Technology and Finance for Low Carbon Energy Development:
Visions and Strategies for INDIA

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Modeling Alternate Development Visions

Stabilization Target and Visions

1. Global Stabilization Target Assumption:

- 550 ppmv CO2e Concentration
- 3.4 W/m2
- @ 3^{o} C temperature increase (50:50)

2. Two Development Pathways for India:

(with same total CO2 emissions from 2005 to 2050)

1. Conventional Vision: **Climate Actions at Margin of Conventional Development path**
2. 'Sustainability' Vision: **Aligning Climate Actions with Mainstream Development Actions**

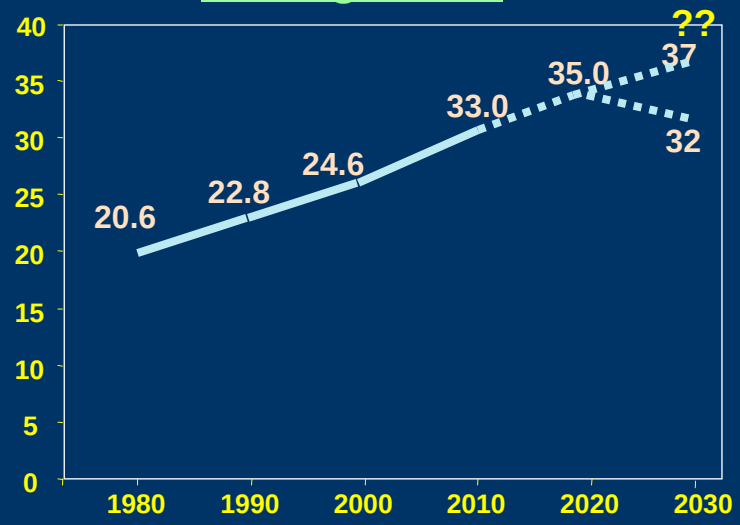
What path shall best deliver national development goals while fulfilling Climate Commitments?

Base Scenario: Assumptions

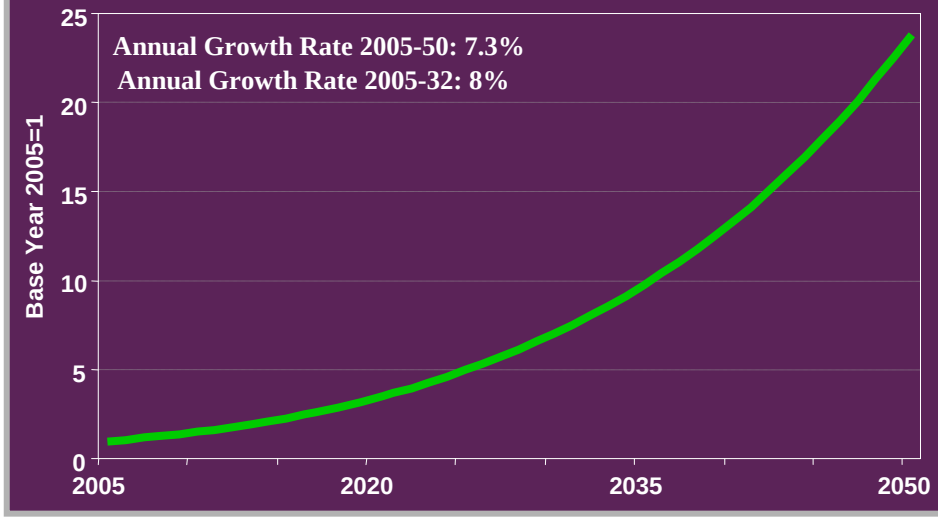
Base Scenario

1. GDP
   - Ann. Growth Rate: 7.2% from 2005-50
   - 2050 Economy: 23 times larger than 2005
2. Population
   - 2000: 1021 Million
   - 2050: 1593 Million
3. 650 ppmv CO2e Concentration Stabilization (or 550 CO2)
4. 4.7 W/m2 Radiative Forcing

