AIM and the role of models: what can they be used for?

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1. A brief introduction of AIM

- AIM(Asian Pacific Integrated Model) is a group of computer models developed by a team composed of NIES(National Institute for Environmental Studies), Kyoto University, and several research institutes in the Asian-Pacific region.
- The objective of AIM is to design and assess policy options for stabilizing the global climate, particularly in the Asian-Pacific region.
- Internationally, AIM has been used as a core tool for developing IPCC scenarios conducted by UN. Many members of AIM team have been deeply involved to IPCC process, as CLA or LAs.
- Also, the assessments conducted by AIM gave influential impacts on the real actual processes;

  1) to determine national GHG reduction targets and in the implementation process, in Japan,

  2) to assess national and regional feasible reduction potential of GHG emissions in China, India, and several local regions in Asian countries

2. What we are now doing, ...

In order to realize Asian Low Carbon Developments (LCD),

1. We are focusing on domestic and international factors which control the realization of Asian LCD,
2. Describing the development, accumulation, and deepening of factors which control LCD with multi-layered, spatial, and integrated quantification models/tools,
3. Applying quantification models/tools to various Asian regions,
4. Taking account of regional distinctive diversified characteristics,
5. And designing positive Asian low carbon societies and roadmaps for LC development, in each region with a back-casting methodology.

3. What are the Asian Low Carbon Development, we expected?

By the middle of this century (2050), the target societies will satisfy the followings;

1. Harmonized with drastically changing future Asian society and economy,
2. Complying with national development targets, under the global, national and regional constraints on fossil and renewal energy resources, land resource, as well as GHG emission
3. Promoting LCD policies based on each region's characteristics ,
4. Also utilizing effectively co-benefits of LCD policies and related policies.

4. Modeling

Development, maintenance and application of multi-layered modeling system

Two groups of models and tools have been developed and applied.

(1) Quantification tools encompassing various spatial scales and disciplines, operated complementary
e.g. **global, country, and regional (city) scales, energy, economical, demographical, industrial, building, transportation systems, etc.**

(2) Integration models/tools which link the above models towards low carbon development visions and roadmaps.

4. Modeling

Up to now, we developed nine national/local scale models for quantifying national development processes related with energy consumption, landuse change their management etc. (*Element models*)

1. ***AIM/enduse:*** National and local level bottom-up engineering type model for energy supply/consumption
2. ***Macro-economy model (EME):*** Supply-side type mid-term econometric model
3. ***Population/Household dynamics model (PHM):*** to describe each country's demographic dynamics
4. ***House and building dynamics model (BDM):*** to describe transition and renovation dynamics towards modern and highly insulated buildings.
5. ***Traffic demand model (TDM):*** to describe passenger and freight transports coupled with economic activity and urban structure
6. ***Material stocks and flow model (MSFM):*** to describe material metabolism towards low material societies
7. ***Energy supply model (ESM):*** to describe scenarios of biomass production, power infrastructure development
8. ***Household production and lifestyle model (HPLM):*** to describe the transition of household consumption, lifestyle etc.
9. ***AFOLU model (AFOLU):*** to describe GHG emissions caused by AFOLU sectors.

Integrated models/tools for describing and evaluating LC development process

- ***AIM/CGE:*** CGE model. One/multi-regional multi-sectoral type. Integration platform with which element models are soft-linked/hard-linked according to analytical objects.

- ***Extended snapshot tool (ExSS):*** Input-Output type model. A tool to designing social accounting matrices, energy balance tables, landuse transition matrix, GHG emission and reduction tables of the target societies. Multi-regional static model.

