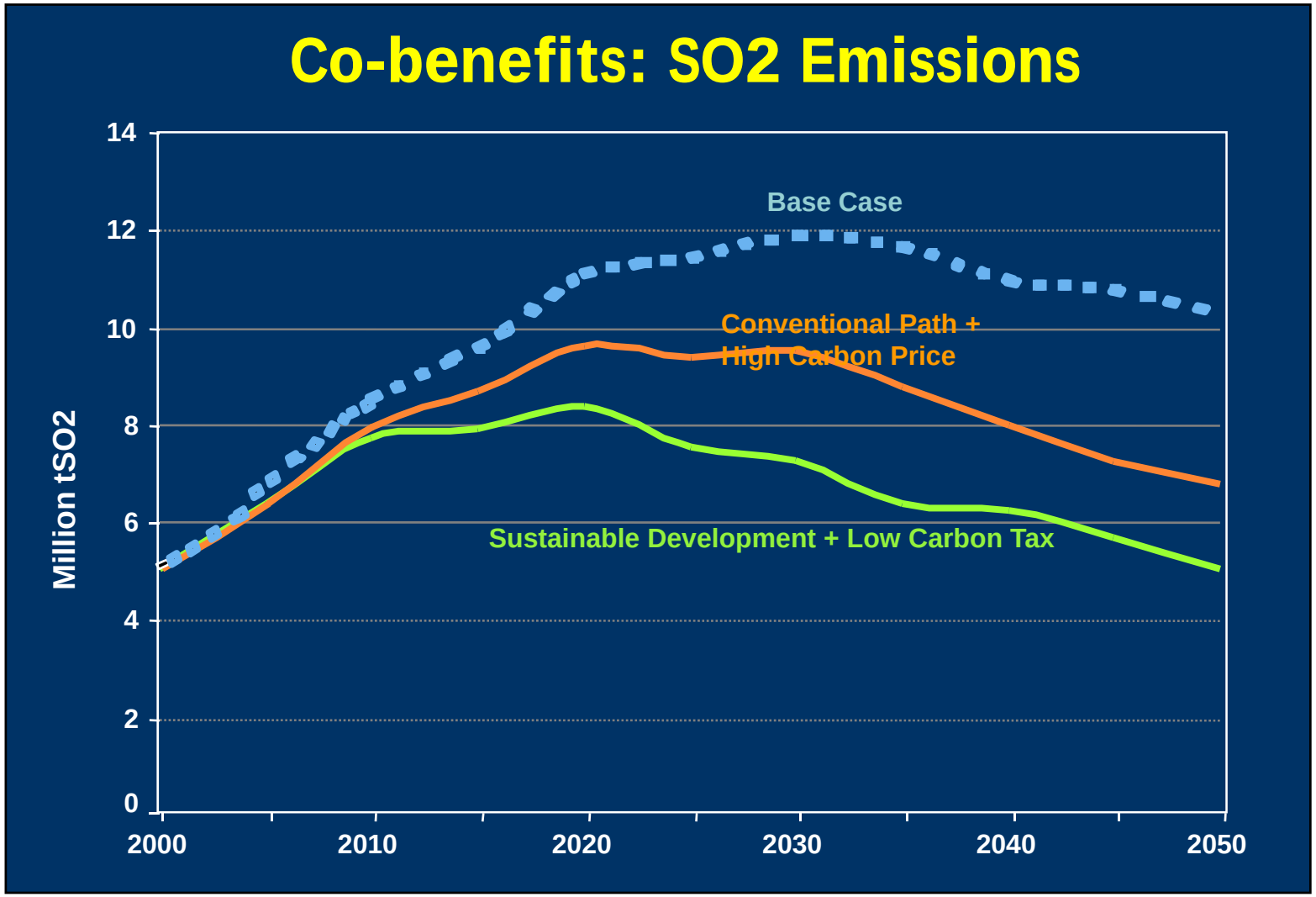
Expanding 'development and climate' frontier through:

- *Innovations (technology, institutions)*
- *International and regional cooperation*
- *Targeted technology and investment flows*
- *Aligning stakeholder interests*
- *Focusing on inputs (& not only outputs)*
- *Long-term perspective to avoid lock-ins*