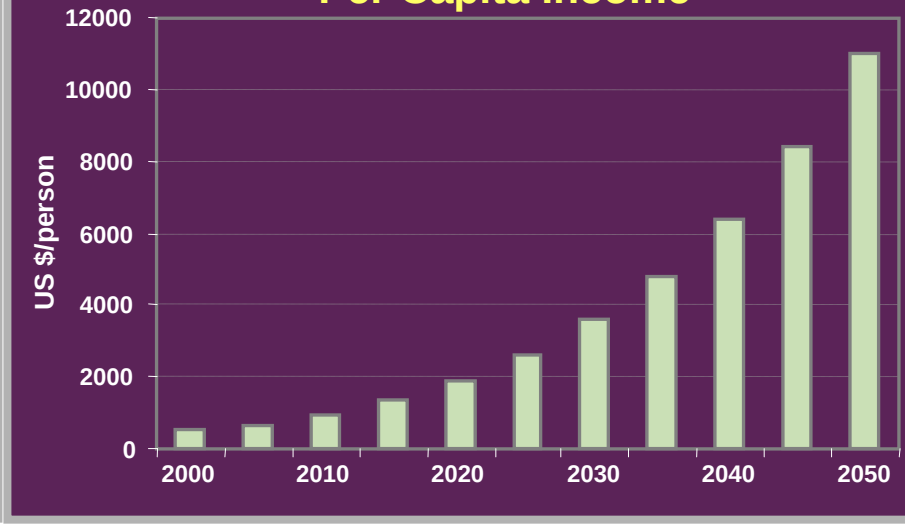
Savings Rate



GDP



Per Capita Income

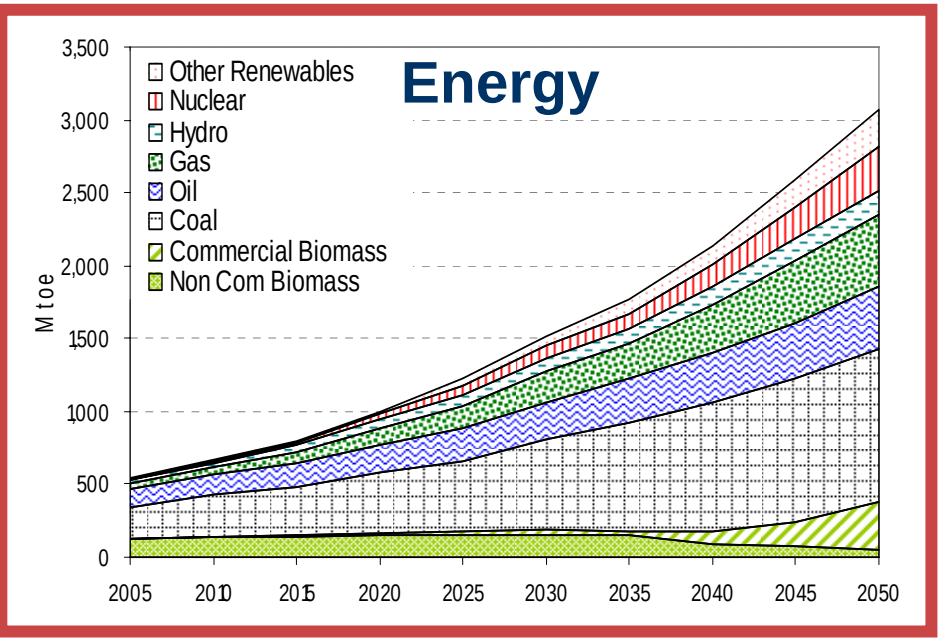


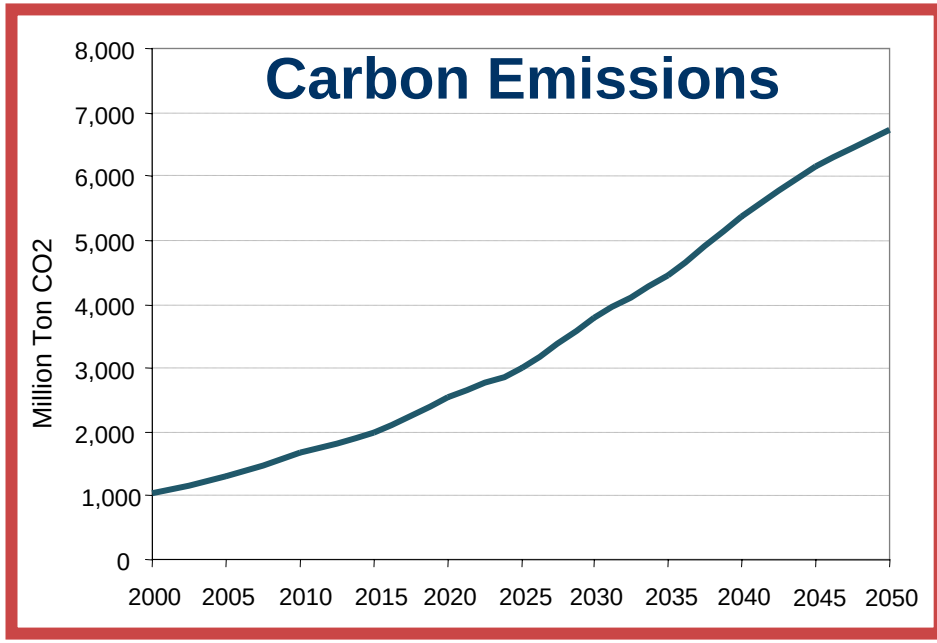
Energy and Carbon: Base Case

Assumptions

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

Increase 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 (%)

Direct Investment in Energy Projects:
2010-30: US$ 1.2 Trillion
2030-50: US$ 2.3 Trillion

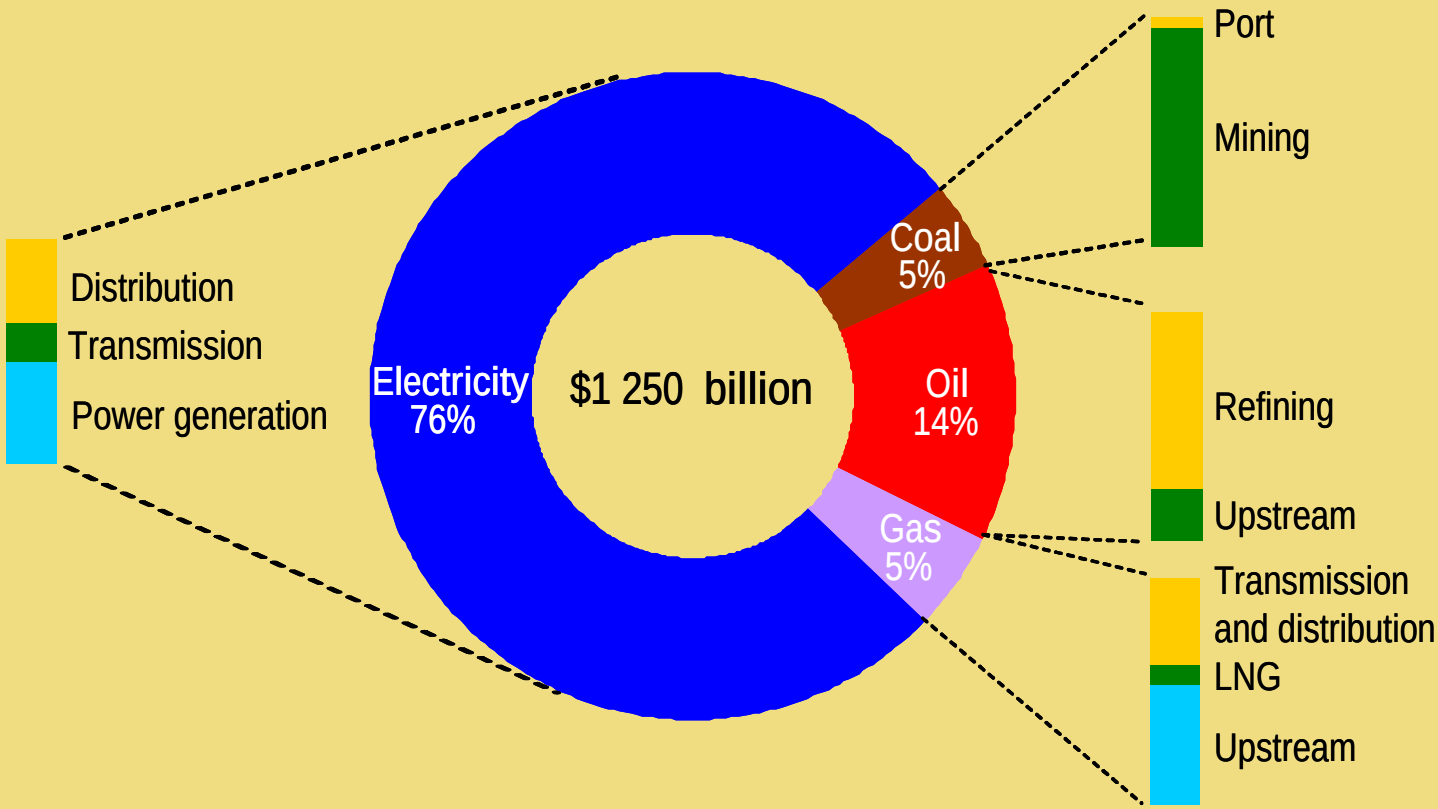
INTERNATIONAL ENERGY AGENCY

WORLD ENERGY OUTLOOK 2007

China and India Insights

Reference Scenario:

India's Investment in Energy Infrastructure, 2006-2030



Three-quarters of total energy-related investment needs to 2030 are for power infrastructure

