AIM/Material Model
1. Modified Structure
2. India Application

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Part 1: Modified Structure

- Need for application to countries with limitations of dataset
- APEIS training workshop in Delhi

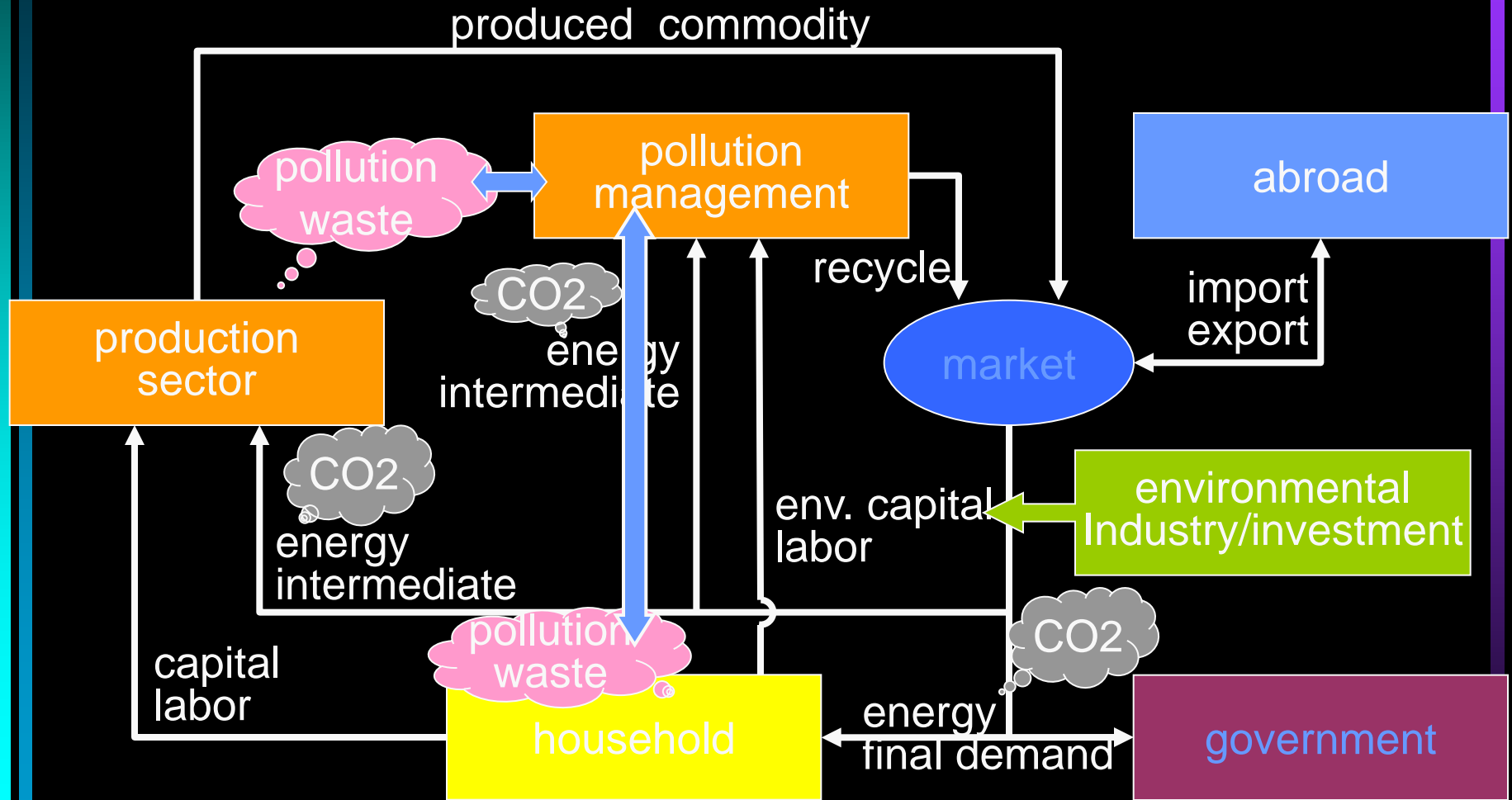**AIM/Material Model**
Features, model and necessary data

Toshihiko MASUI and Ashish RANA
National Institute for Environmental Studies

Session 4: Asia Pacific Integrated Model (AIM):
Introduction to Component Models (Cont.)

