Developing Energy Emission Scenarios for South Asia Using AIM Family of Models

Rajesh Nair, Junichi Fujino, Toshihiko Masui,
Mikiko Kainuma, Yuzuru Matsuoka
AIM (Asia-Pacific Integrated Model) team

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Structure of Presentation

- **A Brief Introduction to the South Asian energy Scenario**
- **Top Down Analysis**
  - Some Preliminary results
- **Linking Top Down and Bottom Up Analysis**
  - For Non CO_2 GHG analysis
- **Future Agenda**
  - Building South Asian Regional Cooperation Scenario

Socio-Economic Indicators for South Asian Countries

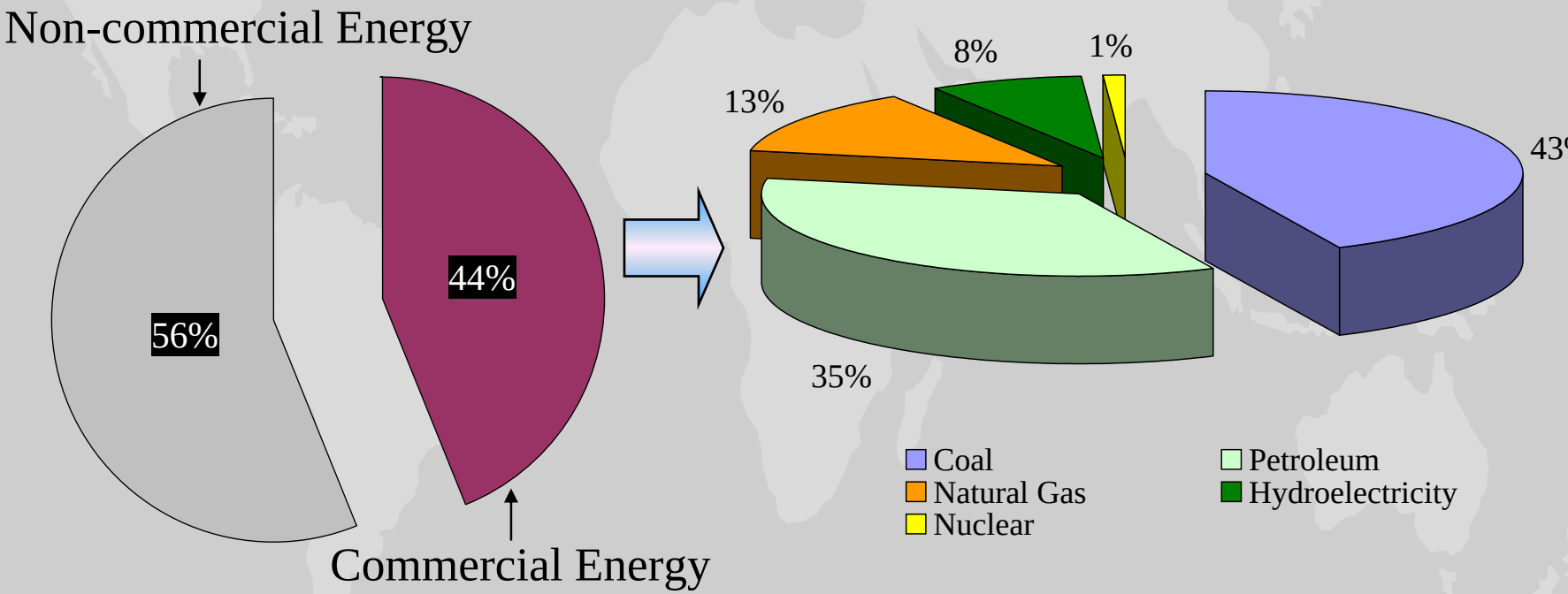
Country	HDI Rank	Population in Million (2000)	GDP per capita (PPP US $) 2001	Electricity Consumption Per Capita 2000 (KWh)
Bangladesh	139	129.15	1610	96
Bhutan	136	2.12	1833	-
India	127	1013.62	2840	355
Maldives	86	0.26	4798	-
Nepal	143	23.93	1310	56
Pakistan	144	145.54	1890	352
Srilanka	99	18.82	3180	293

HDR, 2003

- The region is among the less developed regions of the world.
- A period of transition in economic, political, social and legal structures
- Rapidly increasing energy demand with inadequate sources of supply
- GHG emissions expected to increase sharply

The Context

- **Diversity in geography, climate, energy resources, political and economic structures**
- **Energy mix:**