Mitigation Technology Choices & **Development Visions**

Alternate Development Visions

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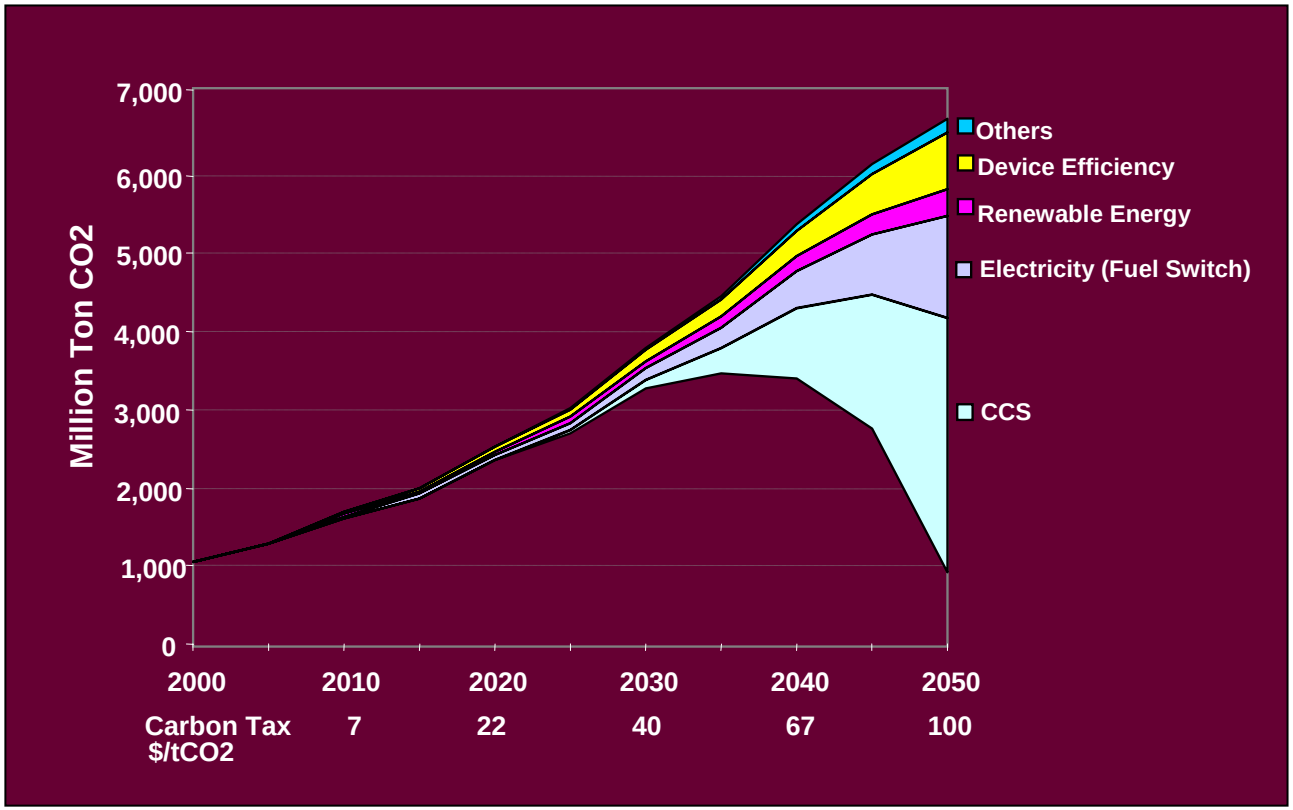
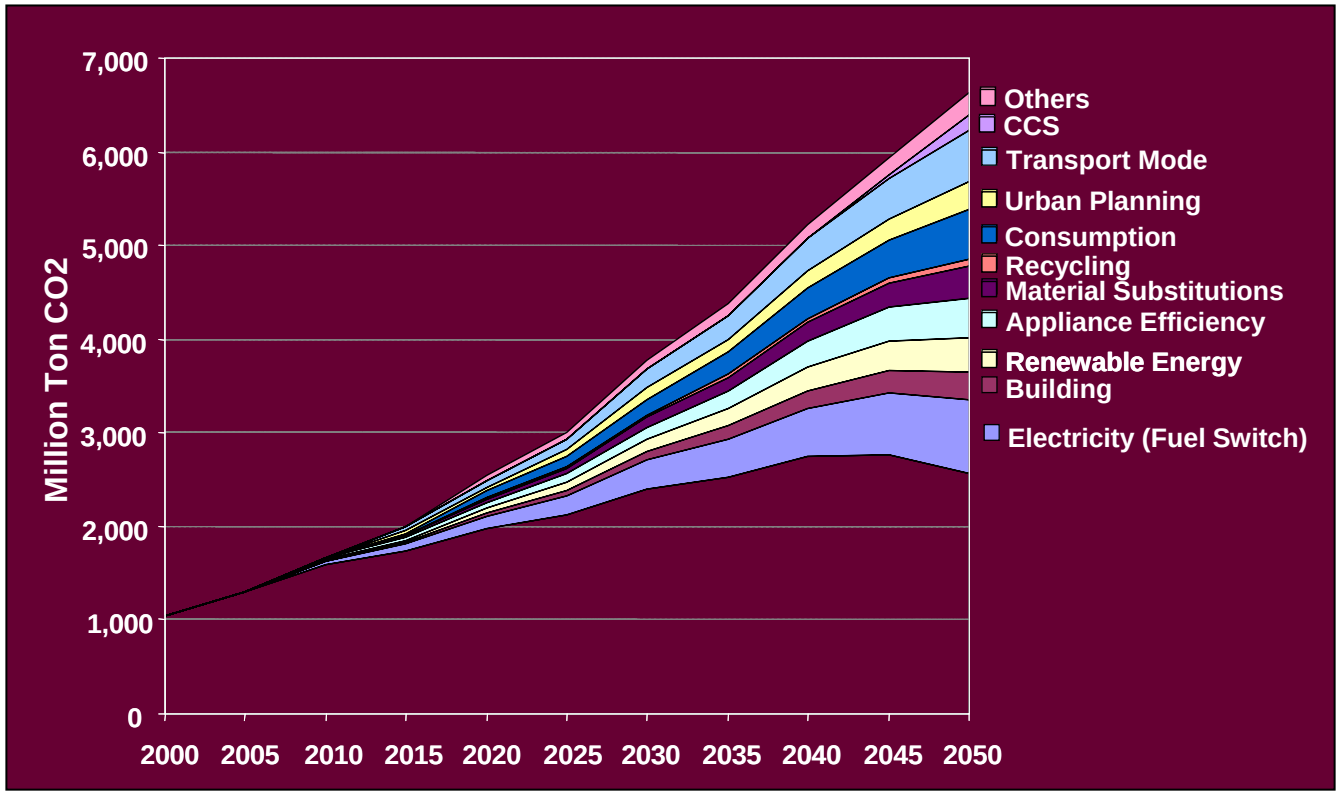
Vision I: *Managing Climate via Conventional Path*

1. **Top-down/Supply-side actions**
2. **High Carbon Price as main instrument**
3. **Climate Focused Technology Push**