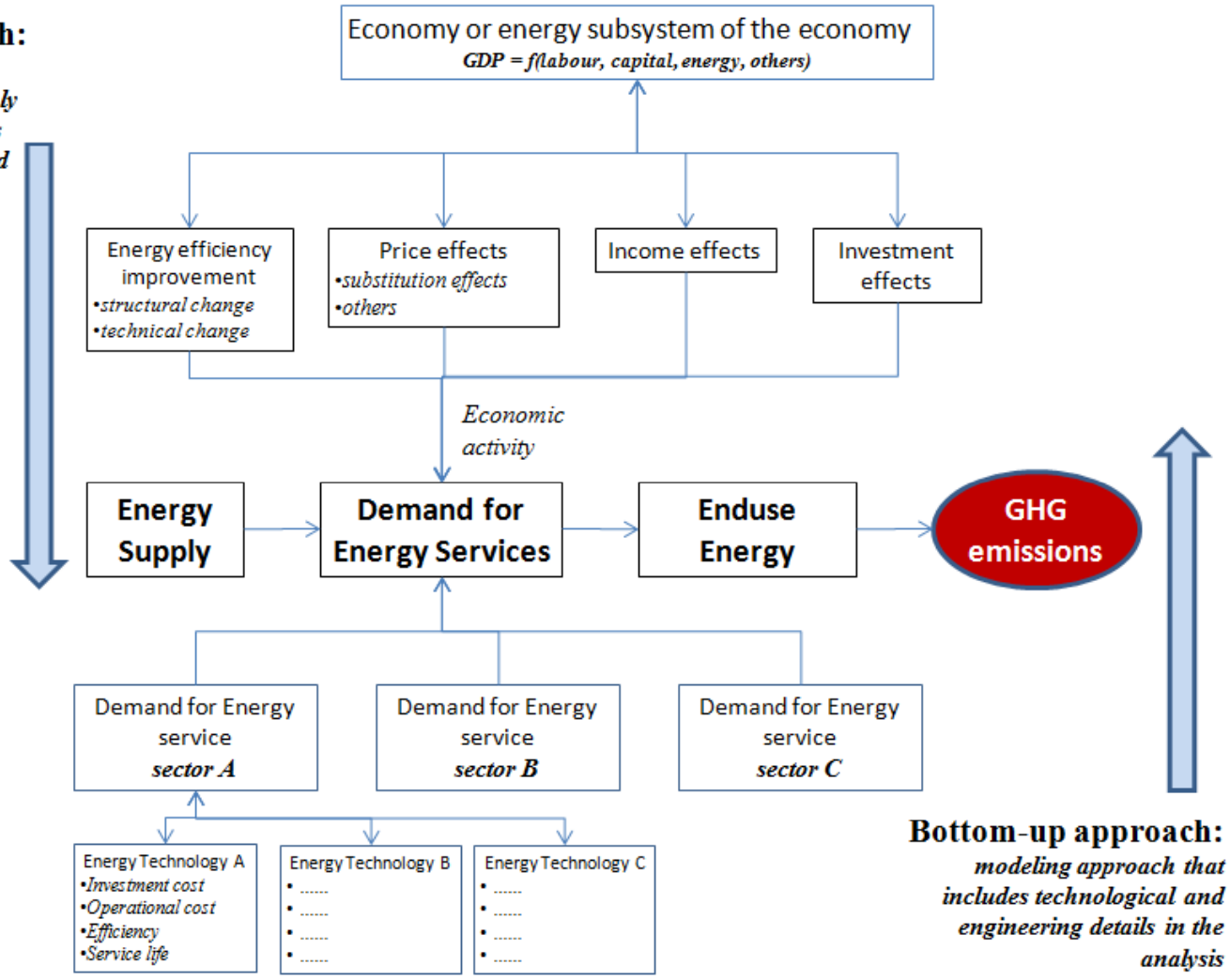
- ***Back-casting model/Tool (BCM/BCT):*** Input-Output type dynamic optimization model. A model for designing roadmaps towards low carbon societies.