APEIS Capacity Building Workshop on
Integrated Environment Assessment in the Asia Pacific Region

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Hotel Grand Inter-Continental, New Delhi, India

Structure of AIM/Material Model

Modifications

- Waste management sector is unified
- Import matrix not used

- Possible to include natural resources sectors
  - Presentation of Dr. Masui in next session

Formulation of AIM/Material

			Production sector			Final Consumption	Investment			Supply	Price	Endowment
			Sector 1	Sector 2	Sector 3		Sector 1	Sector 2	Sector 3			
Input	Intermediate inputs	Commodity 1	X_{11}	X_{12}	X_{13}	C_1	I_{11}	I_{12}	I_{13}	$Y_{11}+Y_{21}+Y_{31}$	P_1	
		Commodity 2	X_{21}	X_{22}	X_{23}	C_2	I_{21}	I_{22}	I_{23}	$Y_{12}+Y_{22}+Y_{32}$	P_2	
		Commodity 3	X_{31}	X_{32}	X_{33}	C_3				Y_{33}	P_3	
		Capital	K_1	K_2	K_3						P_K	K^*
		Labor	L_1	L_2	L_3						P_L	L^*
		Final disposal			W_3						P_W	W^*
Output		Commodity 1	Y_{11}	Y_{21}	Y_{31}						P_1	
		Commodity 2	Y_{12}	Y_{22}	Y_{32}						P_2	
		Commodity 3			Y_{33}						P_3	

Formulation of AIM/Material

- ## Market equilibrium
  - ### Produced commodity

$$P_i \left\{ \sum_{j=1}^{3} Y_{ji} - \left(\sum_{j=1}^{3} X_{ij} + C_i + \sum_{j=1}^{3} I_{ij} \right) \right\} = 0$$

$$P_i \geq 0$$

$$\sum_{j=1}^{3} Y_{ji} - \left(\sum_{j=1}^{3} X_{ij} + C_i + \sum_{j=1}^{3} I_{ij} \right) \geq 0$$

  - ### production factor (capital, labor, …)

$$P_K \left\{ K^* - \sum_{j=1}^{3} K_j \right\} = 0, \ P_K \geq 0, \ \text{and} \ K^* - \sum_{j=1}^{3} K_j \geq 0$$

$$P_L \left\{ L^* - \sum_{j=1}^{3} L_j \right\} = 0, \ P_L \geq 0, \ \text{and} \ L^* - \sum_{j=1}^{3} L_j \geq 0$$

$$P_W \left\{ W^* - \sum_{j=1}^{3} W_j \right\} = 0, \ P_W \geq 0, \ \text{and} \ W^* - \sum_{j=1}^{3} W_j \geq 0$$

Formulation of AIM/Material

- ## Balance of production sector

$$\sum\nolimits_{i=1}^{3} P_i X_{ij} + P_K K_j + P_L L_j + P_W W_j = \sum\nolimits_{i=1}^{3} P_i Y_{ij}$$

- ## Balance of final demand sector

$$H = P_K \sum\nolimits_{j=1}^{3} K_j + P_L \sum\nolimits_{j=1}^{3} L_j + P_W \sum\nolimits_{j=1}^{3} W_j$$

$$H = \sum\nolimits_{i=1}^{3} P_i (C_i + \sum\nolimits_{j=1}^{3} I_{ij})$$

- ## Capital stock and investment
  - ### for dynamics

$$K_{j,t+1} = (1 - \delta_j) K_{j,t} + \sum\nolimits_{i=1}^{3} I_{ij}$$

Formulation of AIM/Material

- **Relationship between input and output**
  - – **Production function**
  - – **Demand function**