- **Energy and environment security concern**

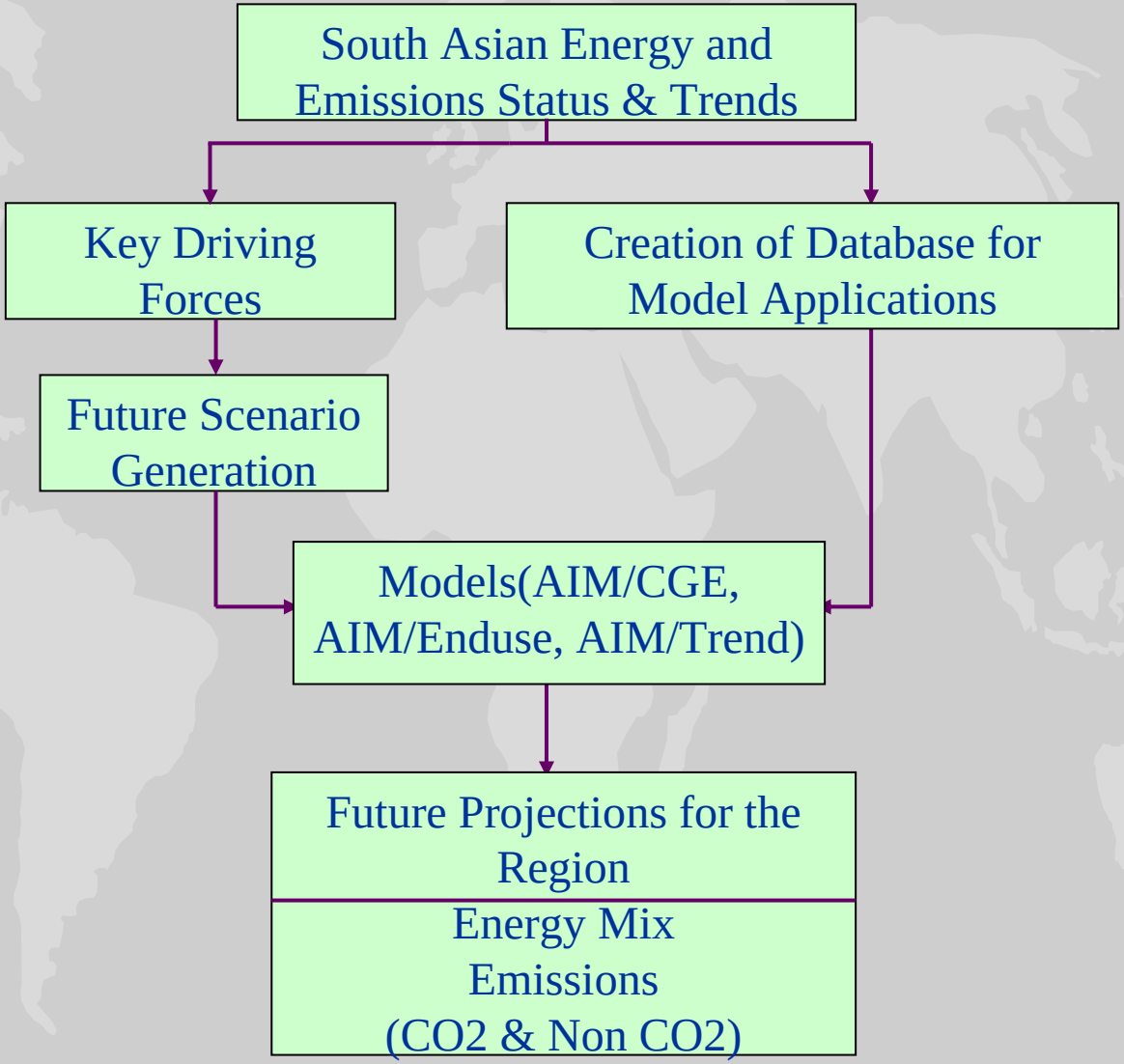
Energy Supply Indicators for South Asian Countries (2002)

Country	Fossil Fuel Proven Reserves		
	Crude Oil (Mb)	Dry Natural Gas (Tcf)	Coal (Bst)
Bangladesh	57	10.6	0
India	4,728	22.8	82.4
Nepal	0	0	0.002
Pakistan	208	21.6	3.2
Total	4,993	55.1	85.6

Mb - Million barrels **Bst- Billion short tons** **Tcf – Trillion cubic feet**

Carbon emissions are expected to increase from about 300 MMTC in 2002 to about 850 MMTC by 2030