Typology of models for LCD

Type of model		Explanation	AIM familly	Other models/study
Abatement Cost Curve analysis		No explicit modelling structures; simply assess the costs of different technological options to reduce GHG emissions	AIM/Enduse[MAC]	McKinsey's ACC
Bottom-up models	Accounting type	Listing up externally prescribed GHG emission activities and summing up the associated GHG emission caused by the activities	AIM/Snapshot	STAIR, LEAP
	Sectoral optimization type	Technology-oriented models which minimize the total costs of the system,often applied to energy system including all end-use sectors, and compute a partial equilibrium for the markets. The costs include investment and operation costs of all sectors based on a detailed representation of factor costs and assumptions about GHG emission taxes	AIM/Enduse, AIM/AFOLU	MARKAL, MESSAGE
Top-down models	Input-Output type	Describing complex interrelationships among economic sectors using sets of simultaneous linear equations. The coefficients of equations are generally fixed, which means that factor substitution, technological change, and behavioural aspects related to climate change mitigation policies cannot be assessed. However, recent models, especially in ExSS, these restrictions are fully relaxed.	ExSS (Extended Snapshot)	TEESE
	Computable General Equilibrium (CGE)	Considering simultaneously all the markets in an economy,and calculating the conditions which permit their simultaneous equilibriums. The models typically simulate markets for factors of production (e.g., labour, capital, energy),products, and foreign exchange, with equations that specify supply and demand behaviour, under various LCD policies.	AIM/CGE	SGM, ENVISAGE
Hybrid of bottom-up and top-down models		Coupling of Bottom-up type and top-down type module	AIM/CGE[basic]	MERGE, IMACLIM-R

Top-down and Bottom-up approach

Top-down approach:
modeling approach that proceeds from broad, highly aggregated generalizations to functional disaggregated details



Bottom-up approach:
modeling approach that includes technological and engineering details in the analysis

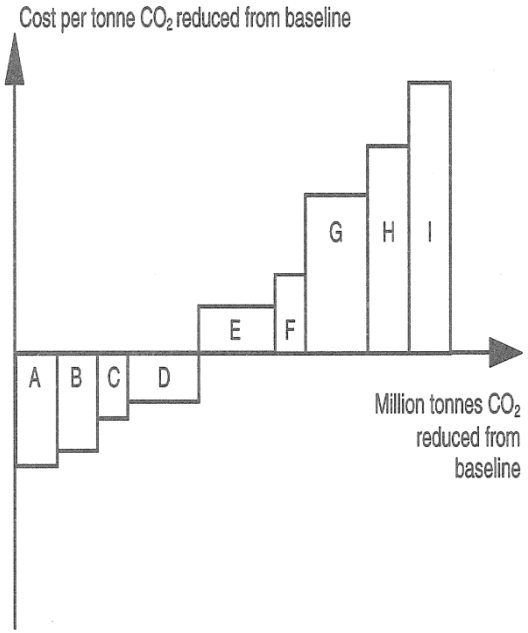
Modified based on "Mapping the energy future", IEA, 1998

Strengths and Weaknesses of Abatement Cost Curve analysis

e.g. AIM/Enduse[MAC], McKinsey's ACC

Key Features and Assumptions	Strengths	Weaknesses
▪ To identify specific cost-efficient technologies and GHG abatement options	▪ Allow ranking of specific options according to cost-effectiveness criteria	▪ No consistent view of the energy and economic system
▪ Compare selected GHG abatement options (e.g. fuel substitution policies)	▪ Help set priorities among GHG abatement options	▪ Fail to consider the timing and interaction of GHG abatement options
▪ Collect technology-specific data to evaluate mitigation options individually	▪ Have simple and transparent structures and input assumptions	▪ Ignore economic transaction costs, which can be significant