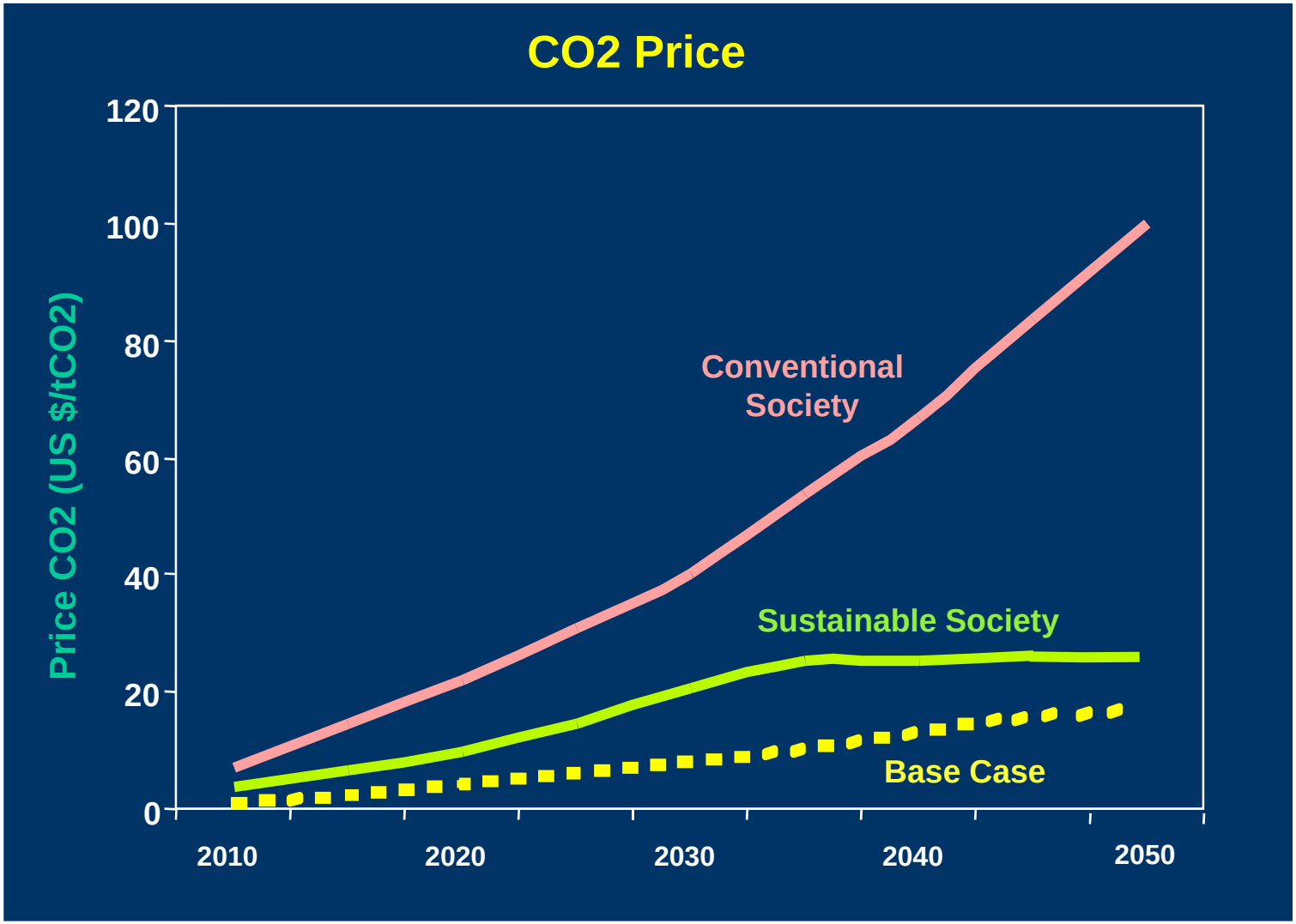
Reinforcing the Income Effect



Co-benefits of Low Carbon Transition

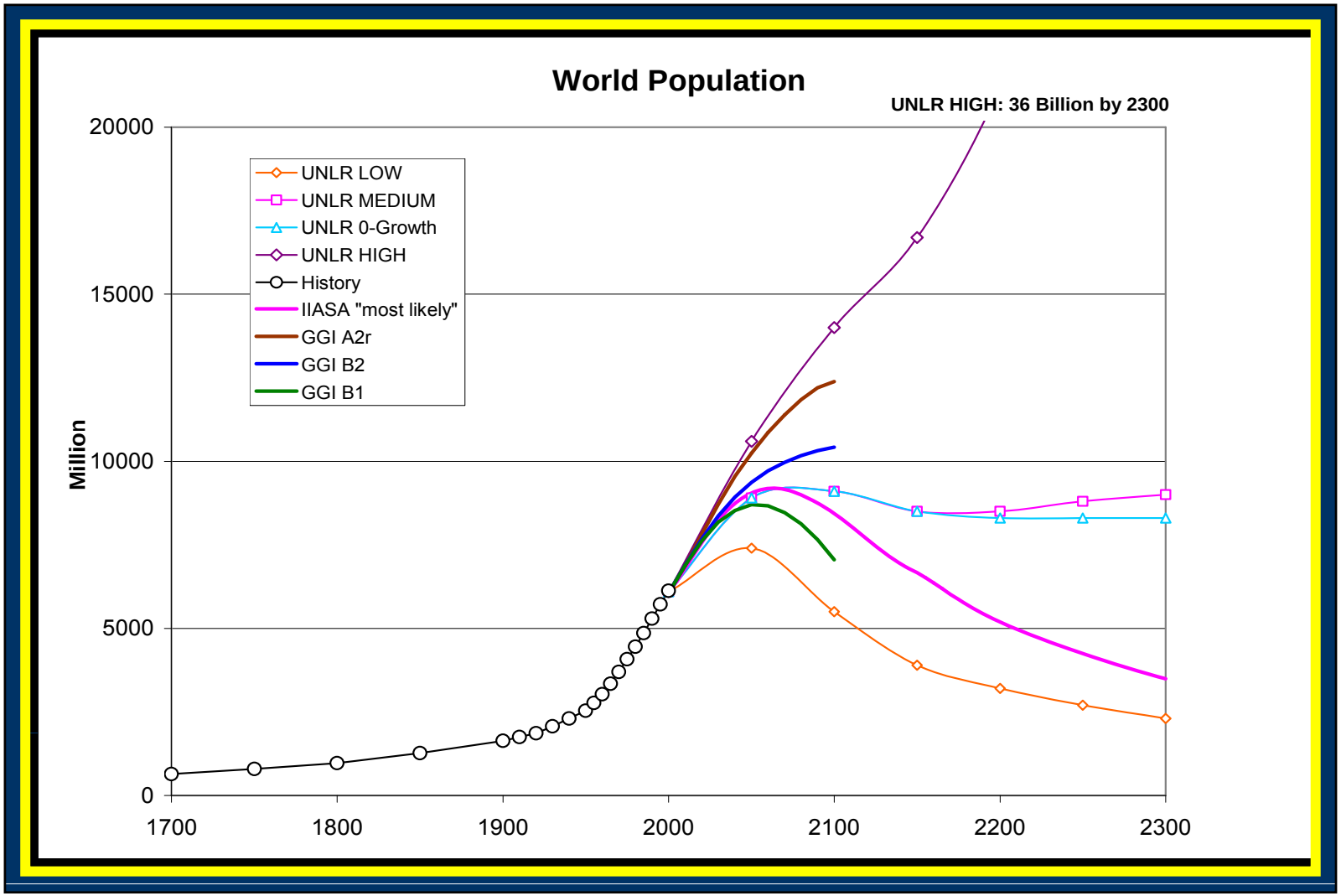


Transition at Low Carbon Price



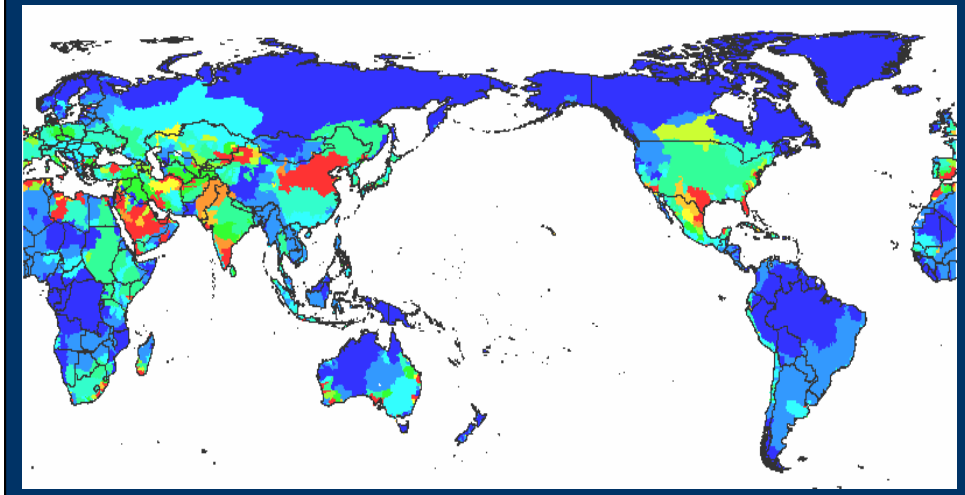
Low Carbon Society:
Integration, Adaptation and Cp-benefits

Integration with Demographics

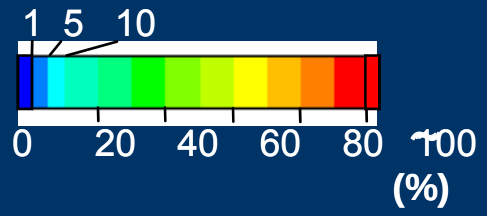


Integration with Water Strategies

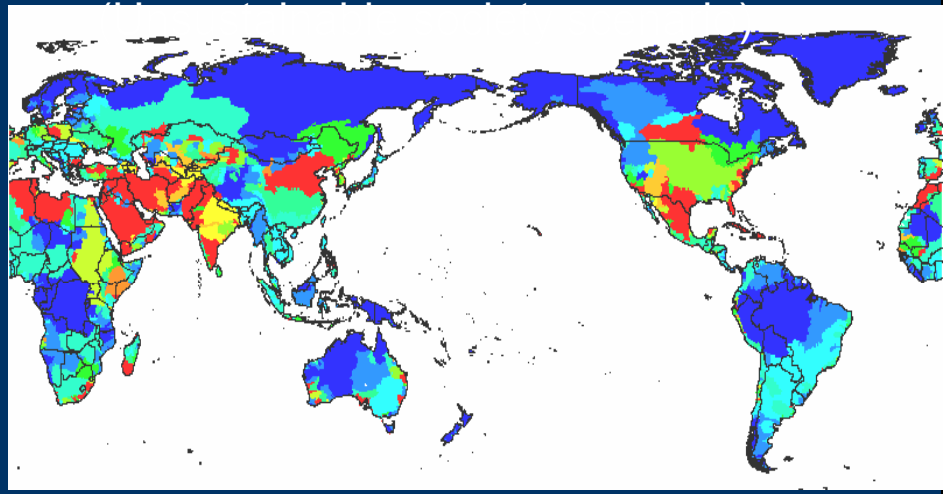
(A) Water stress index in 2000



