New Activities of Emission Modeling

Integration of Climate Change Policy & Solid Waste Treatment Policy

Toshihiko MASUI

National Institute for Environmental Studies

6th AIM International Workshop

NIES

27-28 March, 2001

Object of New Model Analysis

Evaluation of effects of **environmental policies** for both **global environmental problems** (climate change, ...) and **domestic environmental problems** (solid waste, air pollutant, water pollutant, ...) on **economic activities** and **material balance**

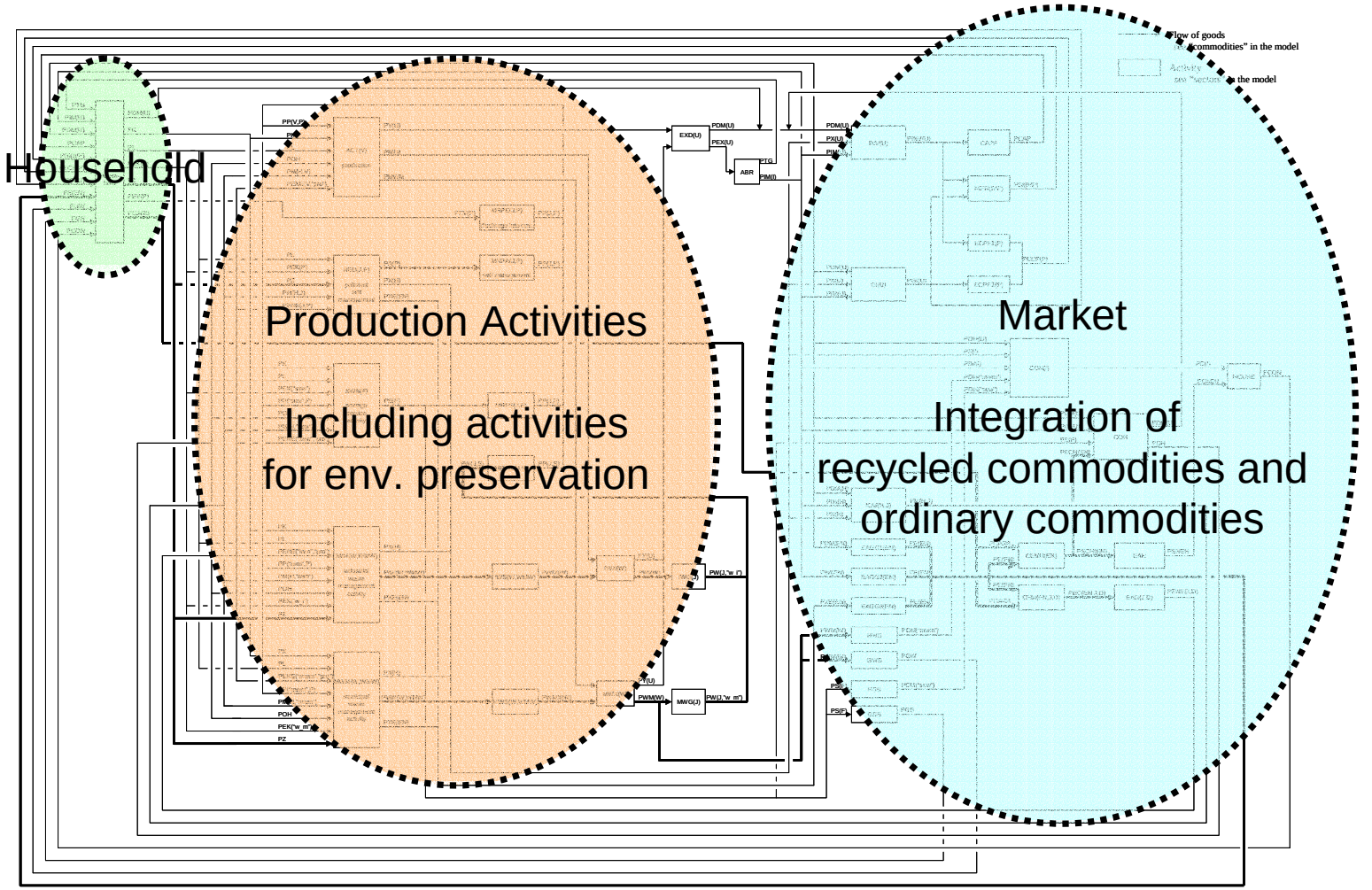
Past & Present of This Analysis

		Activities on AIM Workshop
• 1998	Analysis using dynamic optimization model (EJOR; 15 sectors & 11 wastes)	
• 1999	Construction of recursive model (IGES; 32 sectors & 18 wastes)	Introduction of environmental-economic linkage model **end-use module** **economic module** **material balance module**
• 2000	Preliminary Analysis on Policy (JSCC; 33sectors & 18 wastes)	Introduction of recursive economic model and its preliminary results
• 2001	⇒Future directions	Introduction of modification of economic model and its analysis