Modified based on "Mapping the energy future", IEA, 1998



Strengths and Weaknesses of Bottom-up (accounting type) models

e.g. AIM/Snapshot, STAIR, LEAP

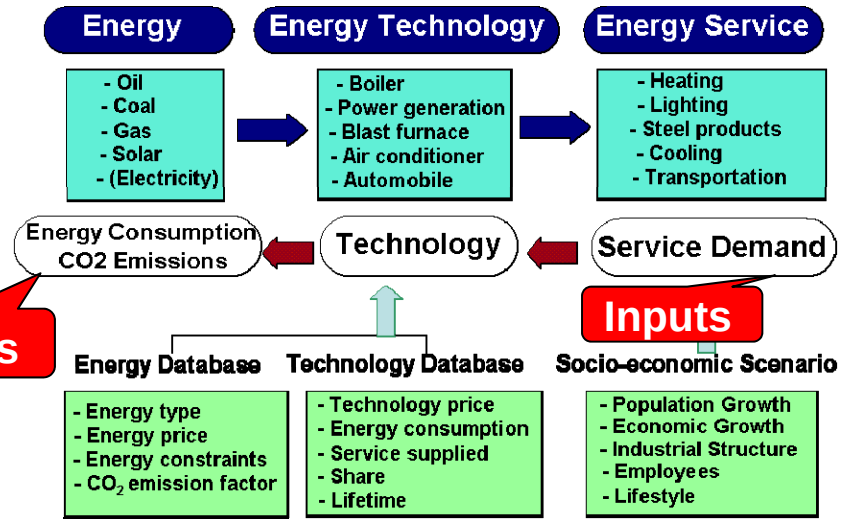
Key Features and Assumptions	Strengths	Weaknesses
▪ Listing up externally prescribed GHG emission activities and suming up the associated GHG emission caused by the activities	▪ Require less data and expertise, spreadsheet programs are sufficient	▪ Macroeconomic factors are considered only as inputs in deriving demand-side
▪ Relation between GHG emission activities and emission quantities are simply discribed by fixed coefficients	▪ Simpler and easier to use than optimization models	▪ No explicit representation of feedback to the overall economy. ▪ Cannot generate a least-cost mitigation solution

Strengths and Weaknesses of Bottom-up (sector optimization) models

e.g. AIM/Enduse, AIM/AFOLU, MARKAL, MESSAGE

Key Features and Assumptions	Strengths	Weaknesses
▪ Choice of the most efficient mix of technologies to deliver services	▪ In case of energy sector, provide a comprehensive, coherent picture of the energy system (from primary energy to final energy and energy services use)	▪ Neglect feedback effects of emission reduction policies on the rest of the economy
▪ Rich collection of related data, abundant in detail on various technologies and countermeasures	▪ Useful for assessing and identifying mitigation and efficiency potentials	▪ Do not capture demand-price interactions
▪ Perfect foresight· simulates perfect competition among technologies and energies	▪ Enable assessment of supply and demand-oriented policies to curb GHG emissions	▪ Undervalue the transaction costs of mitigation policies
		▪ Assume that markets react perfectly to price signals

Modified based on "Mapping the energy future", IEA, 1998



Structure of the AIM/End-Use Model

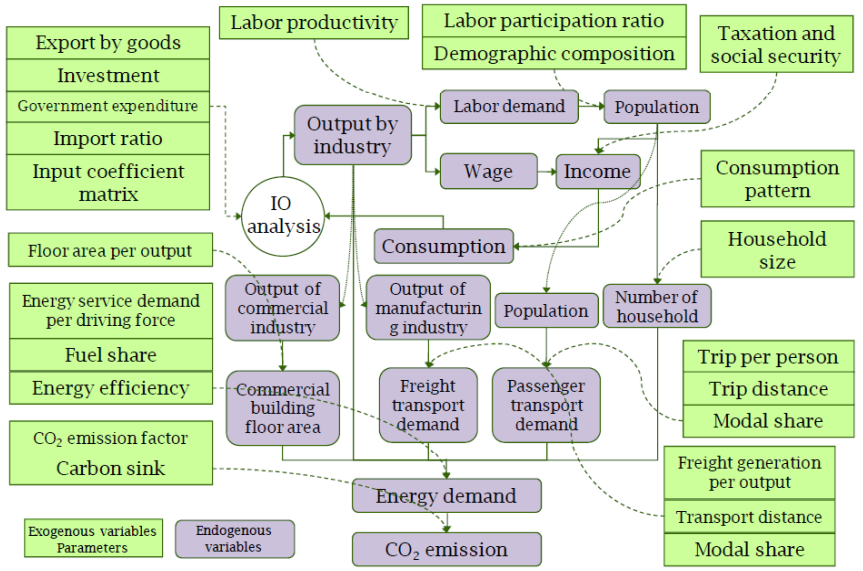
- *"Energy technology" refers to a device that provides a useful service by consuming energy*
- *"Energy service" refers to a measurable need that must be satisfied.*