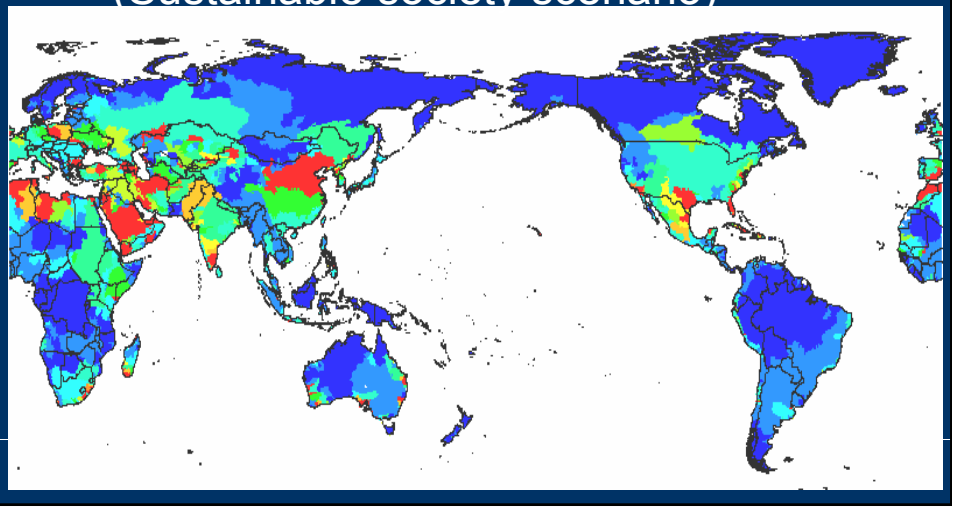
"Water stress index" is defined as the ratio between water withdrawal and renewable water resource in a river basin (figure's case), region, country or other boundaries. High value implies the higher risk of water shortage.