     CES, Leontief, Cobb-Douglas, Linear, …

- **Household: Maximize utility**

- **Production sector: Maximize profit**
  ➔Find equilibrium solution

Dataset for AIM/Material Model

- IO table (commodity x commodity)
- U matrix (commodity x sector)
  - Disaggregate pollution management
- V matrix (sector x commodity)
- Investment by sector
  - Disaggregate pollution management
- Pollution flow by sector
  - Generation, treatment, discharge, recycle, …
- Supply and demand of reused material

IO/U/V/investment/
pollution/reuse

Input-Output table

household consumption, government consumption, investment, export

	commodity 1	...	commodity i	final demand	total output
commodity 1					
:					
commodity i					
value added					
total output					

Distribution of produced commodity to production of commodity and final demand is presented.

In order to produce commodity, what kind of inputs and how much of them are necessary.

IO/U/V/investment/
pollution/reuse

U matrix (Use matrix)

	sector 1	…	sector j	final demand	total output
commodity 1					
:					
commodity i					
value added					
total output					

Distribution of produced commodity
to sectors and final demand
is presented.

What kind and how much
of input for production activity
are necessary in sector.

IO/U/V/investment/
pollution/reuse

Revised U matrix
(disaggregate production and pollution management)

	sector j				
	production	management of pollution a	...	management of pollution p	total
commodity 1					
comm...					original U matrix
value added					
total output					

Data of original U matrix are disaggregate into production and pollution management.

IO/U/V/investment/
pollution/reuse

V matrix (Make matrix)

	commodity 1	…	commodity i	total output
sector 1				
:				
sector j				
total output				

How much of commodity i
produced by sector j
is represented.

IO/U/V/investment/
pollution/reuse

Investment by sector

	commodity 1	…	commodity i	total investment
sector 1				
:				
sector j				
total output				

How much of commodity invested to sector j.

IO/U/V/investment/
pollution/reuse

Pollution flow by sector

Pollution type

- **Air pollution: SOx, NOx, CO2, ...**
- **Water pollution: BOD load, COD load, ...**
- **Solid waste: sludge, scrap metal, slag, ...**
- **Other:**
  - **Toxic waste: Pb, dioxin, ...**

IO/U/V/investment/
pollution/reuse

Supply and demand of reused material

	commodity 1		commodity i	total generation of reused pollution
pollution a				
pollution p				
total supply of reused commodity				

How much of pollution/waste
can be supplied as commodity i.

IO/U/V/investment/
pollution/reuse

Supply and <u>demand</u> of reused material

	sector 1		sector j	total supply of reused pollution
commodity 1				
commodity i				
total demand of reused commodity				

How much of recycled commodity i can be demanded in sector j.

Optional Data
for AIM/Material Model

- ## Energy balance table
  - ### Link physical data from energy balance table and monetary data from U matrix

- ## Other physical material data
  - ### Raw materials such as wood, paper, steel, ...
  - ### Link these physical data and monetary data

Not yet completed

Scenarios for AIM/Material Model

- ## Technology change
  - Energy efficiency, pollution generation, pollution management, recycled material input, and so on for new equipment (investment)
- ## Labor force
- ## Export and export
- ## Preference change
 - Final consumption, investment, …