Strengths and Weaknesses of Top-down (input-output) models

e.g. ExSS, TEESE

Key Features and Assumptions	Strengths	Weaknesses
▪ Systematic description of sectoral interrelationships in an economy	▪ Provide detailed analysis of inter-sectoral feedback effects for GHG abatement policies on a sectoral level	▪ External assumption of IO coefficients, macroeconomic structures
▪ Focus on statical snapshot status of emission reduction policies	▪ Easy to operate and interpret the results than CGE model	▪ Cannot consider price effects
	▪ Well suited to look at recycling of carbon taxes (the "double-dividend" issue)	▪ Not well internalize to address issues of dynamic, technological, behavioral change

Modified based on "Mapping the energy future", IEA, 1998



Framework of Extended Snapshot Tool (ExSS)

Strengths and Weaknesses of Top-down (Computable General Equilibrium) models

e.g. AIM/CGE, SGM, ENVISAGE

Key Features and Assumptions	Strengths	Weaknesses
▪ Markets and the economy, as a whole, reach equilibrium, through price adjustments	▪ Able to estimate economy-wide costs of reduction policies, including trade effects	▪ Poor description of energy end uses and technologies
▪ Markets work efficiently (no market barriers, hidden costs or information barriers)	▪ Describe economic interactions among sectors in detail	▪ Assume that markets always work efficiently
▪ Able to analyze long-term resource allocation	▪ Able to assess long-term effects of GHG abatement policies on structural change in a coherent macro-setting	▪ Do not well reflect short-run economic adjustment costs
		▪ Have a weak statistical basis (usually models are calibrated on a single-year basis)

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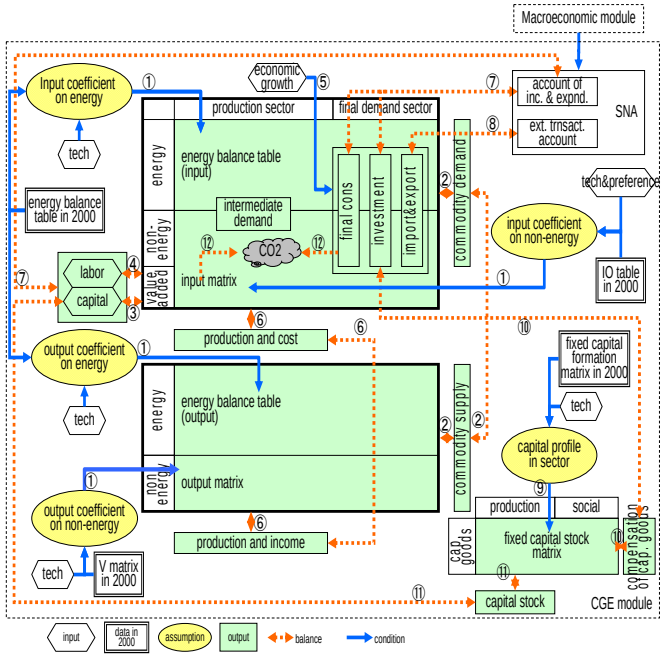


Framework of AIM/CGE

① production function
② commodity market
③ capital market
④ labor market
⑤ calculation of GDE
⑥ expenditure and income in production sector
⑦ expenditure and income in household and government
⑧ assumption of import and export
⑨ fixed capital stock matrix
⑩ investment goods market
⑪ capital stock
⑫ CO_2 emissions

Model Implementation

Generally speaking;

Type of model		Data requirement	Software requirements
Abatement Cost Curve analysis		Light-Moderate	Spreadsheet
Bottom-up models	Accounting type	Light-Moderate	Spreadsheet
	Energy sector optimization type	Moderate	GAMS
Top-down models	Input-Output type	Moderate	Spreadsheet/ GAMS
	Computable General Equilibrium	Moderate-Heavy	GAMS
Hybrid of Bottom-up and CGE models		Heavy	GAMS