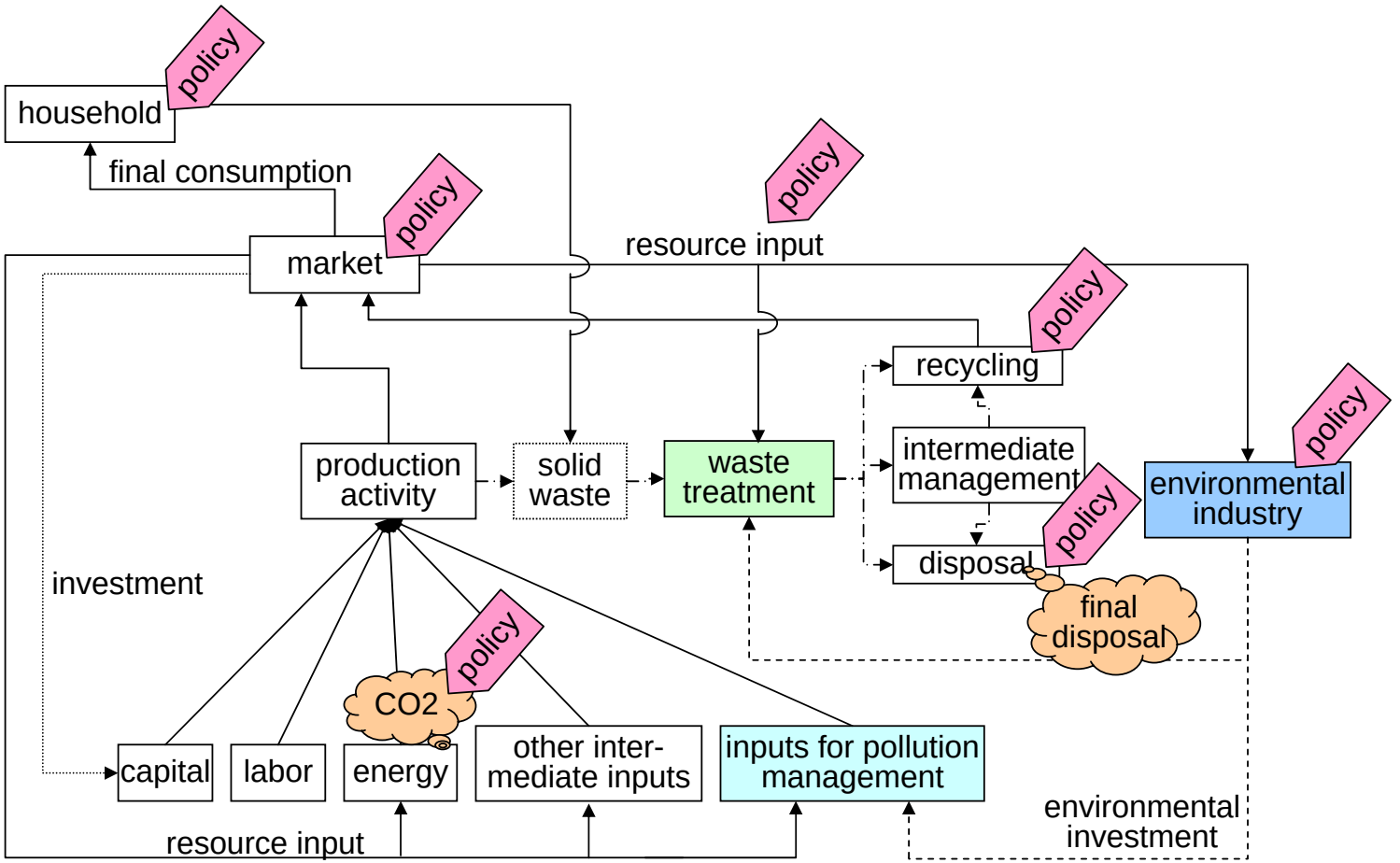
Overview of Economic Model

- Computable General Equilibrium Model
- Recursive Dynamics
- Pollutant Generation and Treatment
  - Pollutant is regarded as "**bads**"
- Environmental Constraints:
  - CO2 Emissions
  - Final Disposal of Solid Wastes
- 33 Sectors, 31 Commodities, and 18 Solid Waste

Model Flow (Sorry too Small!)



Model Overview



Economic Sectors & Commodities

ID	contents	ID	contents
AGR	agriculture, forestry and fisheries	WTR	collection, purification and distribution of water
MIN	mining	SAL	wholesale and retail trade
FOD	manufacture of food	FIN	finance and insurance
TEX	manufacture of textile mill products	EST	real estate
PLP	manufacture of lumber, wood products, pulp, paper and paper products	TRS	transportation and communications
		SRV	services
CHM	manufacture of chemical and allied products	GOV	government service
NMM	manufacture of ceramic, stone, and clay products	NPS	non-profit institution services
BMT	manufacture of iron, steel, non-ferrous metals and products	EMC	manufacture of equipment for environmental preservation
		SEW	sewage service
FMT	manufacture of fabricated metal products	MWM	municipal waste treatment service
MCH	manufacture of general machinery	IWM	industrial waste treatment service
ELM	manufacture of electrical machinery, equipment and supplies	COL	coal mining and manufacture of coal products
		OIL	crude oil production and manufacture of petroleum
TRE	manufacture of transportation equipment	GAS	natural gas production and manufacture of gas
PRI	manufacture of precision instruments and machinery	THE*	thermal power generation
		HYD*	hydro power generation
OTH	miscellaneous manufacturing industries	NUC*	nuclear power generation
CNS	construction	ELE**	electricity

*: only sector, and **: only commodity.

Treated Solid Wastes

ID	Contents
ASH	ash
SLD	sludge
WOL	slush, waste oil
WAC	waste acid
WAL	waste alkali
WPL *	waste plastics
WPP *	waste paper
WWD *	waste wood
WTX *	waste fiber and textile
WAP *	animal and plants wastes
WRB *	waste rubber
SCM *	metal trash, scrap metal
WGC *	waste glass
SLG	slag
WCT	construction and demolition waste
DST	dust, soot
EXC	animal excrement
CRC	animal carcass

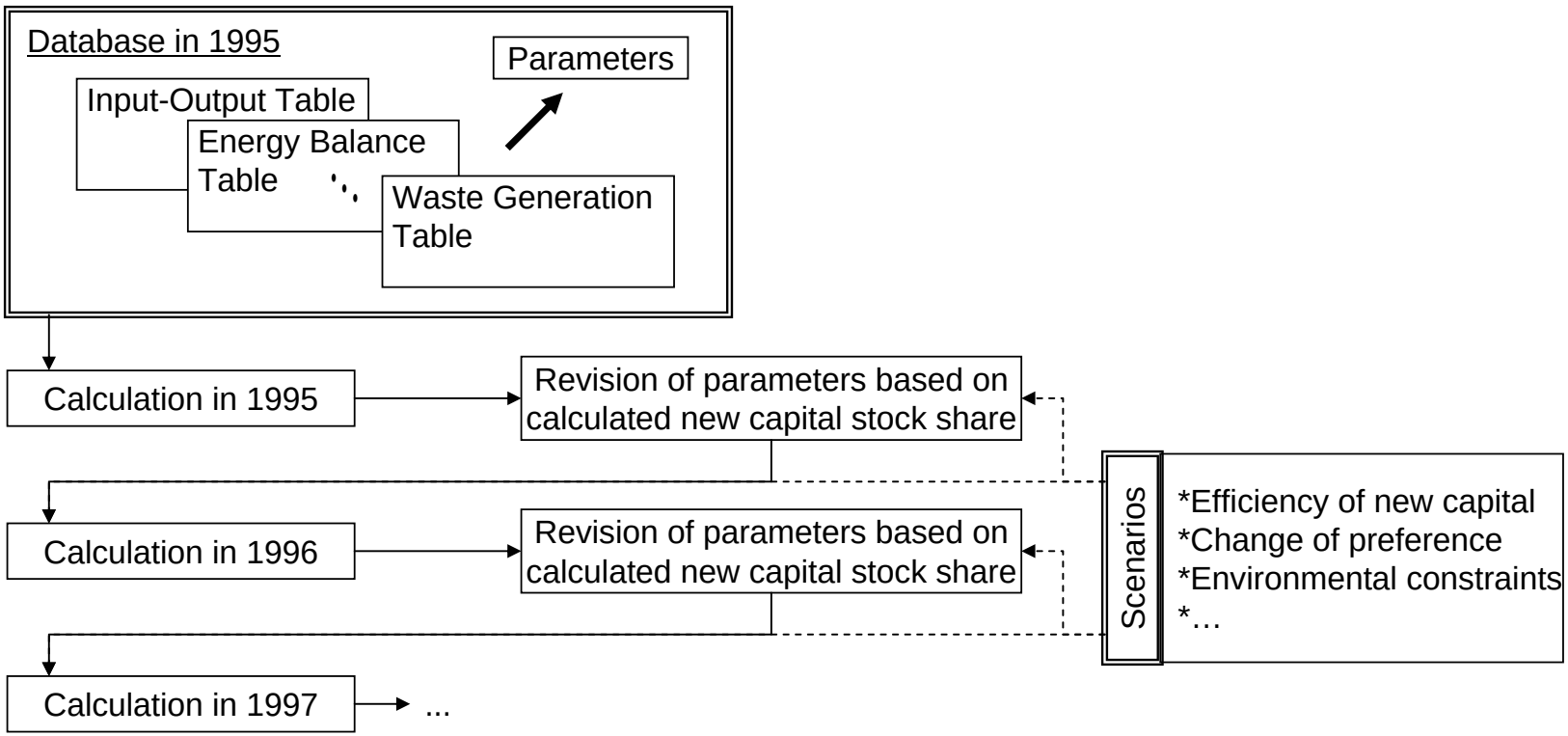
*: category of municipal waste.