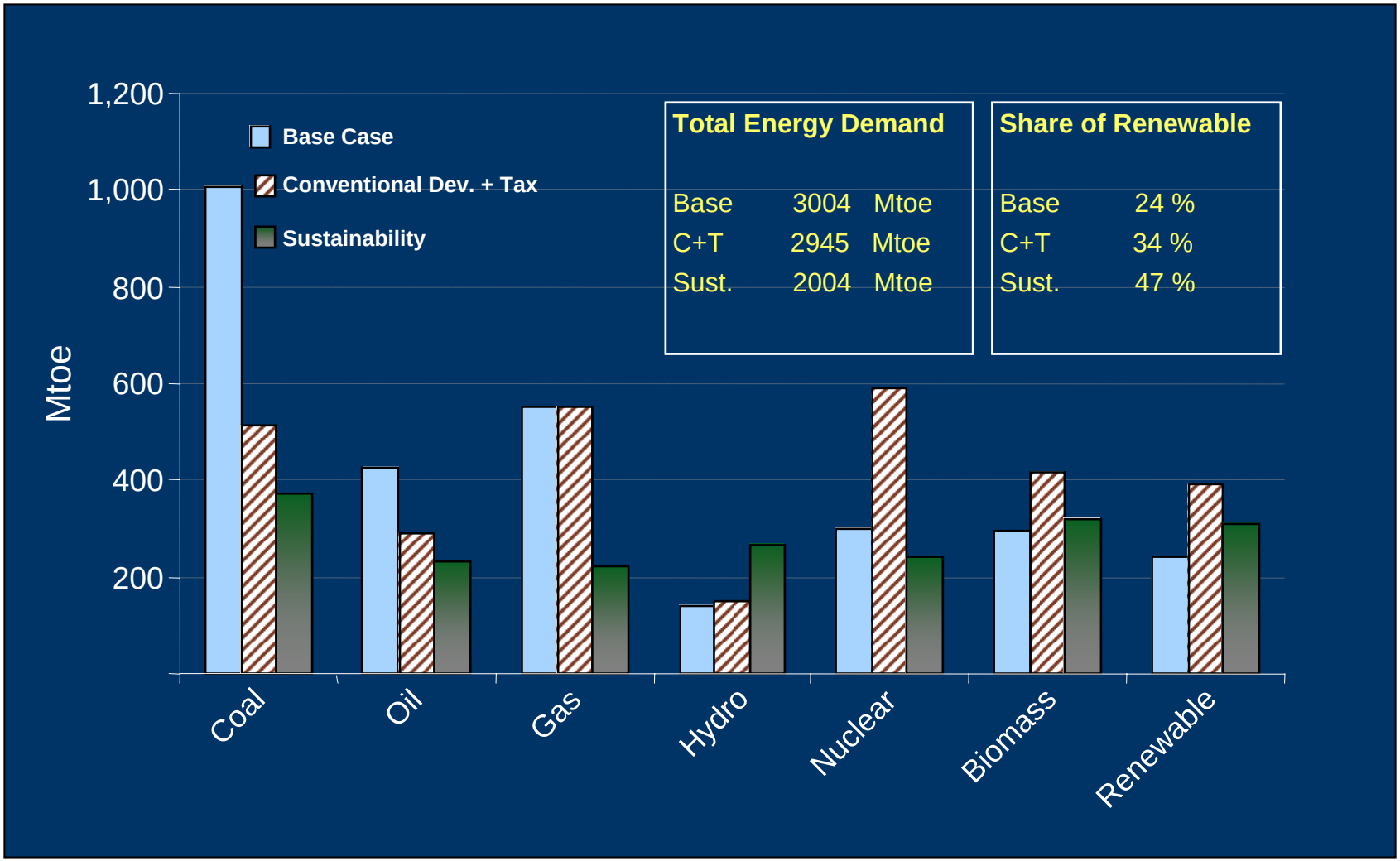


Vision II: *Managing Climate via Sustainable Path*

1. **Low Carbon Price**
2. **Bottom-up/Demand-side Actions**
3. **Behavioural Change**
4. **Diverse Technology Portfolio**



Energy Technology Mix in 2050



Technology Cooperation for **Energy Supply-side Choices**

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.

CCS Mapping for India

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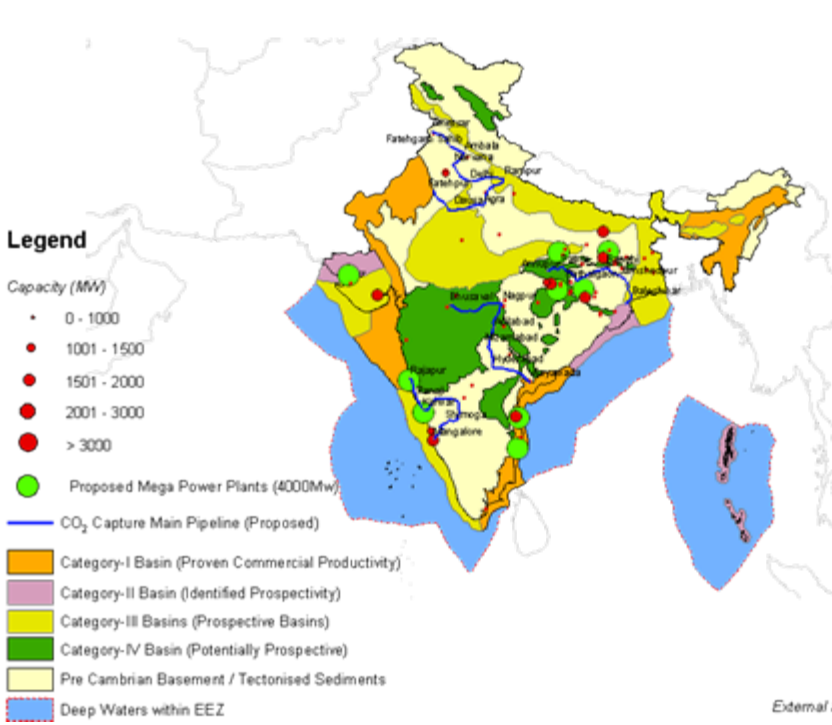
Proposed Coal Based Power Plants & CO_2 Capture Pipeline



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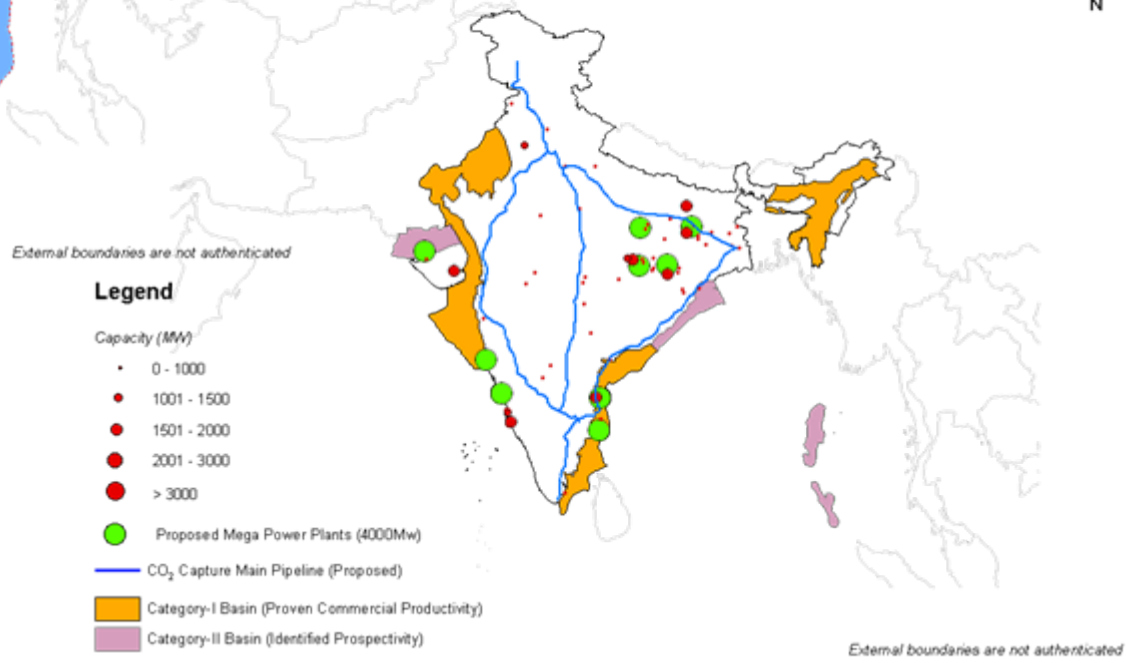
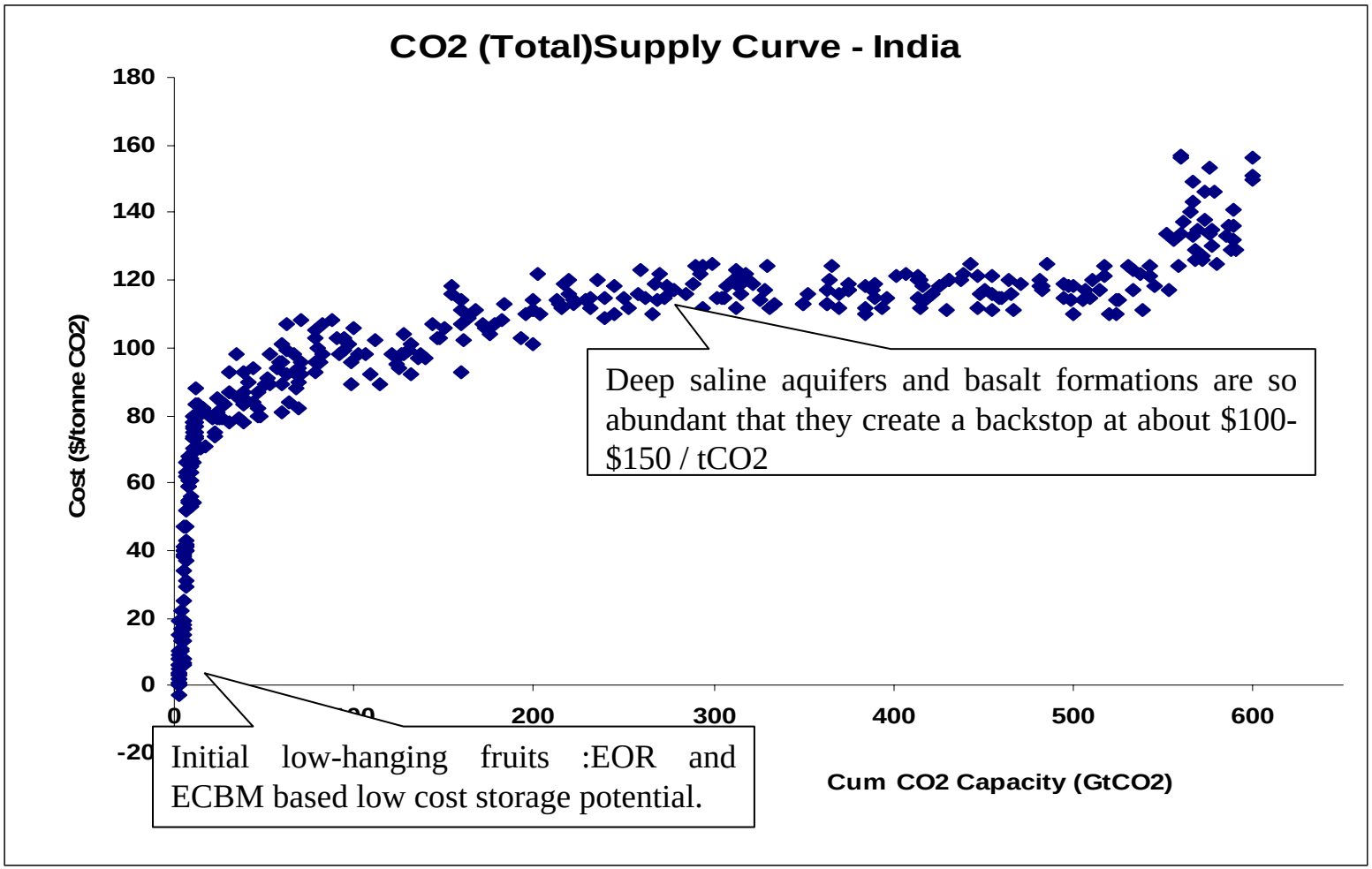
Proposed CO_2 Capture Pipeline, Proposed Power Plants & Sedimentary Basins