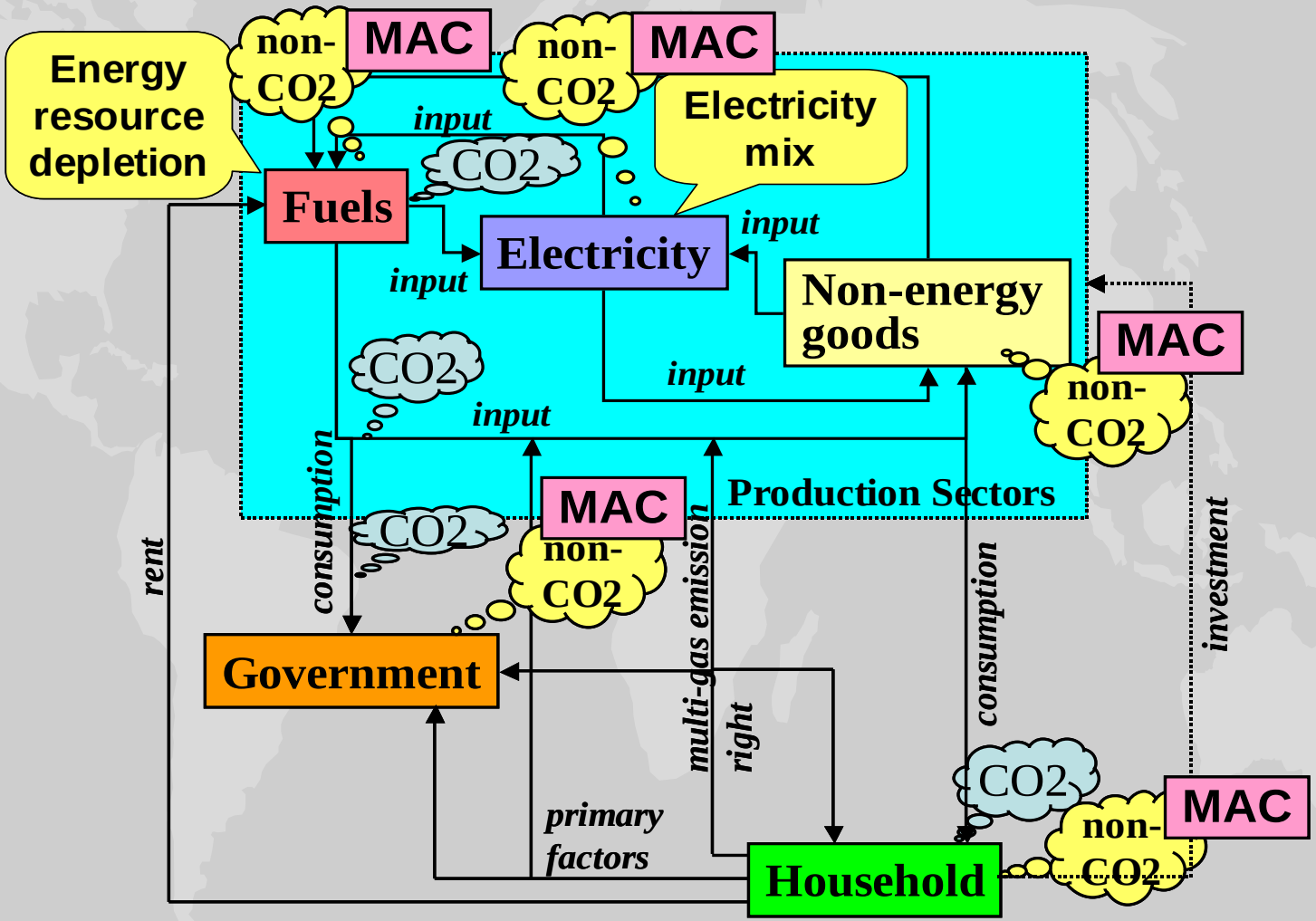
The Framework



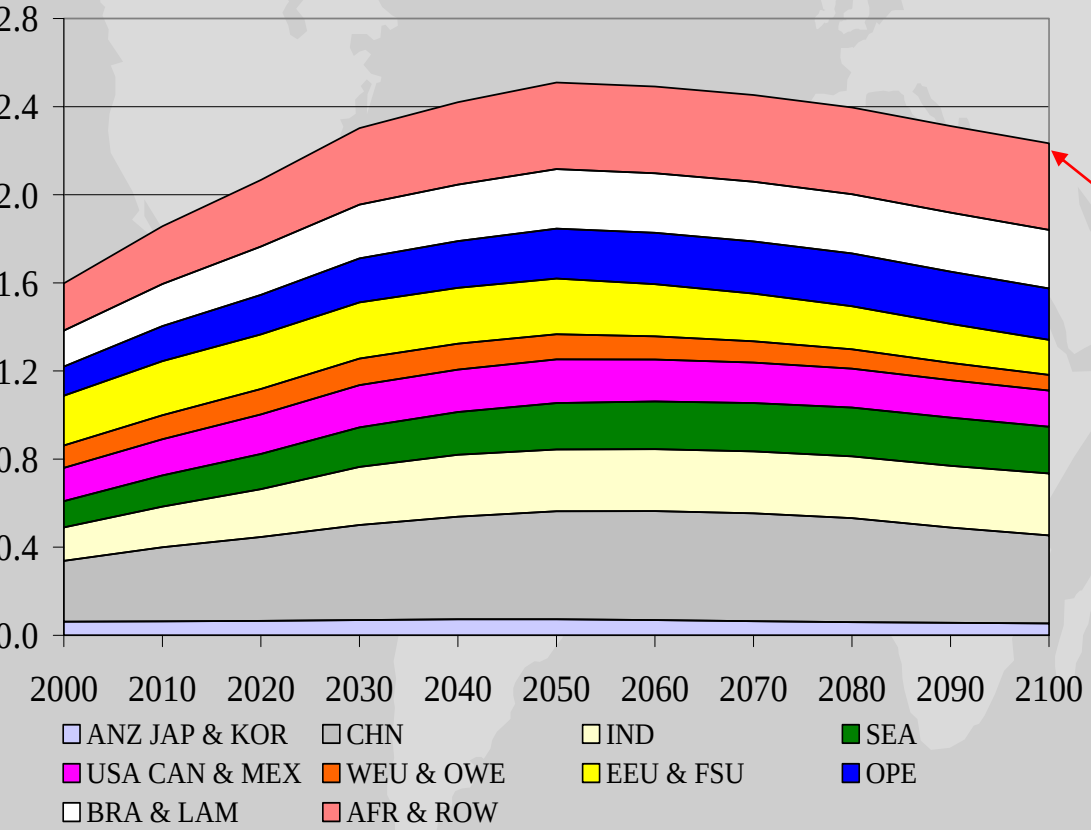
Top Down Analysis

- Some Preliminary results…….

Structure of AIM/CGE (Asia)

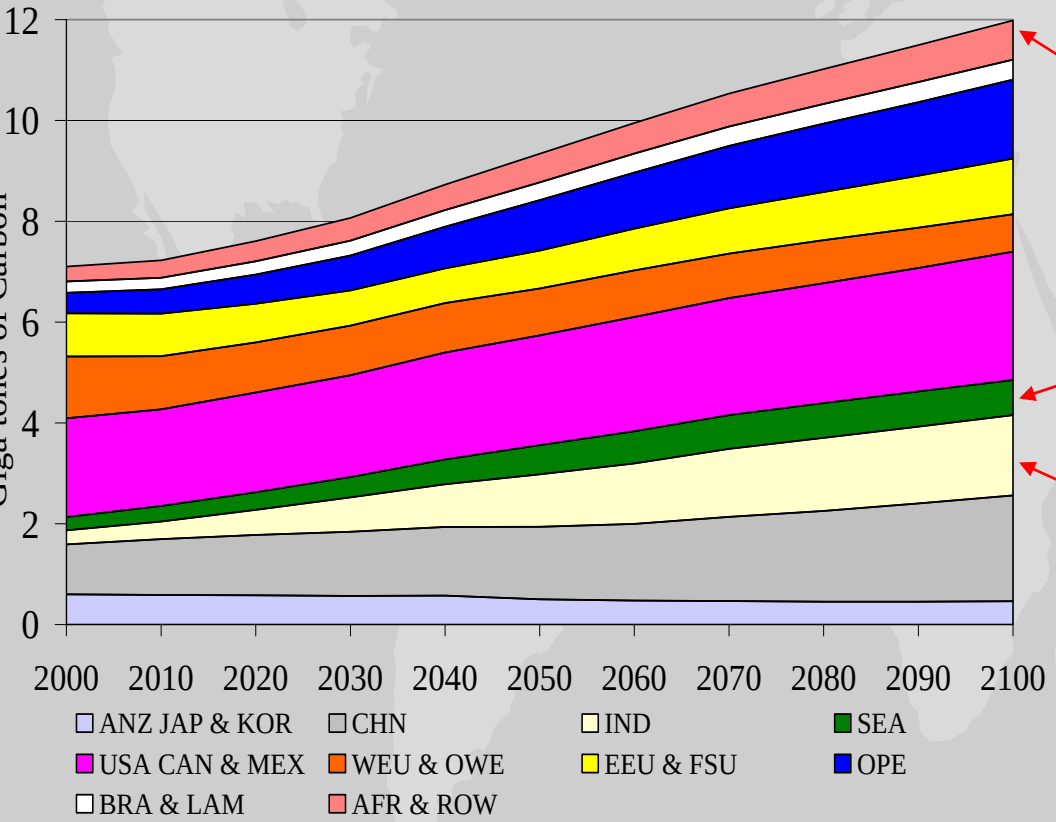


Global Methane Emissions



•Global CH_4 emissions are expected to increase from about 1.6 Giga tones of carbon equivalent (Gt-C eq) to about 2.25 Gt-C eq by the end of the present century.