Modification since Last Year

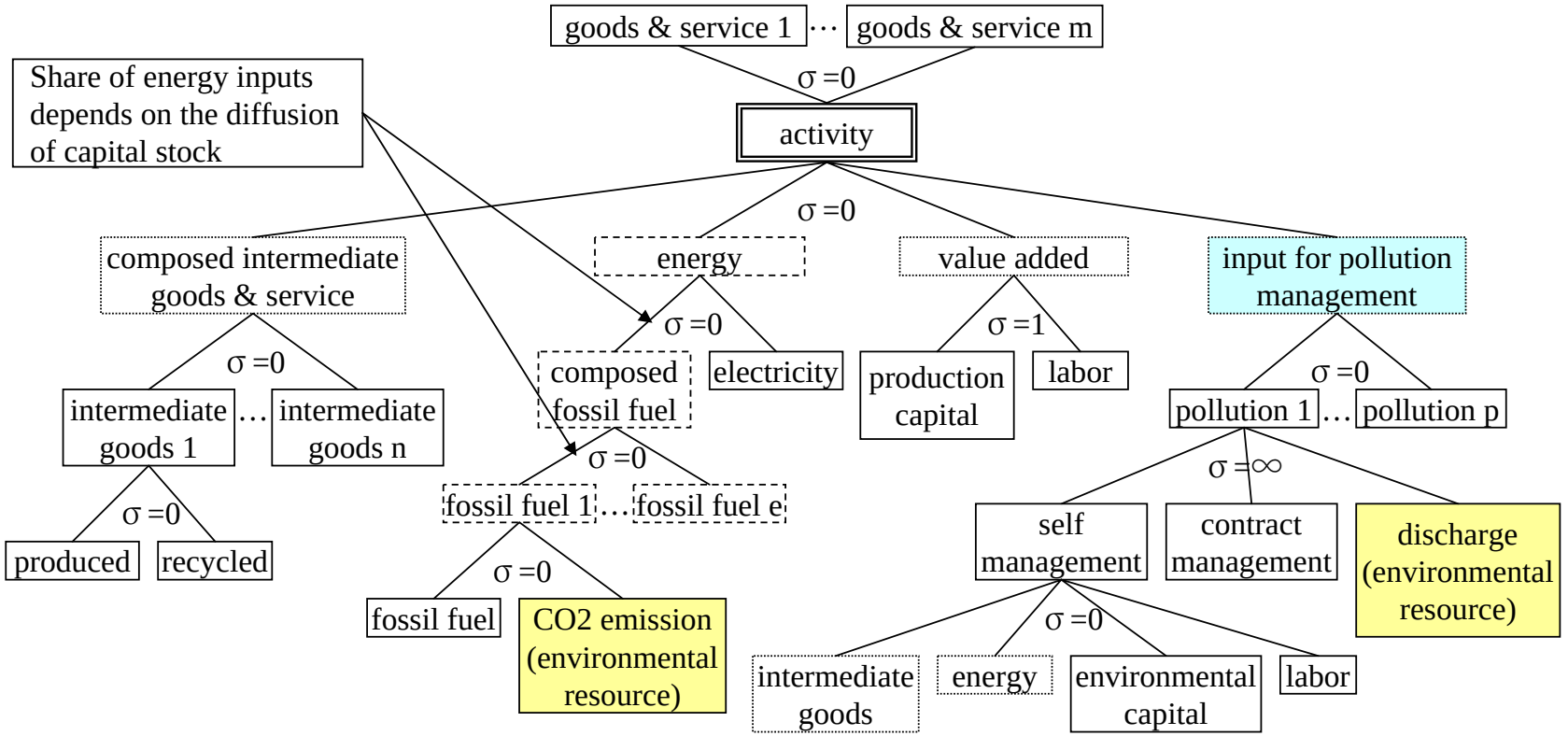
- Base Year: 1990 ⇒ 1995
  - Revision of Database
- Time Step: 5 years ⇒ 1 year
- Efficiency Improvement:

  Exogenous ⇒ Change by New Capital Formation
- Taxation: Not Expressed ⇒ Expressed
- Capital Stock: Whole Sector ⇒ Individual Sector
- Material Balance: Inconsistent ⇒ Consistent
- English Manual: Nothing ⇒ Ver. 0 (almost finished)