Application of AIM/Material Model

- **Economic impacts due to environmental preservation**
  - CO2 reduction (Kyoto target), waste reduction, waste water treatment, ...
- **Mitigation by countermeasures**
  - Environmental investment, preference change, new technology, tax reform, CDM, ...
- **Link with bottom up model such as AIM/Emission**
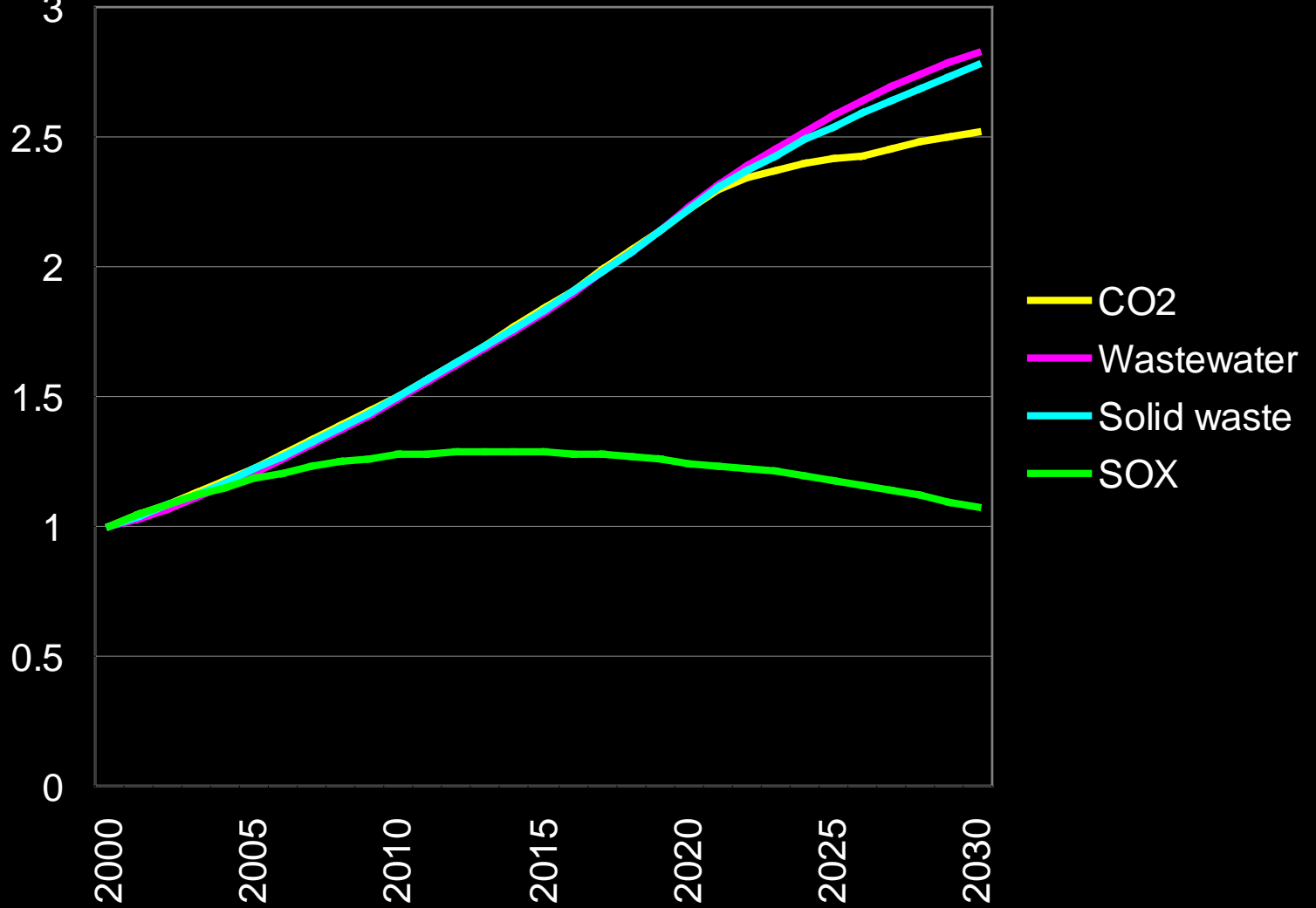
Part 2: Application to India