External boundaries are not authenticated

Carbon Capture & Storage Supply Curve



- **Long run Carbon capture & storage cost for India –100-150$ / t CO2**
- **Additional geological investigation**

Nuclear Technology

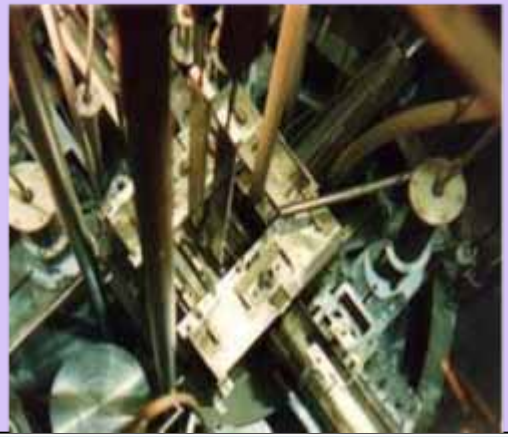
Technology Cooperation Tasks

- **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

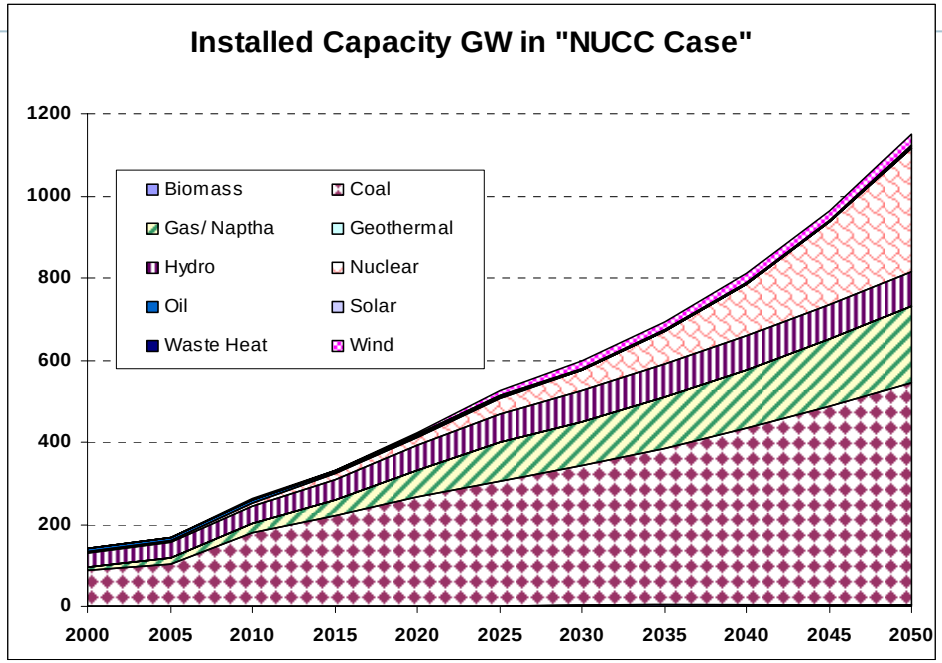
Inside view of Kamini reactor, 100 MW
Went critical in Sept 96, using U-233 fuel