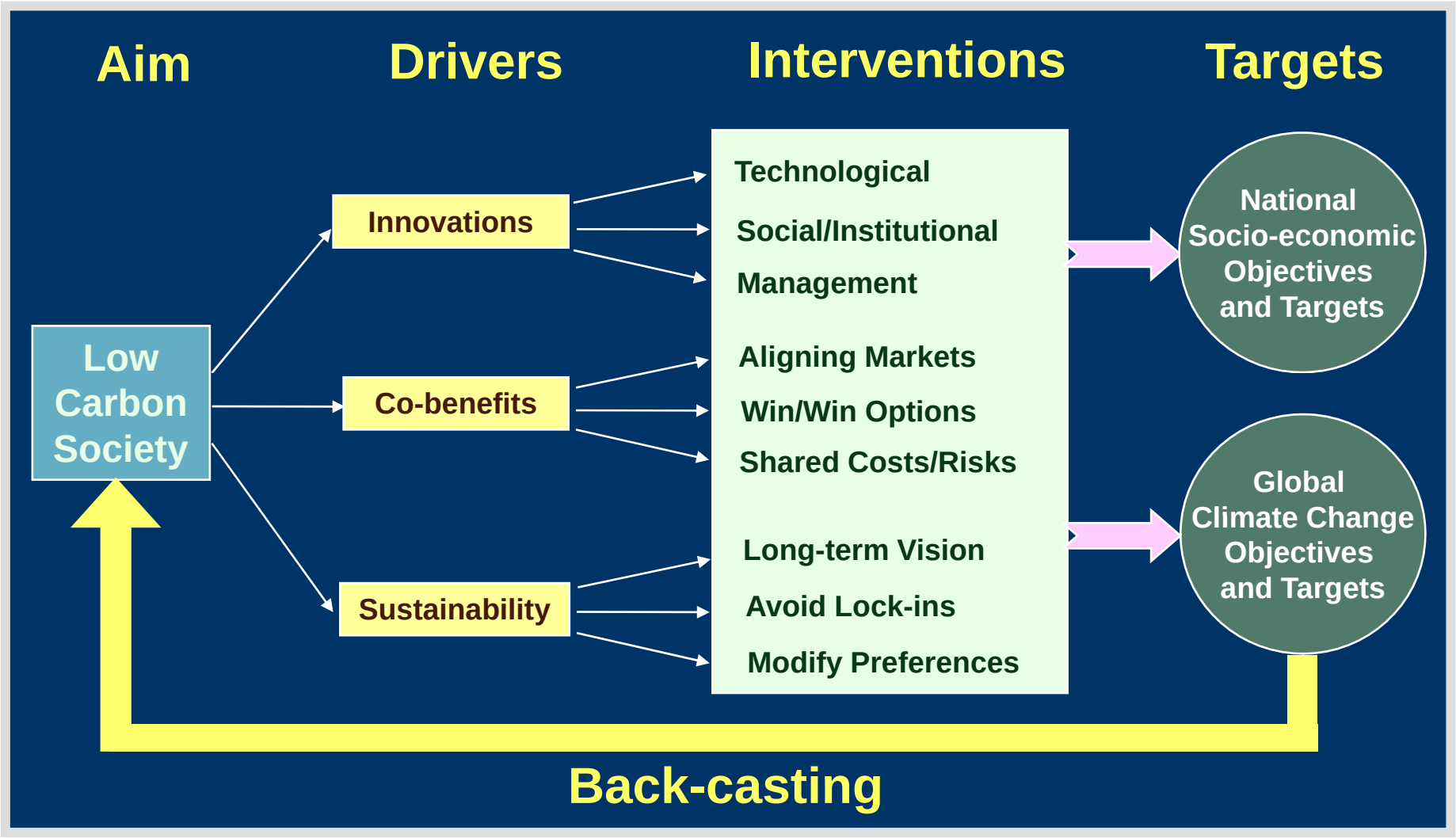
(B1) Water stress index in 2100



(B2) Water stress index in 2100 (Sustainable society scenario)