- Sectors
  - From 26 commodities, 24 sectors
  - To 40 commodities, 33 sectors
- Electricity sector
  - Disaggregated
- Pollutants
  - Wastewater
  - Sox
  - CO2
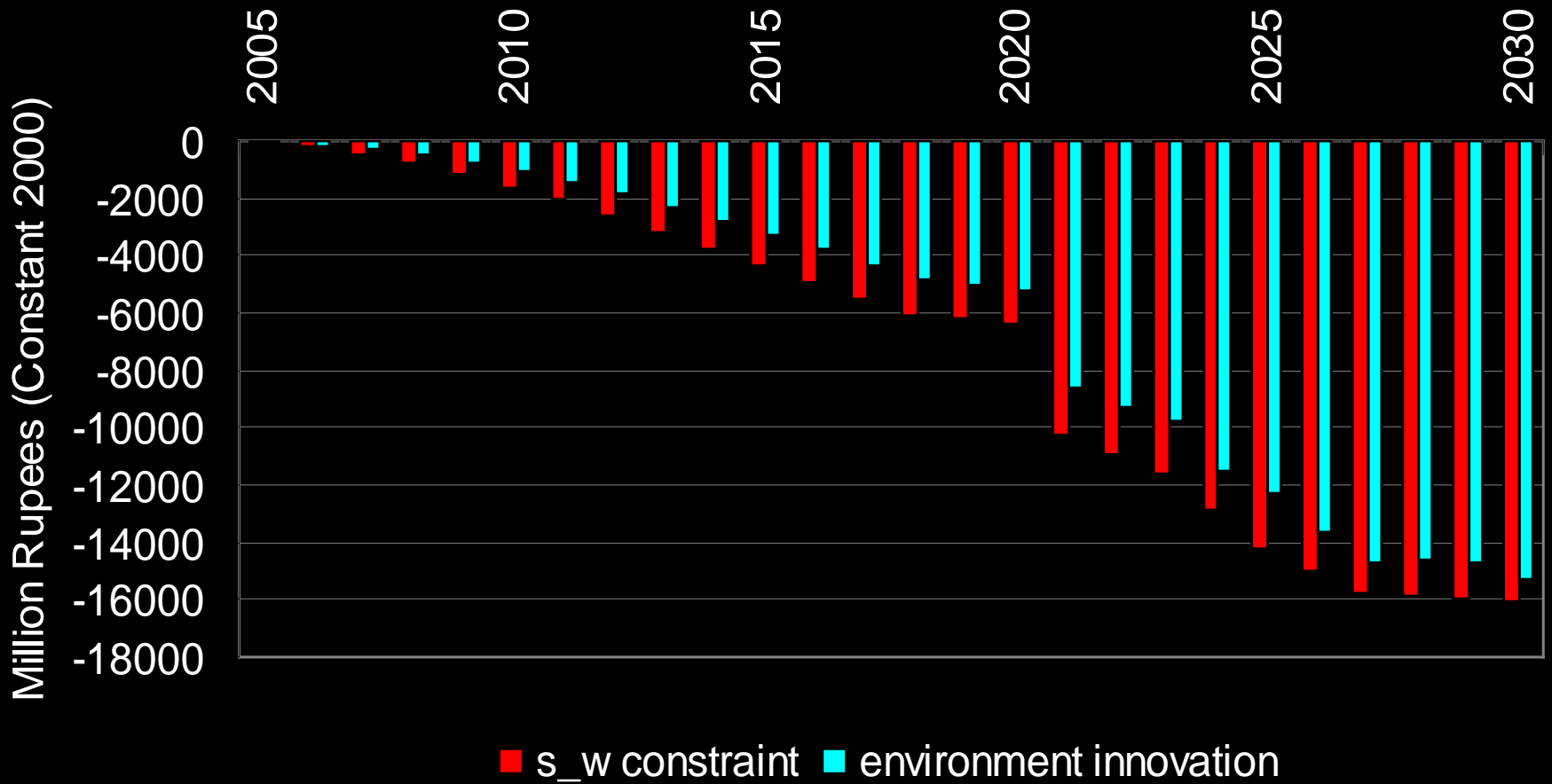 - Solid waste
- Time period – till 2030