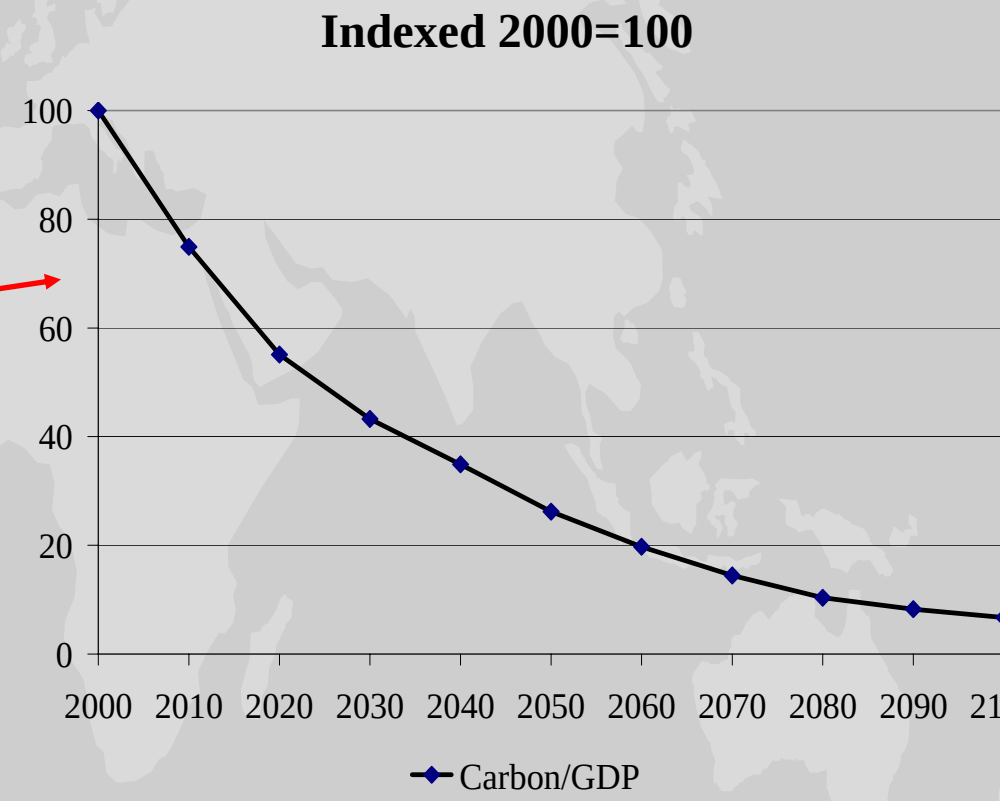
Global Carbon Emissions



- Global Carbon emissions increase from about 7 GtC in the year 2000 to about 12 GtC in the year 2100
- For South and South East Asia the emissions triple
- Carbon emissions from India increase from about 280 MMTC in 2000 to about 1.58 billion tones of C.

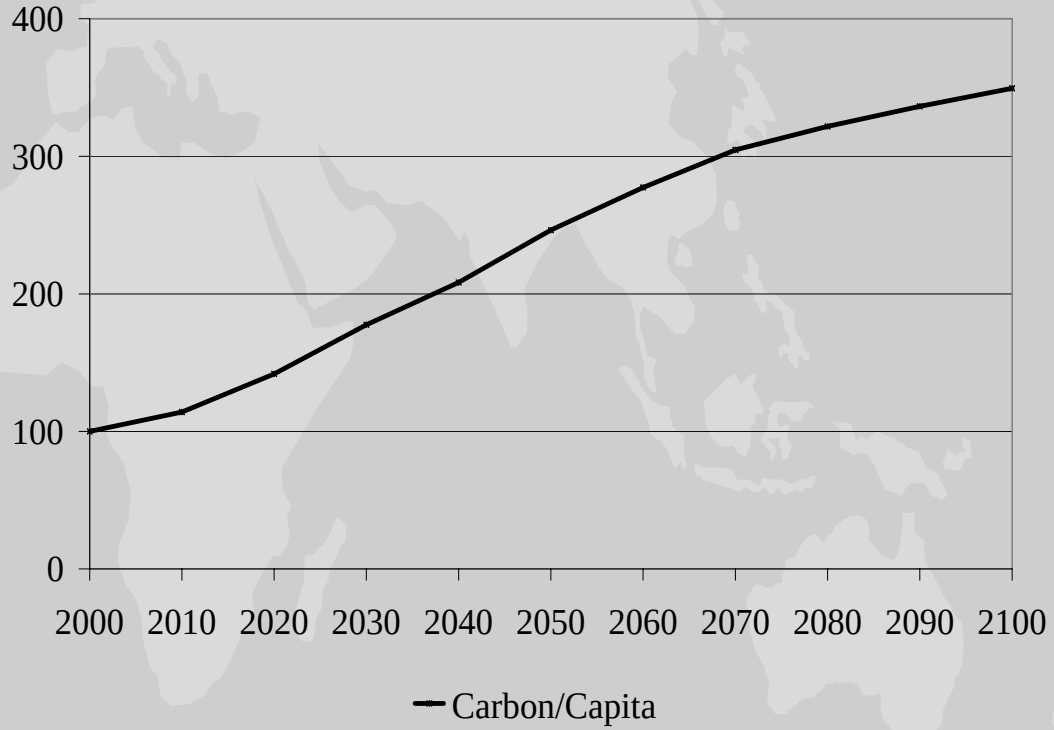
Future Intensities for India

- Strong decoupling between GDP growth and carbon emissions
- Also reduction in carbon intensity of electricity observed



Carbon Per Capita Trend for India

- India's per capita carbon emissions is expected to increase by about three and a half times
- From about 0.26 tons per person in 2000 to close to 1 ton per capita by 2100



Linking Top Down and Bottom Up Analysis

- For Non CO_2 GHG analysis…..