Simulation and Parameters Modification



Production Structure of CGE Model



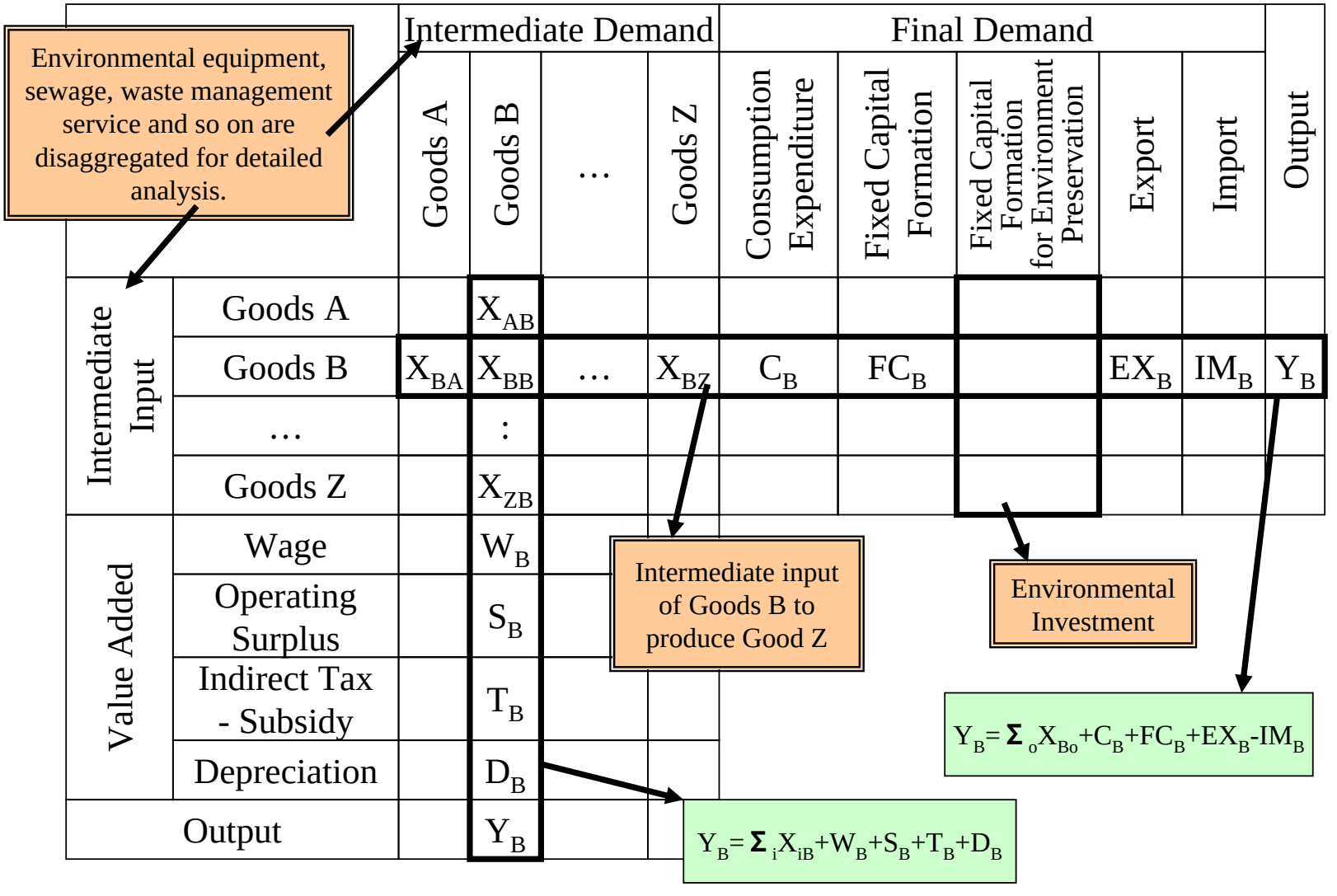
σ：elasticity of substitution

Necessary Datasets for Model Development

- Input-output table
  - Environmental industries are disaggregated for detailed analysis.
- Energy balance table
- Pollutant generation, emission & reduction
- Solid waste flow
  - Quantity of solid waste generation, management, disposal, and recycle
- Input for pollutant management
  - Including not only environmental investment but also energy, labor, and other inputs for pollutant management.
- Make matrix
  - This matrix should be prepared when joint products[*1] are modeled.

[*1] **joint products**: technologically inseparable products ex. town gas and coke

Necessary Data (1) –Input-output Table



Necessary Data (2) –Energy balance table

Energy balance table is used for estimation of energy related pollutant generation such CO2, SOx.

		Energy Type				
		Energy 1	Energy 2	:	Energy e	Total
Primary Energy	Indigenous Production					
	Imports					
	:					
Transfer	Petroleum Refineries					
	Electricity					
	:					
Final Consumption	Sector A					
	Sector B					
	:					
	Residential (Household)					

Energy type is at least classified into energy goods in IO table.

Sector classification is the same as that in IO table.

Necessary Data (3) –Pollutant generation, reduction & emission

Sector classification is the same as that in IO table.

Treated pollutants depend on the analysis.

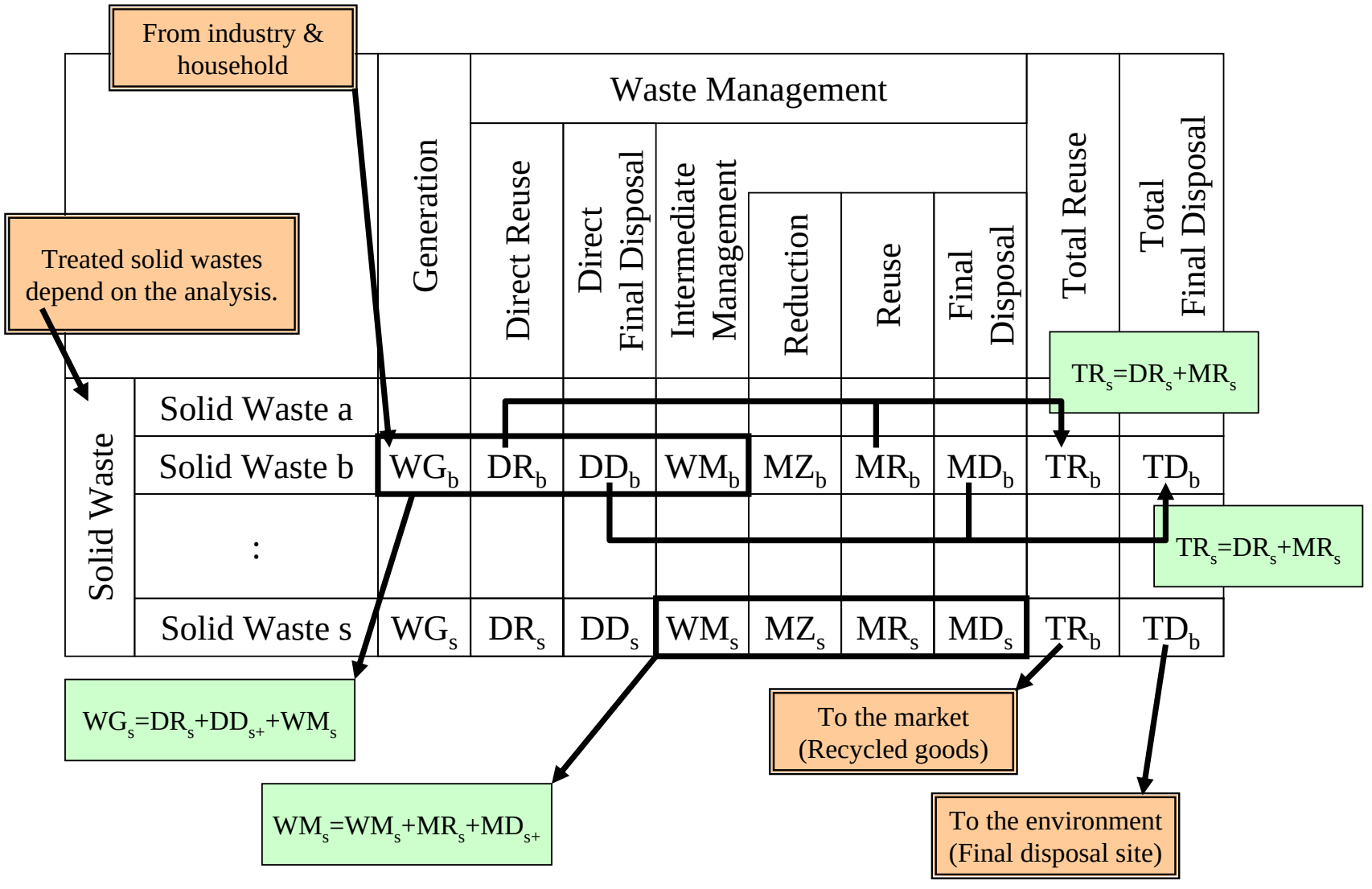
		Industrial Sector				Household	Total
		Sector A	Sector B	…	Sector Z		
Pollutant a	Generation	G_{Aa}	G_{Ba}	…	G_{Za}	G_{Ha}	G_{TOTa}
	Self Reduction	SR_{Aa}	SR_{Ba}	…	SR_{Za}	SR_{Ha}	SR_{TOTa}
	Contract Reduction	CR_{Aa}	CR_{Ba}	…	CR_{Za}	CR_{Ha}	CR_{TOTa}
	Emission	E_{Aa}	E_{Ba}	…	E_{Za}	E_{Ha}	E_{TOTa}
…		…	…	…		…	
Pollutant p	Generation	G_{Ap}	G_{Bp}	…	G_{Zp}	G_{Hp}	G_{TOTp}
	Self Reduction	SR_{Ap}	SR_{Bp}	…	SR_{Zp}	SR_{Hp}	SR_{TOTp}
	Contract Reduction	CR_{Ap}	CR_{Bp}	…	CR_{Zp}	CR_{Hp}	CR_{TOTp}
	Emission	E_{Ap}	E_{Bp}	…	E_{Zp}	E_{Hp}	E_{TOTp}