Baseline trends
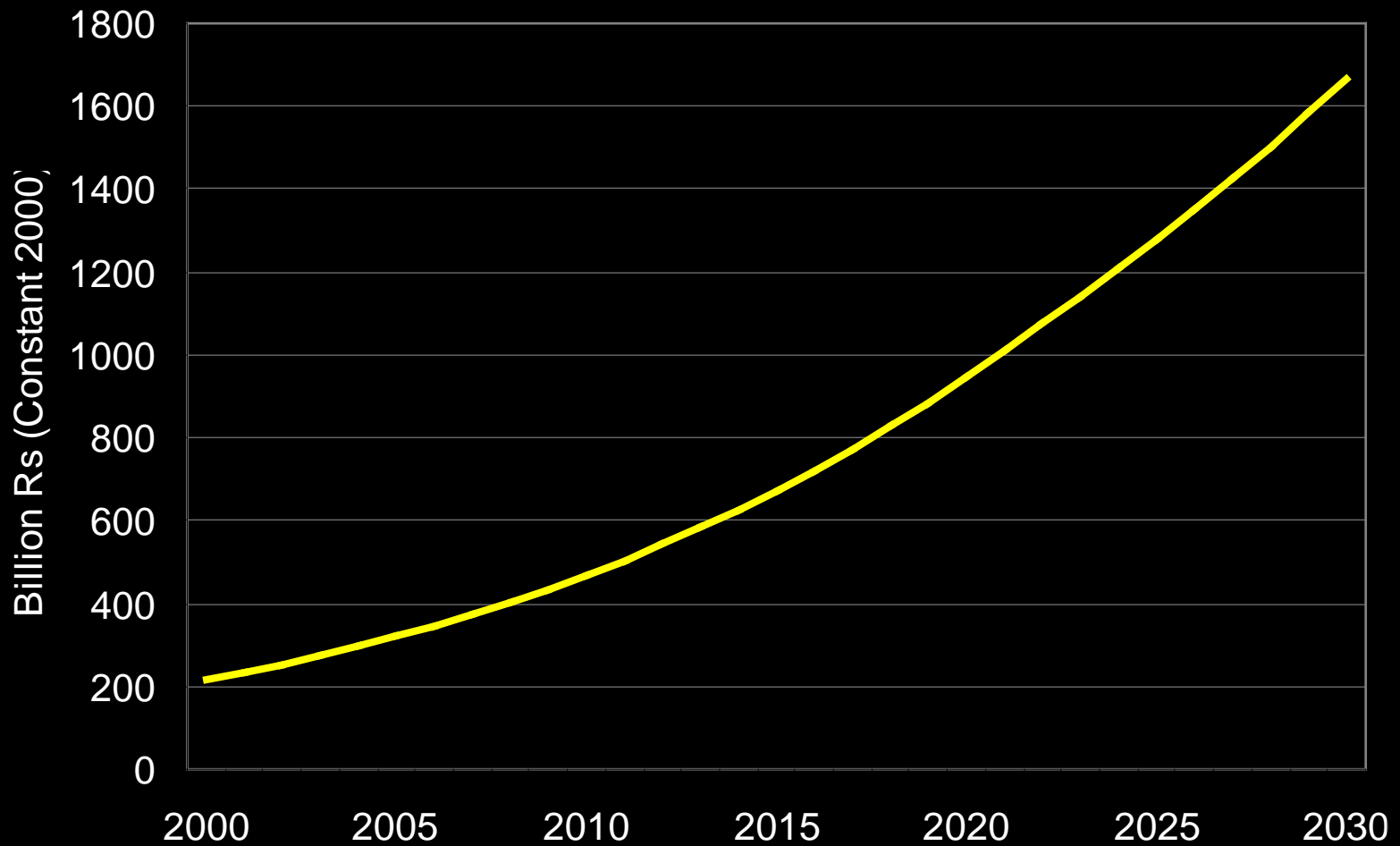
Baseline trends

Scenarios

GDP Change over baseline

Future works of AIM/Material

- Part 1: Modification
  - Application to other countries
- Part 2: Application to India
  - New scenarios of environmental innovation
  - CDM scenarios
  - Link to bottom-up model