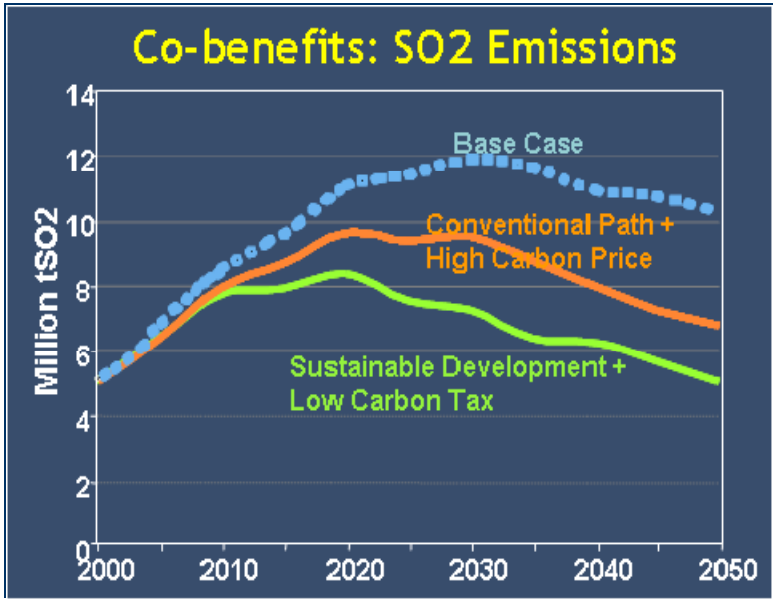
Sustainable Low Carbon Development



Delivering Co-Benefits

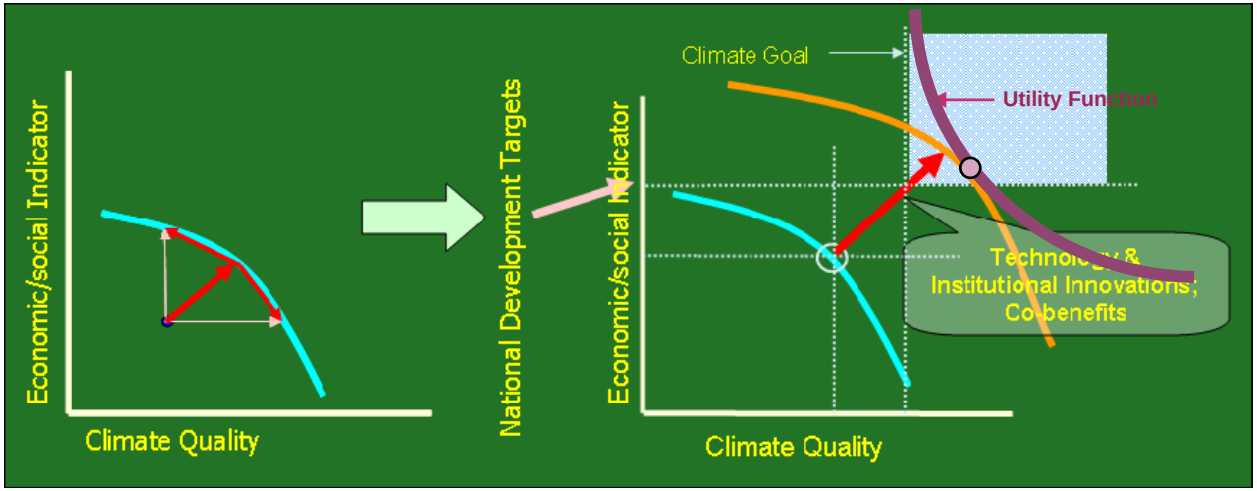
Mitigation Choices deliver multiple dividends

- In developing countries, significant opportunities exist for gaining co-benefits
- Mitigation Assessment should consider all costs and benefits



"For developing countries, the 'good news' is that their environment and natural resources policies are often so bad that there are reforms which would be both good for the economy and good for the environment."