$G_{TOTp} = \Sigma_i G_{ip} + G_{Hp}$

$G_{ip} = SR_{ip} + CR_{ip} + E_{ip}$

To the environment

Necessary Data (4) –Solid waste flow



Necessary Data (5) –Input for pollutant management

		Sectors							
			Sector B						
		Sector A	Total	Production	Pollutant a	…	Pollutant p	…	Sector Z
Intermediate Input	Goods A		X_{AB}	X_{ABY}	X_{ABa}	…	X_{ABp}		
	Goods B	X_{BA}	X_{BB}	X_{BBY}	X_{BBa}	…	X_{BBp}	…	X_{BZ}
	…		:	:	:		:		
	Goods Z		X_{ZB}	X_{ZBY}	X_{ZBa}	…	X_{ZBp}		
Value Added	Wage		W_B	W_{BY}	W_{Ba}	…	W_{Bp}		
	Operating Surplus		S_B	S_{BY}	S_{Ba}	…	S_{Bp}		
	Indirect Tax - Subsidy		T_B	T_{BY}	T_{Ba}	…	T_{Bp}		
	Depreciation		D_B	D_{BY}	D_{Ba}	…	D_{Bp}		
Output			Y_B	Y_{BY}	Y_{Ba}	…	Y_{Bp}		

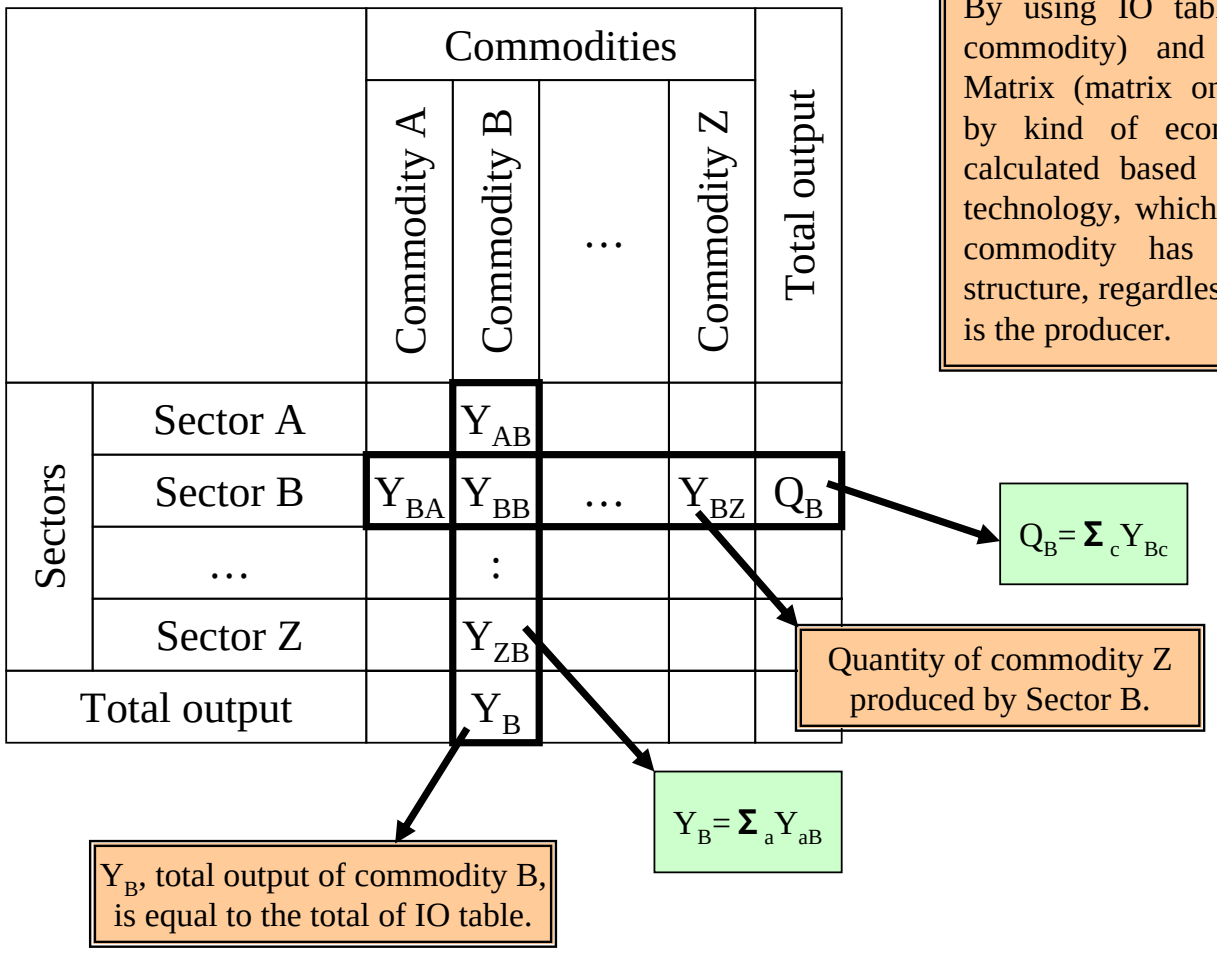
Each sector is disaggregated into sub sectors such as production and pollutant self management.

$X_{io} = \Sigma_p X_{iop} + X_{ioY}$

Output of pollutant sub sector is equal to the quantity of self reduced pollutant

$Y_{Bp} = \Sigma_i X_{iBp} + W_{Bp} + S_{Bp} + T_{Bp} + D_{Bp}$

Necessary Data (6) –Make matrix



By using IO table (commodities x commodity) and make matrix, U Matrix (matrix on commodity input by kind of economic activity) is calculated based on the commodity technology, which assumes that each commodity has its typical input structure, regardless of which industry is the producer.