Linking Top Down And Bottom Up Analysis

- Attempts to link top down and bottom up analysis in an integrated modeling framework
- Analysis of scenarios using AIM/CGE (Asia) and AIM/Enduse
  - AIM/CGE: A top down computable general equilibrium model
  - AIM/Enduse: A bottom up partial equilibrium model

Bottom Up Modeling Approach for Non CO_2 Gases

- Bottom Up analysis using the AIM/Enduse model
  - AIM/Enduse models energy and materials through detailed representation of technologies
  - Based on a linear optimization framework where system cost is minimized under several demand and supply constraints
  - The model is being structured to include Non CO_2 gas emission sectors and linking to removal processes
  - Current work includes developing cost and technology database for emission sources and removal processes .

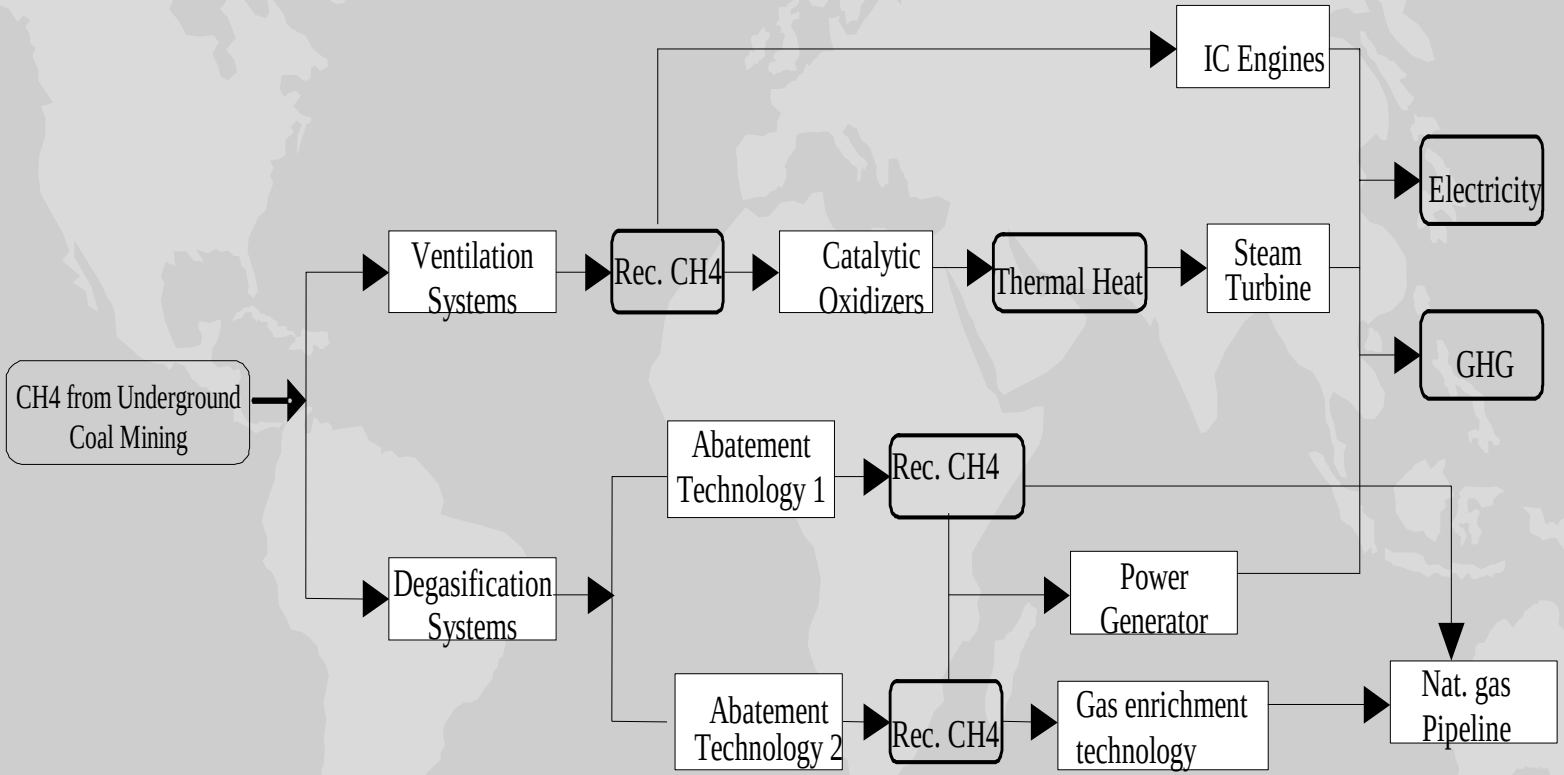
Modeling Emission Sources and Removal Processes

- Most studies currently on Non CO_2 gases are long term economic analysis of independent projects
- The major sources of cost and technological information for Bottom Up analysis include
  - USEPA reports (costs mainly pertain to those prevailing in Developed countries)
  - Studies by the European Commission, IPCC reports
  - Estimates from sector experts in Developing countries (India), for developing country analysis
- The above sources provide information for linking Non CO_2 emission sources to removal processes