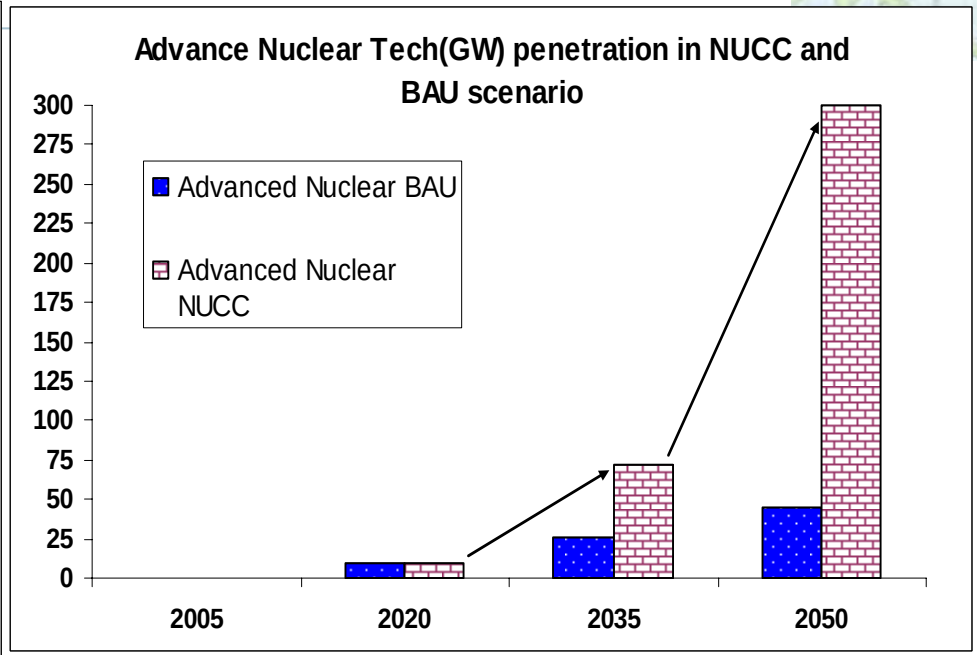


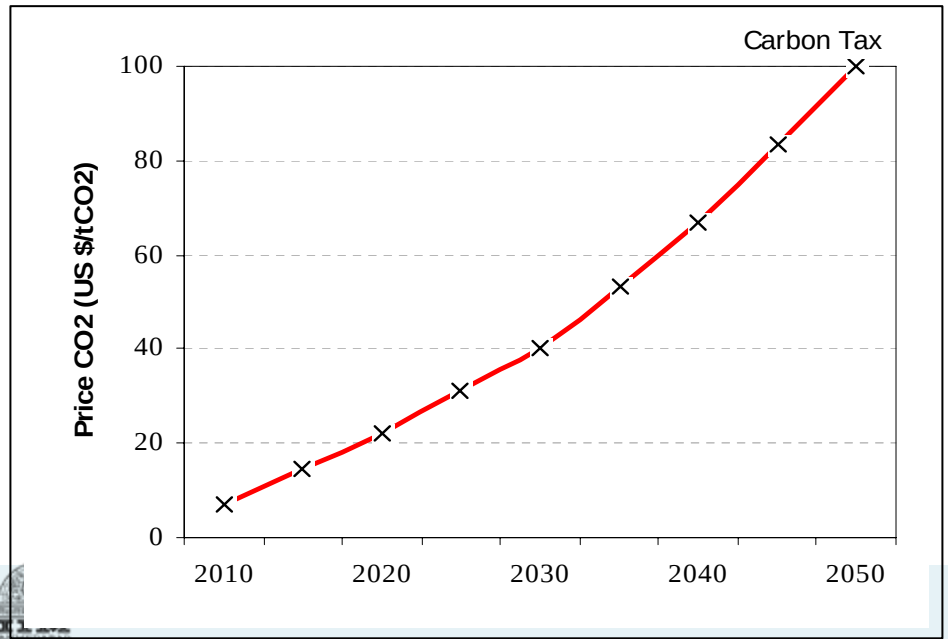
India's First 540 MWe Nuclear Power Plant (Started 09/2005)

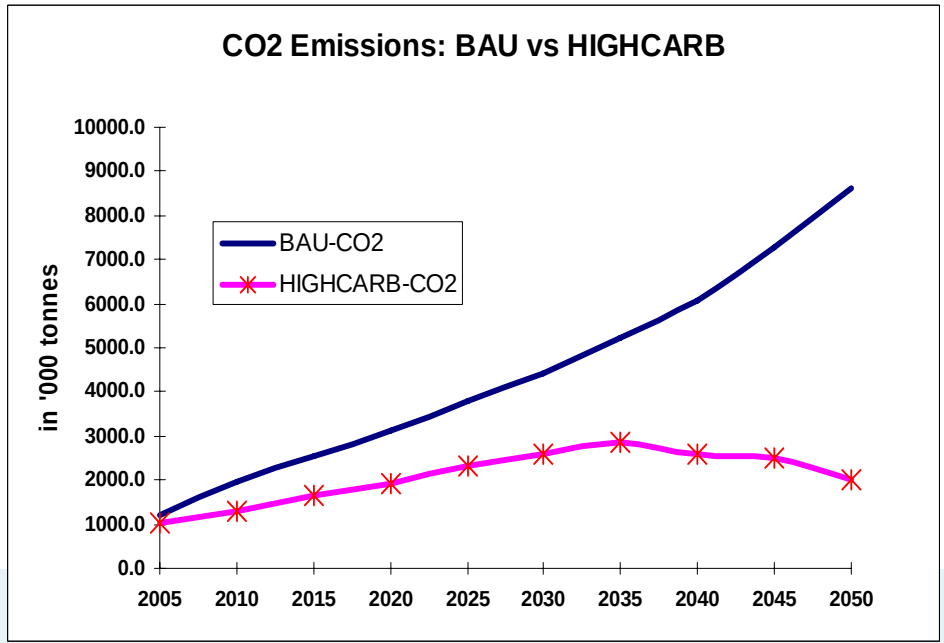
2X1000MWe VVER reactors under construction at Koodankulam (Going Critical in 2008)

Nuclear Co-operation & Climate Change (NUCC)









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

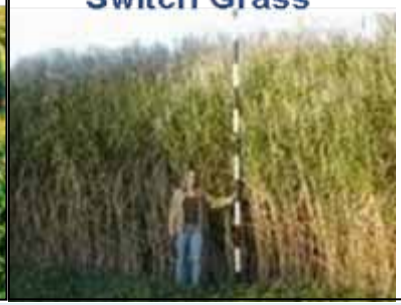
Jatropha plant

Bio-diesel Extraction Plant

Sugarcane Plantation

Corn Field

Switch Grass



Poplar Trees

Bio-diesel: Co-benefits and Conflicts

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

Technology and Finance for a **Sustainable Low Carbon Society**

India: National Climate Change Action Plan

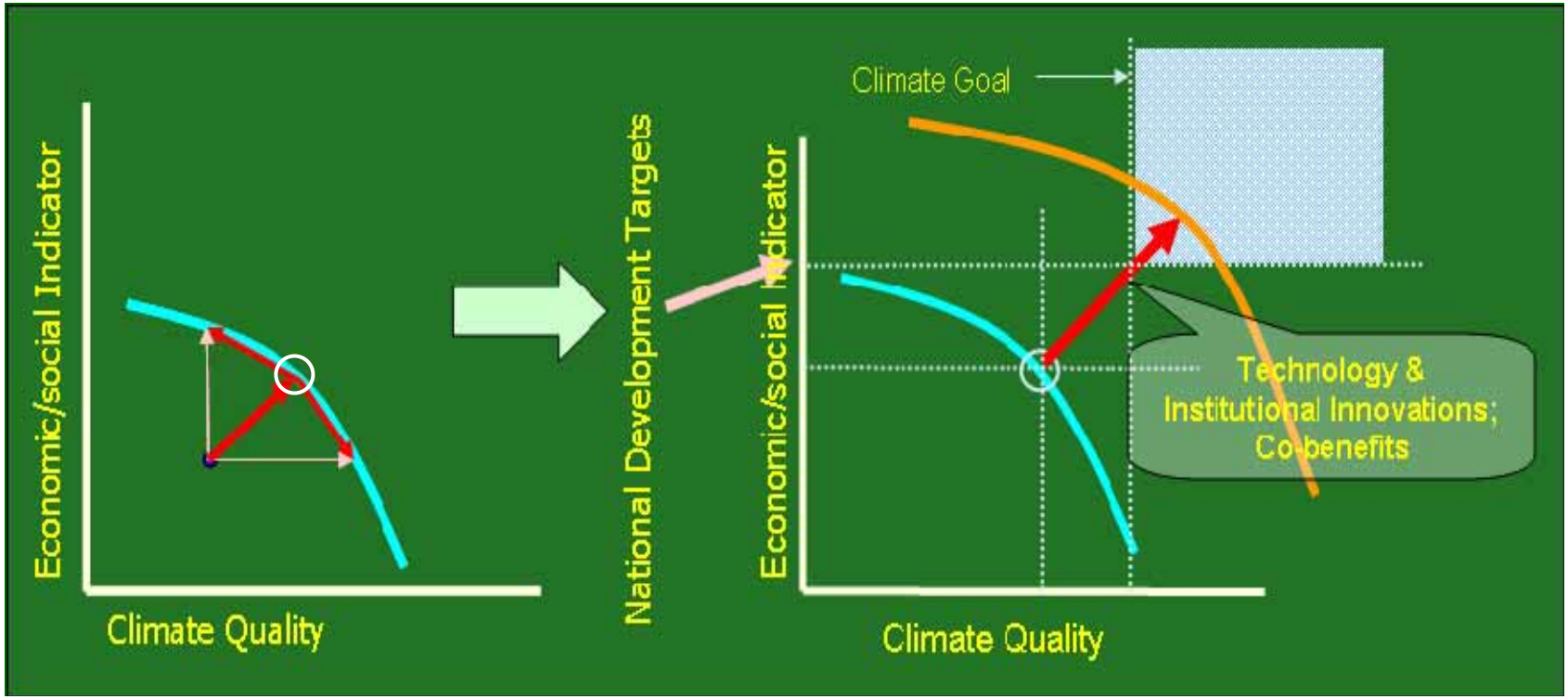
8 National Missions:

1. Solar Energy (100 MW PV/yr; 1000 MW Thermal by 2017)
2. Enhanced energy efficiency (10000 MW saving by 2012)
3. Sustainable habitat
4. Water Sector (20% water use efficiency improvement)
5. Sustaining the Himalayan eco-system
6. A “Green India” (6 Mil. Hectare afforestation; Forest cover from 23 to 33%)
7. Sustainable agriculture
8. Strategic knowledge for climate change

Sustainability and Co-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



Investing in Sustainable LCS: Framing

- **Lower (& hyperbolic) Discount Rate**
- **Uncertainty, Risks, Security and Insurance**
- **Investing in options that deliver Co-benefits**
  (Enlarging Options)
- **Cooperation Coordination and Institutions**
  (Reducing Transaction Costs)
- **Creating Positive Path Dependence**
  (Preventing Lock-ins)
- **Investments: Supply versus Demand**
  (Influencing Behavior)
- **Focus on: Projects and Processes**

Sustainable Cities: Planning and Infrastructures

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

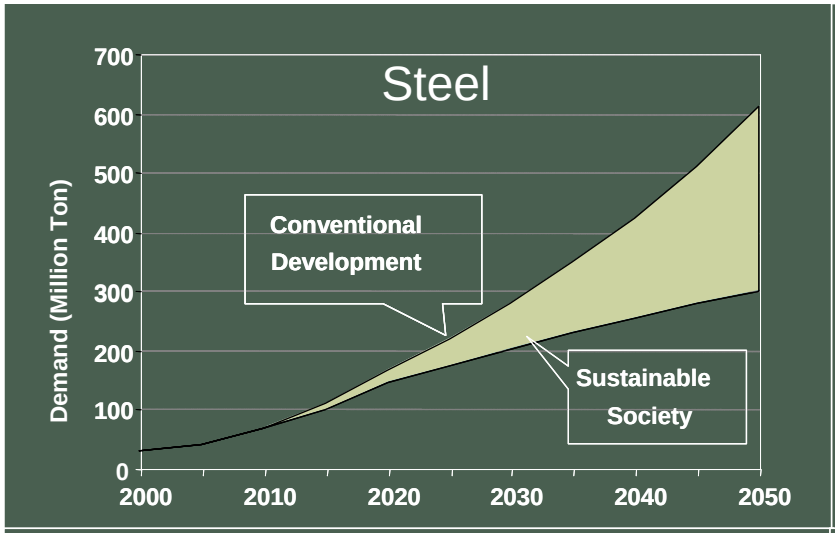
Bus Rapid Transport System

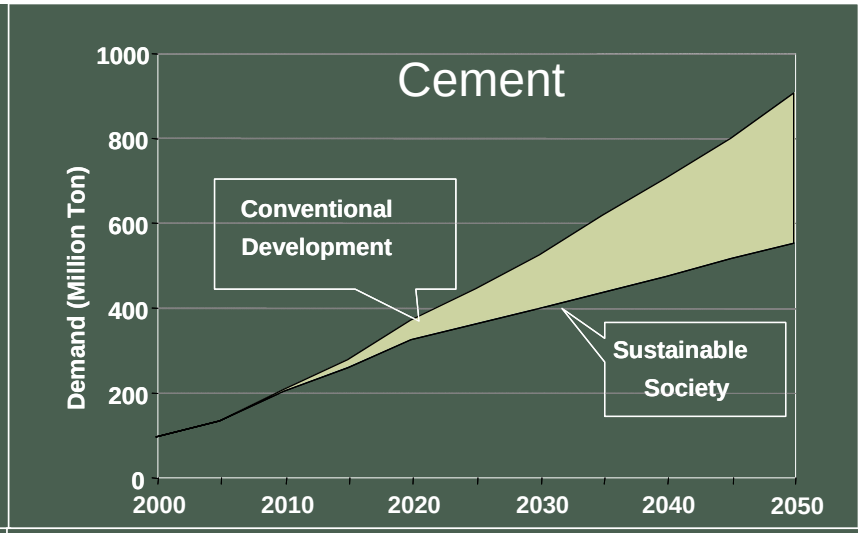
Technologies for Train Corridors

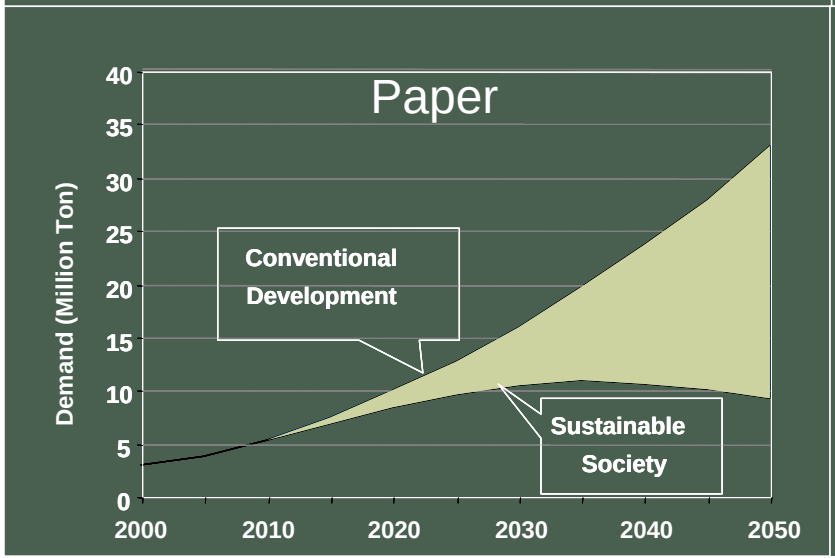
Japan will provide technology and financial support for Delhi-Mumbai Industrial Corridor (DMIC) to be developed similar to Tokyo-Osaka corridor for Rail transport

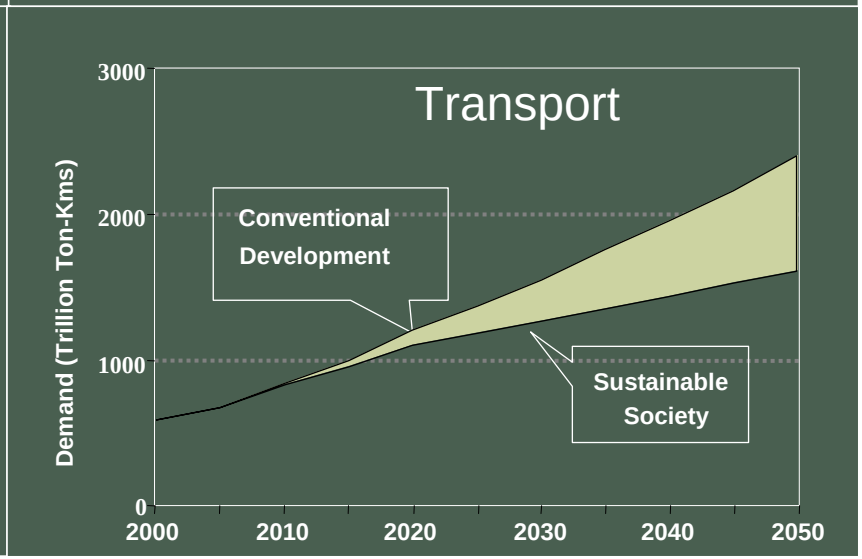
DMIC will result in substantial and sustained reduction in GHG since rail will replace road transport along this corridor