Simulations

1. Evaluation of Environmental Policies

   Recycled paper, low emissions vehicle, and environmental investment for waste management

2. Evaluation of Production Activity Change

   Increase of reused material input share

3. End-use Model for Waste Management

   Sewage sludge treatment

Environmental constraints

CO2 constraint: Kyoto Target (CO2 emissions in 2010/1990 ⇒ 6 % reduction)

Final disposal site: Government Target (Quantity of final disposal in 2010/1996 ⇒ 50% reduction)

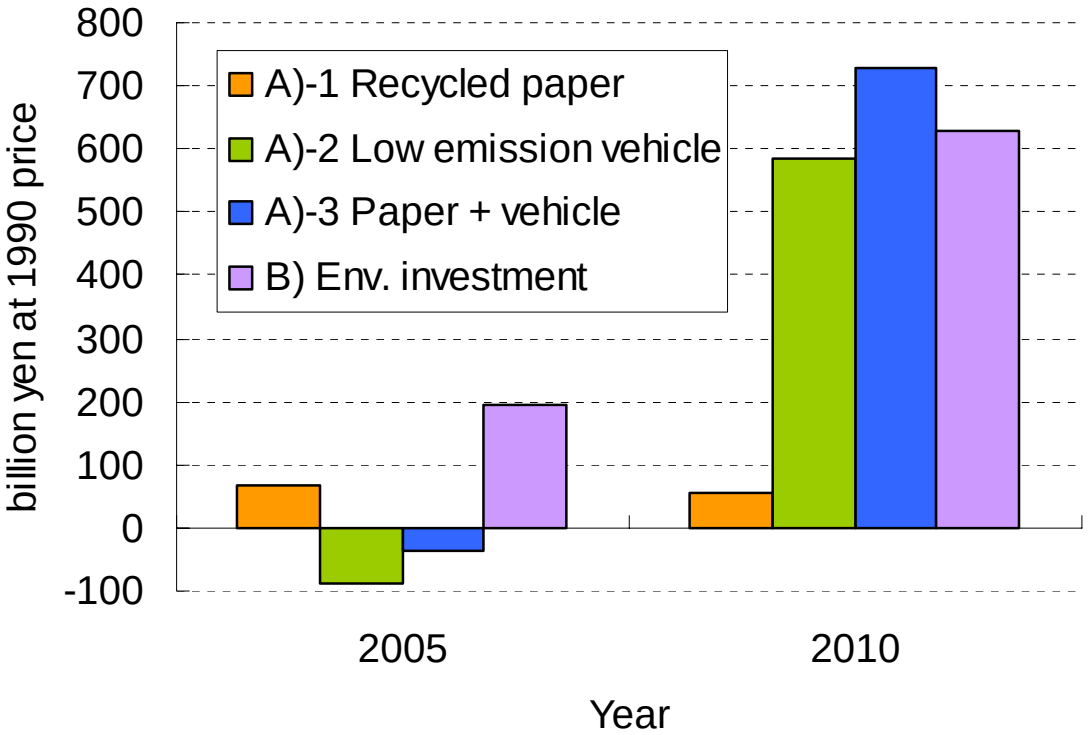
Simulation Results 1(1)

1. Evaluation of Environmental Policies
   A) Enhancement of demand of recycled paper and low emissions vehicle
   B) Enhancement of environmental investment to solid waste management

Background: Operation of several law for enhancement of demand of recycled commodities

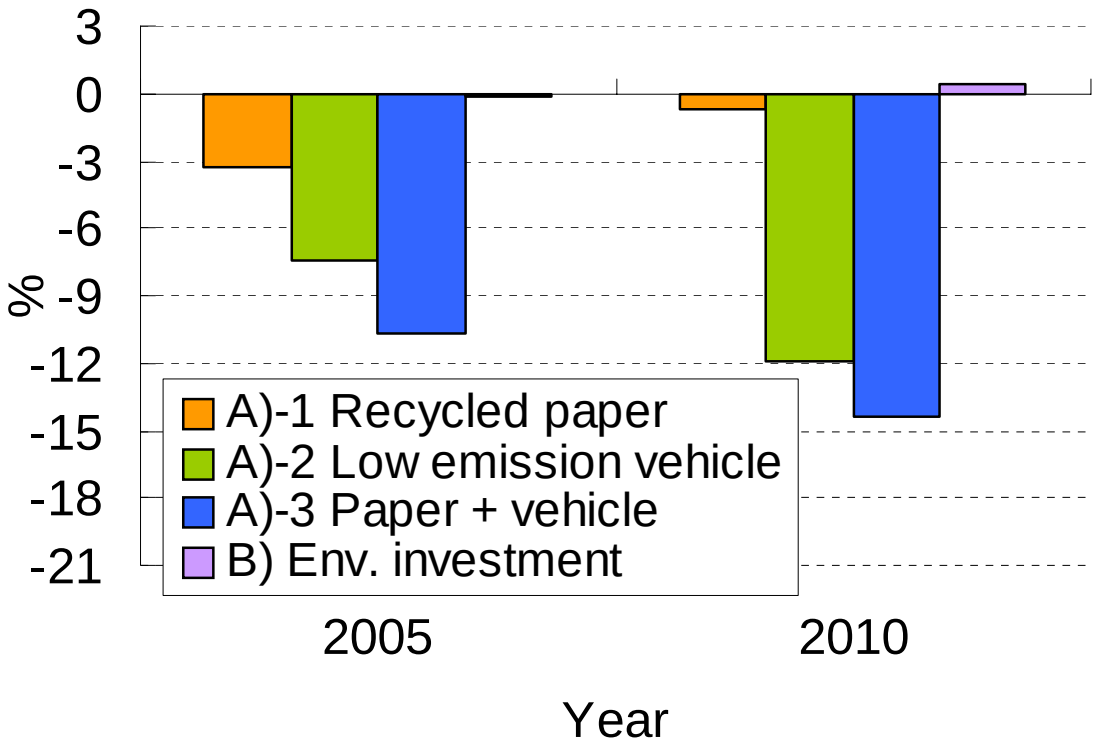
Simulation Results 1(2)

GDP Changes from No Policy Case



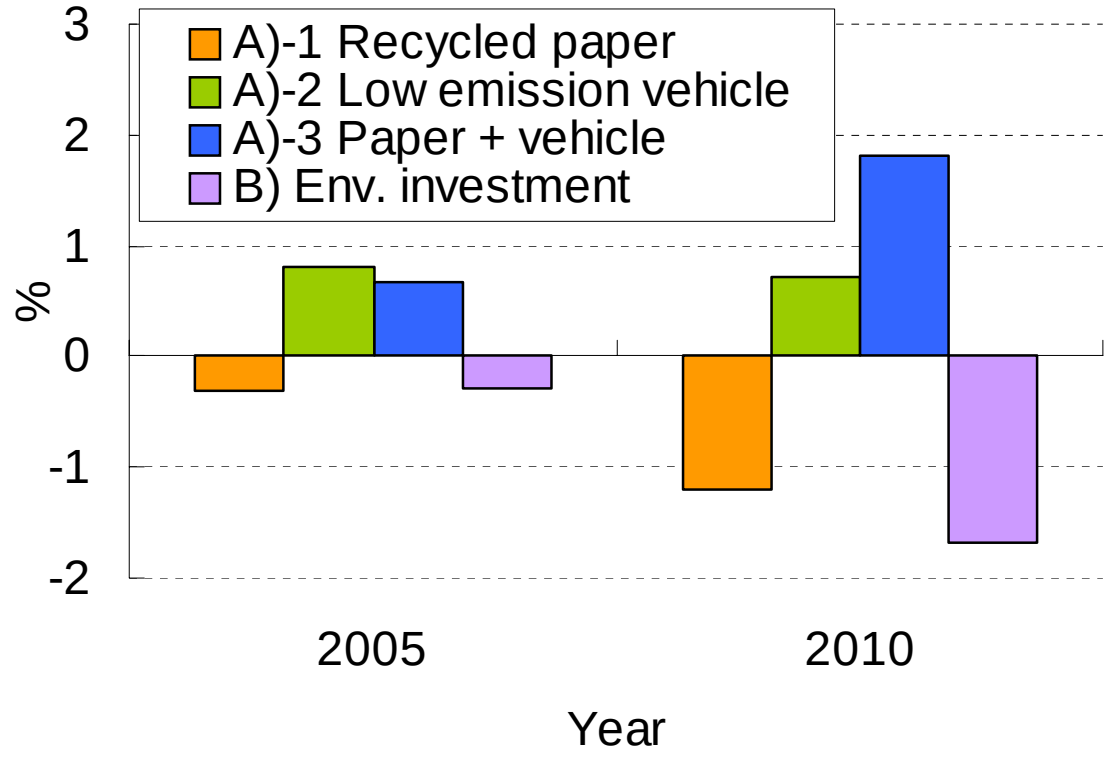
Simulation Results 1(3)