Emission Sources and Removal Processes

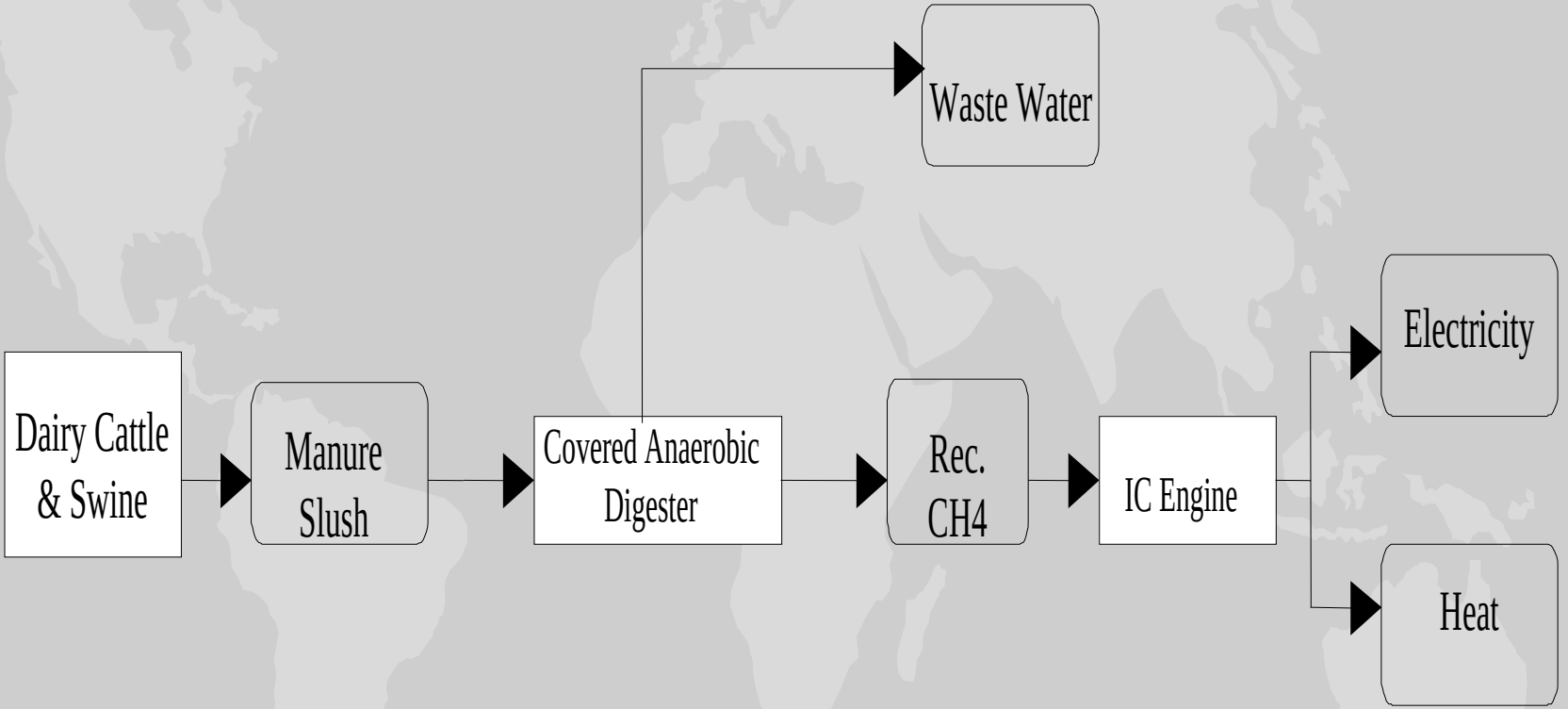
Emission source (CH_4)	Emissions in 2000 (MMTCE)	Driving force	Removal process considered
Coal Sector	123	Coal consumption	Degasification and pipeline injection
Enteric Fermentation	476	Livestock population	Partial replacement of Roughages with Concentrates
Manure Management	61	Livestock population	Anaerobic digester technology
Solid Waste Management	213	Urban human population	Landfill gas to electricity
Natural Gas sector	244	Natural gas consumption	Better maintenance of equipments and replacement of devices
Paddy	177	Area under cultivation	Under discussion

Emission Sources and Removal Process Linkage



Coal sector emissions and linkages to removal processes

Emission Sources and Removal Process Linkage



Dairy sector emissions and linkages to removal processes

Emission Sources and Removal Process Linkage (Soft technology options)

- Enteric CH_4
  - Partial replacement of roughages with concentrates
  - Improved Genetics with Improved Level of Feed Intake
- Rice CH_4 Emissions
  - Changes in drainage systems to reduce anaerobic conditions
  - Replace urea with ammonium sulfate (AS)
- Soil N_2O Mitigation Options
  - More uniform spreading of fertilizer to increase efficiency
  - Avoid fertilizer loss by leaving fertilizer free zone at field edges