Joseph Stiglitz



Conclusions

Strategies for Low Carbon Transition

Conclusions: **Strategies to gain Co-benefits**

Align Development and Climate Actions

- **Mainstream Climate Actions**
  - Mainstreaming climate action in development strategies yield multiple co-benefits
- **Promote Actions suiting sustainable and climate-friendly development path**
  - 'Reduce, Reuse and Recycle (3R)'
  - Infrastructure technologies that act as backbone for low carbon activities (e.g. railway and information networks)
  - Low carbon substitutes (e.g. IT for transport)
- **Use Combination of Direct and Indirect Policies**
  - Regional Cooperation to diversify energy mix
  - Energy Intensity Targets
  - Carbon Price

Conclusions: National Technology Strategy

Develop National Technology Strategy

- **Technology RD&D**
  - Public Funding (e.g. Nuclear)
  - Private Investment (e.g. Bio-diesel, Wind)
  - Technology Mandates
  - Intellectual Property Rights
- **Technology Transfer**
  - Pilot Projects (e.g. Carbon Capture and Storage)
  - Technology Adaptation and Deployment
  - Collaborations to create National Industry and Market (e.g. Fuel-efficient cars)
- **Technology Export**
  - Export of Equipments (e.g. Wind Power)
  - Direct investment/ Joint venture in host country
  - Export of Technology R&D Services

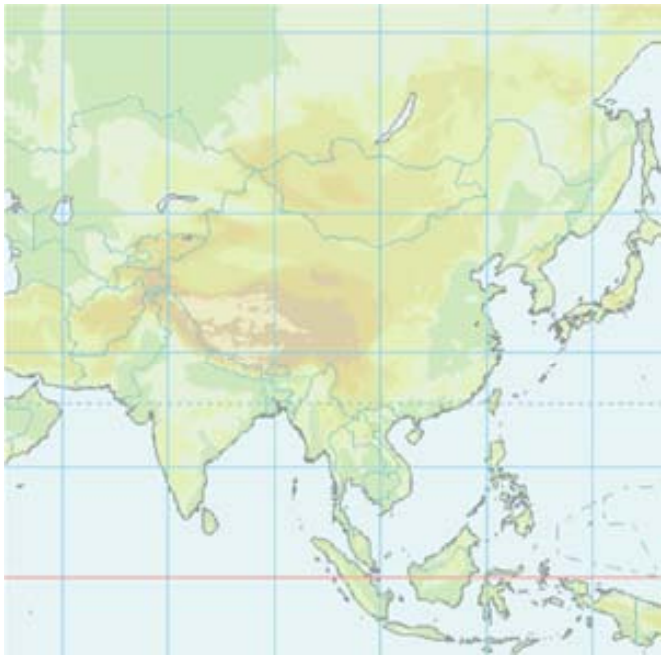
Conclusions: **Link with Global Actions**

Link Global and National Strategies

- **Participate in Global Innovations**
  - Global R&D Projects (e.g. 'Deep Dive' Technologies, ITER)
  - Develop National Registry
  - National Carbon Exchange (e.g. with commodities exchange)
- **Prepare to Participate in Carbon Market**
  - Capacity building in government and industry
  - National Registry
  - National Carbon Exchange (e.g. with commodities exchange)
- **Align with Global Policies**
  - Global Carbon Finance / Trading
  - Global Trade Regime

Conclusions: LCS through Sustainability

- **Changing Behavior and Technology RD&D/ Transfer are key to LCS transition**
- **Moving from Margin to Mainstream**
  - **Development vision** matters to LCS transition
  - Managing climate change at the margin is **costly**, **risky**, and **unsustainable**
- **Post-Kyoto needs a 'Paradigm Shift towards 'Co-benefits' and 'Co-operation':**
  - Negotiations have followed '**burden sharing'** metaphor, which poses climate stabilization as a **high cost** and **zero-sum game** and this has caused conflicts
  - **Sustainable development** delivers **co-benefits** and reduces costs of stabilizing climate.
  - Netting **co-benefits** is a **positive-sum** game that would induce **co-operation** and help:
    - developed countries to transit to low carbon trajectories at lower costs &
    - developing countries to pursue economic development with lower climate barriers
  - Even **sustainable Low Carbon Societies** shall need exclusive **climate-centric actions** for stabilization and adaptation, but their costs and risks shall be much lower



Thank you