Change of CO2 emissions costs from No Policy Case



Simulation Results 1(4)

Change of final disposal costs from No Policy Case



Simulation Results 2(1)

2. Evaluation of Production Activity Change
   A) Expansion of share of recycled material input
   B) Increase of waste collection cost
   C) Introduction of waste power generation

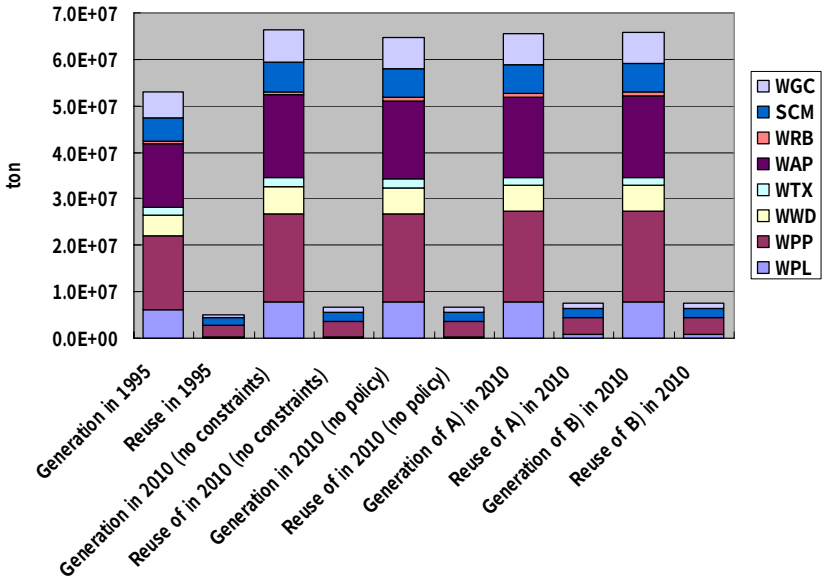
Background:

- Targets of material reuse by government and business organization
- Uncertainty of recycling activities –collection cost, additional cost, …

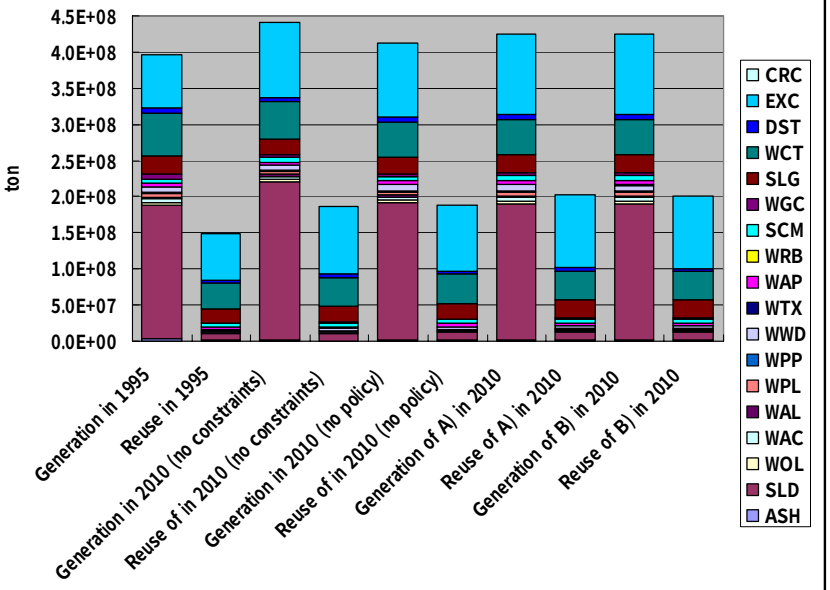
Simulation Results 2(2)

Change of Waste Treatment

Municipal waste

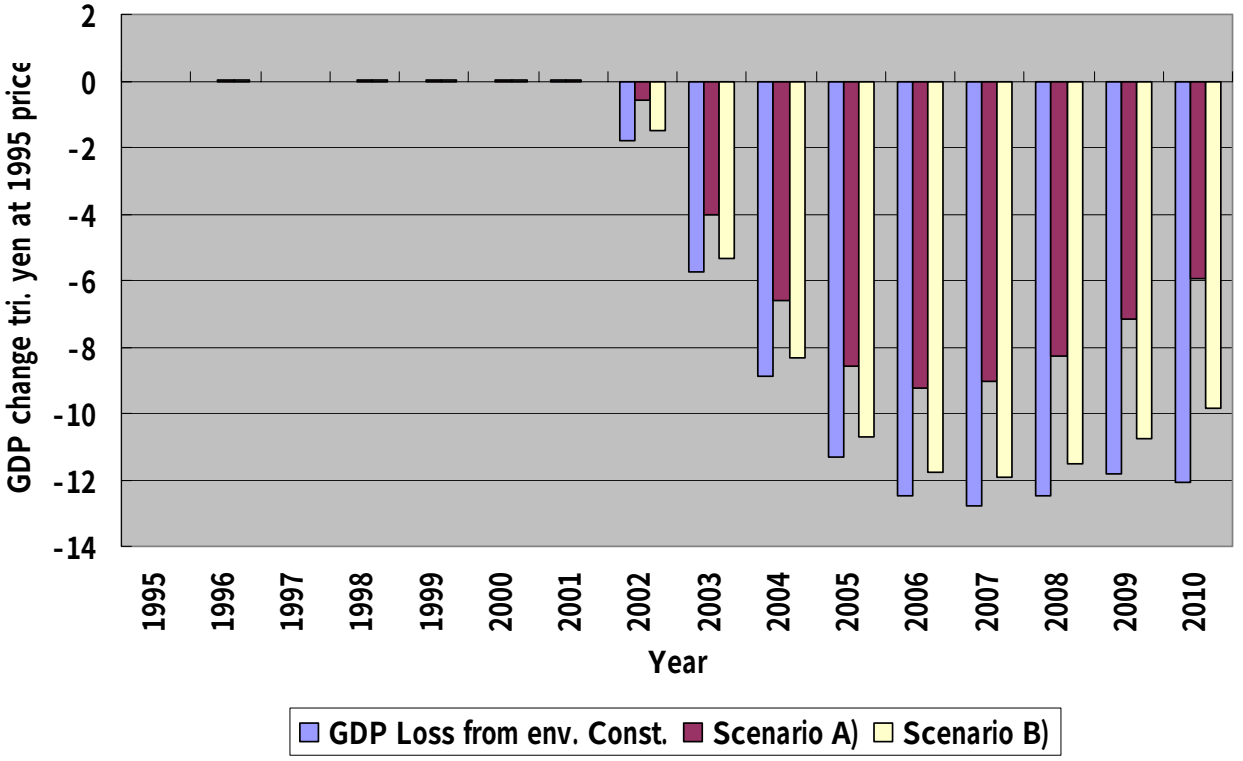


Industrial waste



Simulation Results 2(3)