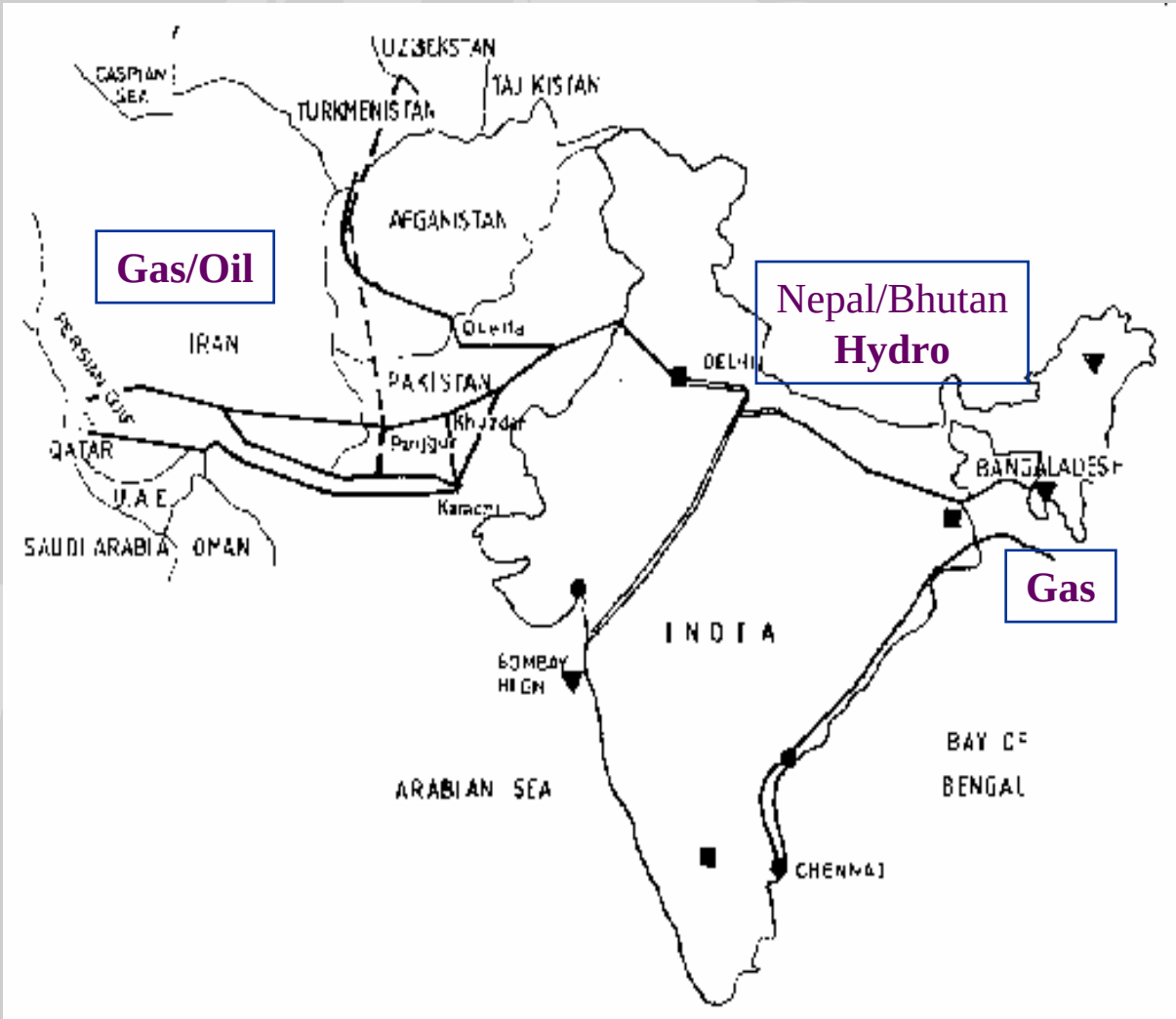
Future Agenda

- Building South Asian Regional Cooperation Scenario…….

Regional Energy-Electricity Markets

Energy Markets

- Gas
- Coal
- Electricity
- Hydro (Elec./Water)



Why South-Asia Energy-Electricity Market Integration?

- **Diversity of Energy Resources among countries**
  - India relies on poor quality domestic coal
  - Bangladesh has reserves of Natural Gas
  - Nepal and Bhutan have Hydro power potential
  - Sri Lanka needs to import fuel for power
  - Pakistan has an important role as a transit state
- **Little Energy/ Electricity Trade in the Region**

Regional Cooperation Scenarios

- **Capture benefits of cooperation through comparing**
  - Reference case Sceneraio

    vis-à-vis
  - Medium cooperation scenario

    vis-à-vis
  - Strong cooperation scenario
- **The cooperation scenarios differ in terms of the strength of the cooperation regimes defined by the ability to overcome existing barriers to cooperation**

Conclusion: The AIM framework for South Asian Analysis

- **AIM/CGE**
  - Energy emission scenarios for the South Asian region.
- **AIM/Enduse**
  - Linking AIM/Enduse with Top Down analysis for more robust Non CO_2 GHG analysis
- **AIM/Trend**
  - Results would help set up a regional model for analyzing South Asian regional cooperation scenarios.

Thank You