Dematerialization



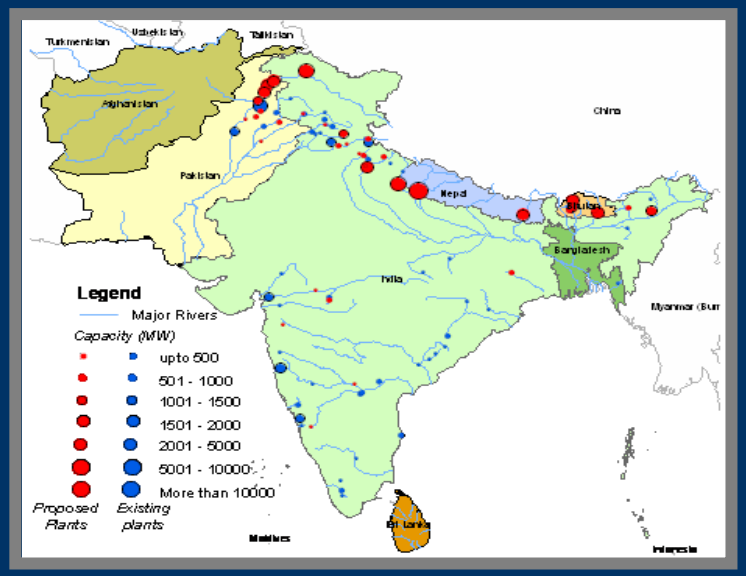


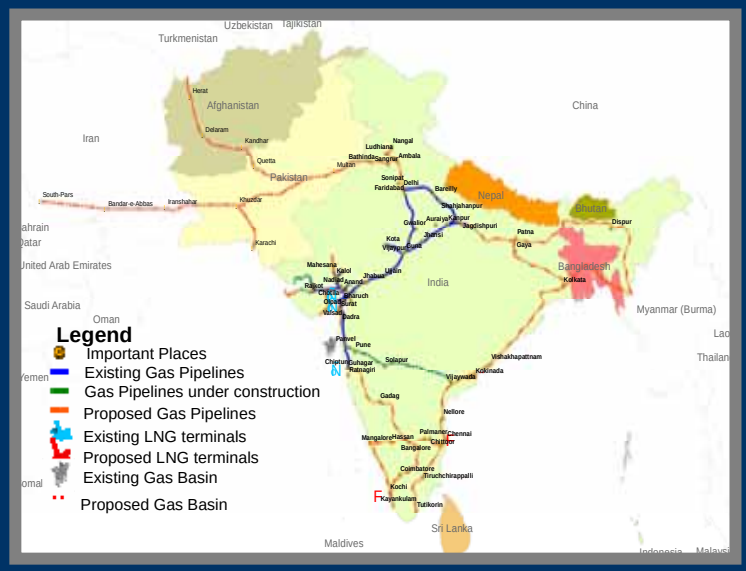




Co-benefits of Cooperation

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





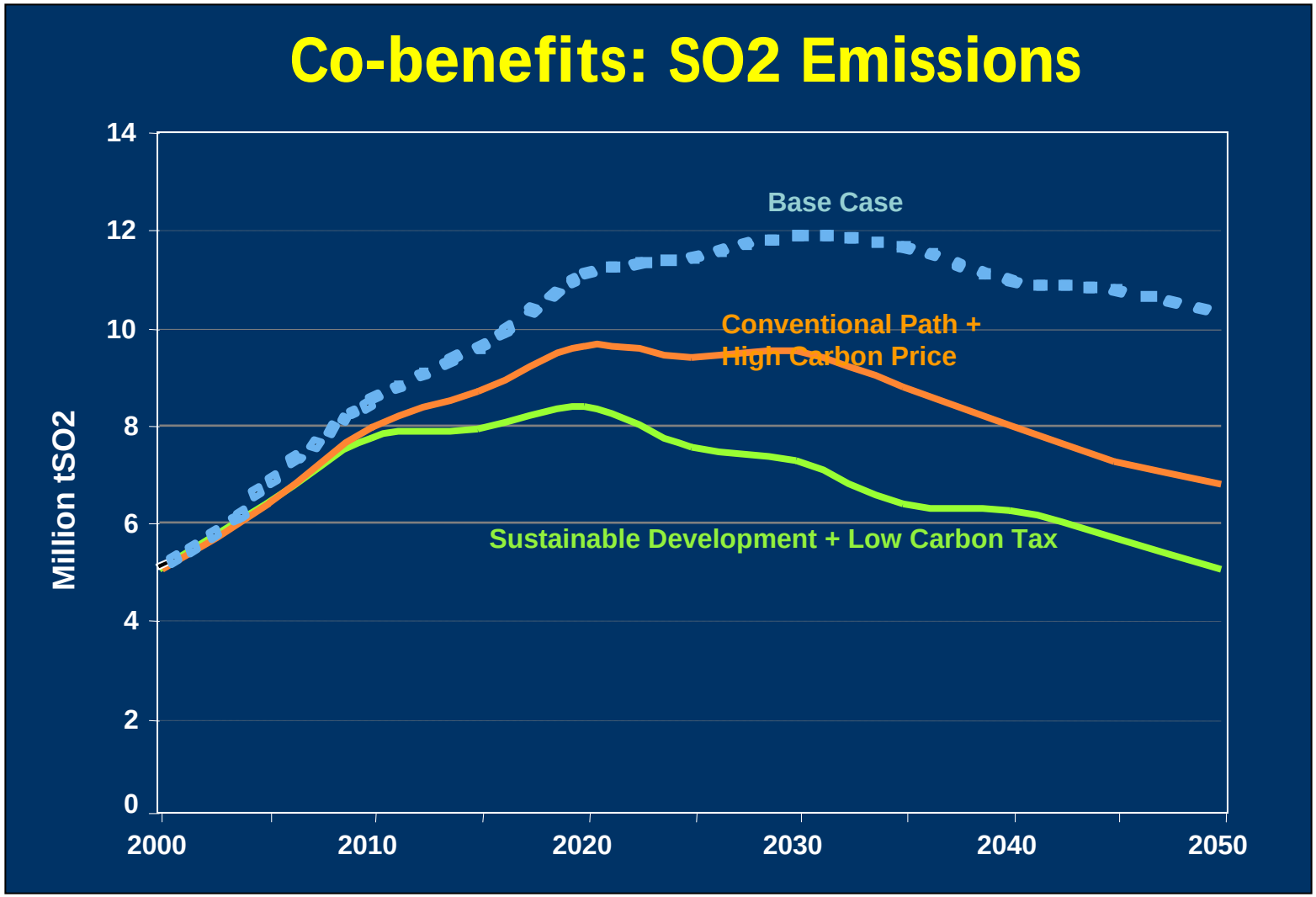
Co-benefits of South-Asia Integrated Energy-Water Market

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)

Air Quality Co-benefits



Which is the Social Cost of Carbon?

Conclusions: Cooperation & Development Vision

- **Technology & Finance depend on development pathway**
  - Energy supply technologies are key options in **Conventional Vision**
  - End-use service technologies are key options in **Sustainability Vision**
- **Alternate Finance and Technology Strategies**
  - Early Actions for technology capacity building and preparedness
  - Investments to alter consumer and producer behavior (e.g. 3R)
  - Investments that avoid lock-ins (e.g. infrastructure choices)
  - Investments in wide range of development choices (co-benefits)
  - Cooperation & coordination to enlarge and upscale choices (lower costs)
- **Sustainability Vision shall minimize the Social Cost of Carbon, i.e. the carbon price trajectory to stabilize emissions at targeted level by coordinated global actions to minimize welfare losses resulting from mitigation, impacts and adaptation.**

Thank you