GDP Change

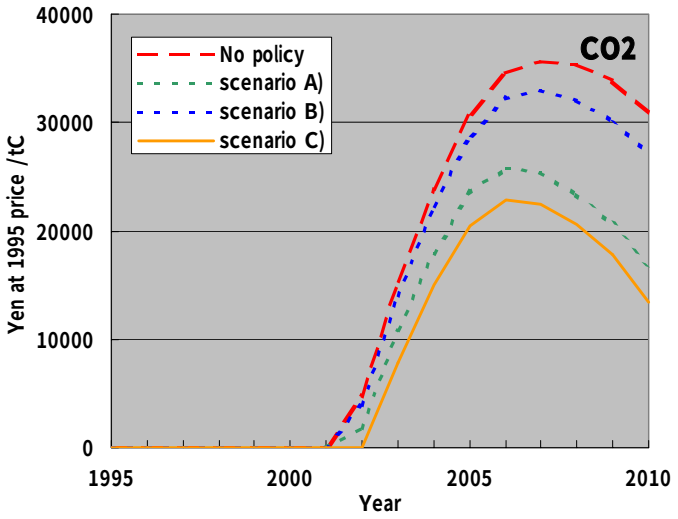


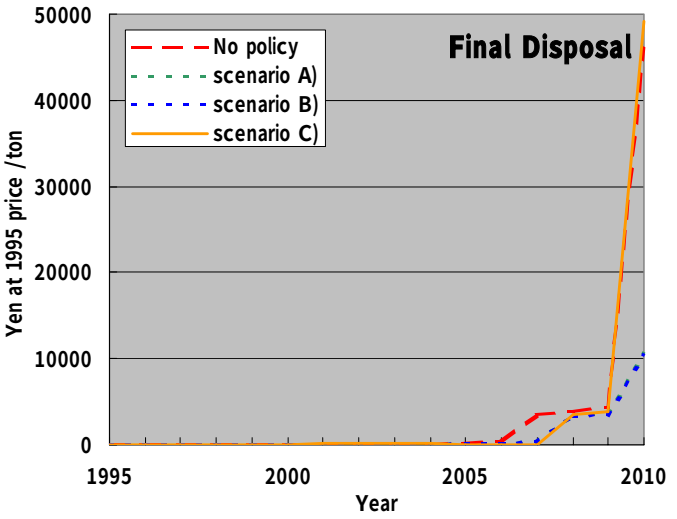
Simulation Results 2(4)

GDP Change in each sector (2010/1995)

Simulation Results 2(5)

Marginal cost of CO2 and final disposal





Simulation Results 3(1)

End-use model construction

- Sewage sludge* treatment from 1997 to 2026
- 26 technologies for treatment
- Minimization of total treatment cost

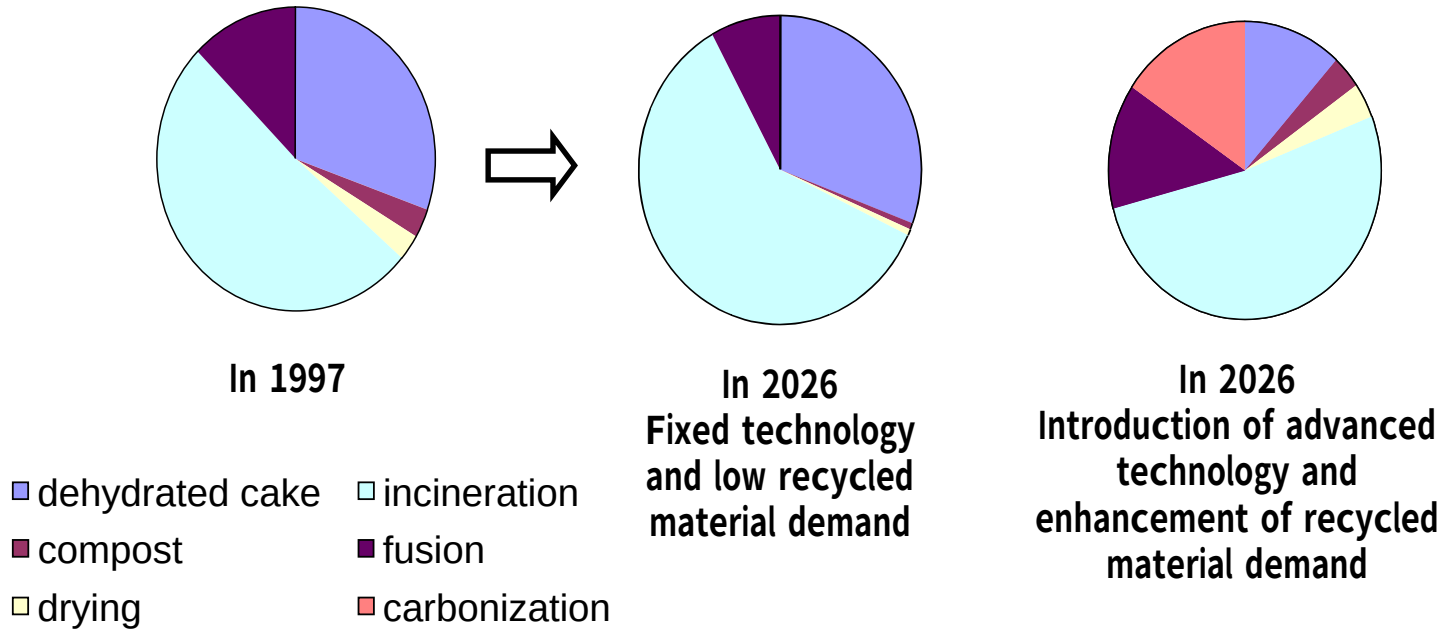
  subject to upper limit of quantity of final disposal and material recycling demand

* Volume of sludge is 36 % of final disposal.

Background: Parameter modification by technology change

Simulation Results 3(2)

Change of technology share



Future Directions

- Separation of some sectors
  - Recycled paper, electric furnaces of crude steel, ...
- Separation of intermediate treatment of solid wastes
  - Incineration for reduction / other treatments for recycling
- Apply this model to AIM collaboration countries
  - Modification of model for wide use
  - Application to India with Dr. Rana
- Apply to Material Balance Analysis
  - Steel, paper, wood, carbon, ...
- Integration with Bottom-up Model
  - AIM end-use model / energy efficiency
  - Waste treatment technology model / solid waste treatment