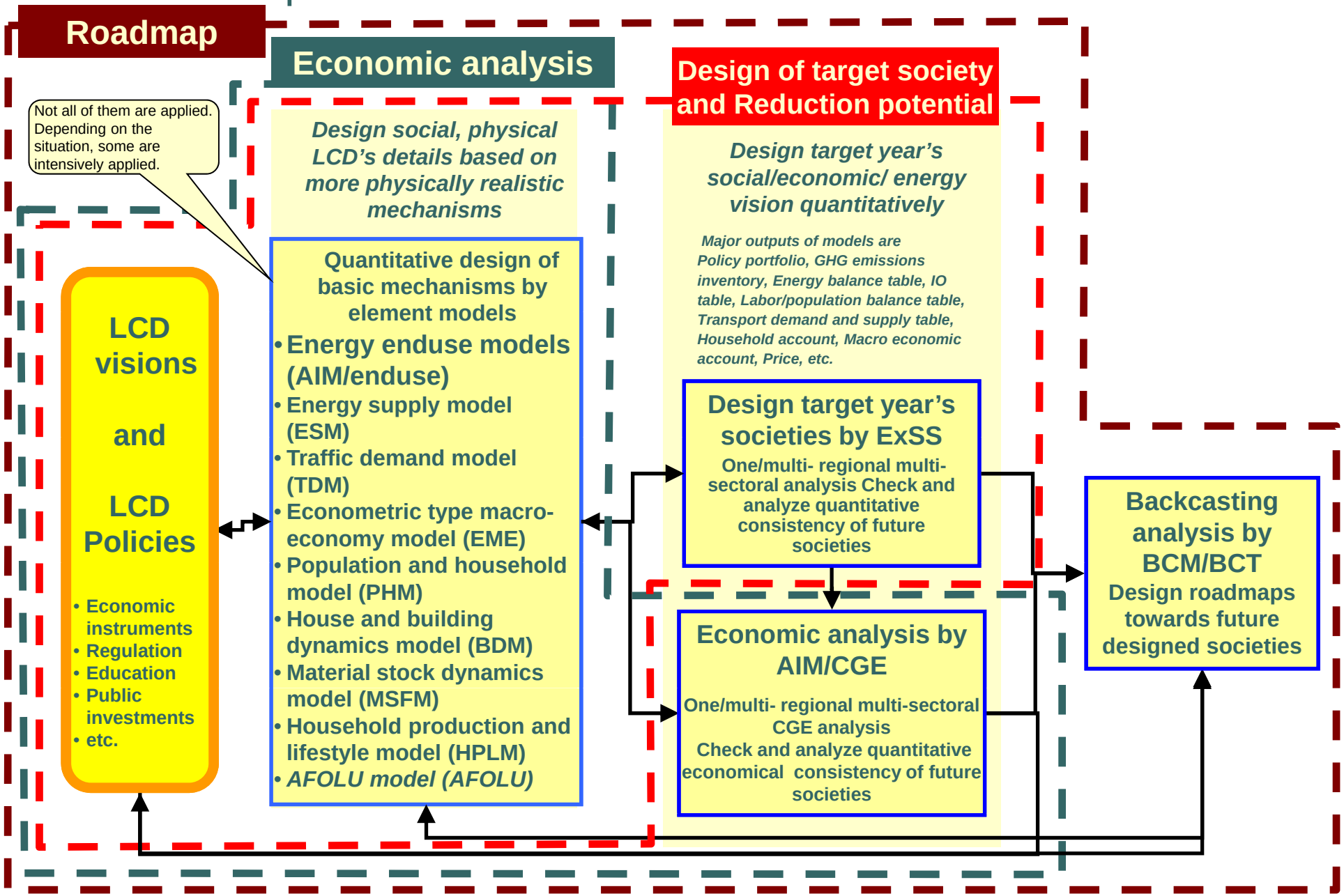
In case of AIM

- All models are on MS-Windows XP or later,
- Most models are implemented with,
  1) GAMS (Mathematical programming Language),
  2) MS Office,
  3) Gnu tools in GnuWin
- And some models use,
  4) Fortran/C
  5) ArcGIS

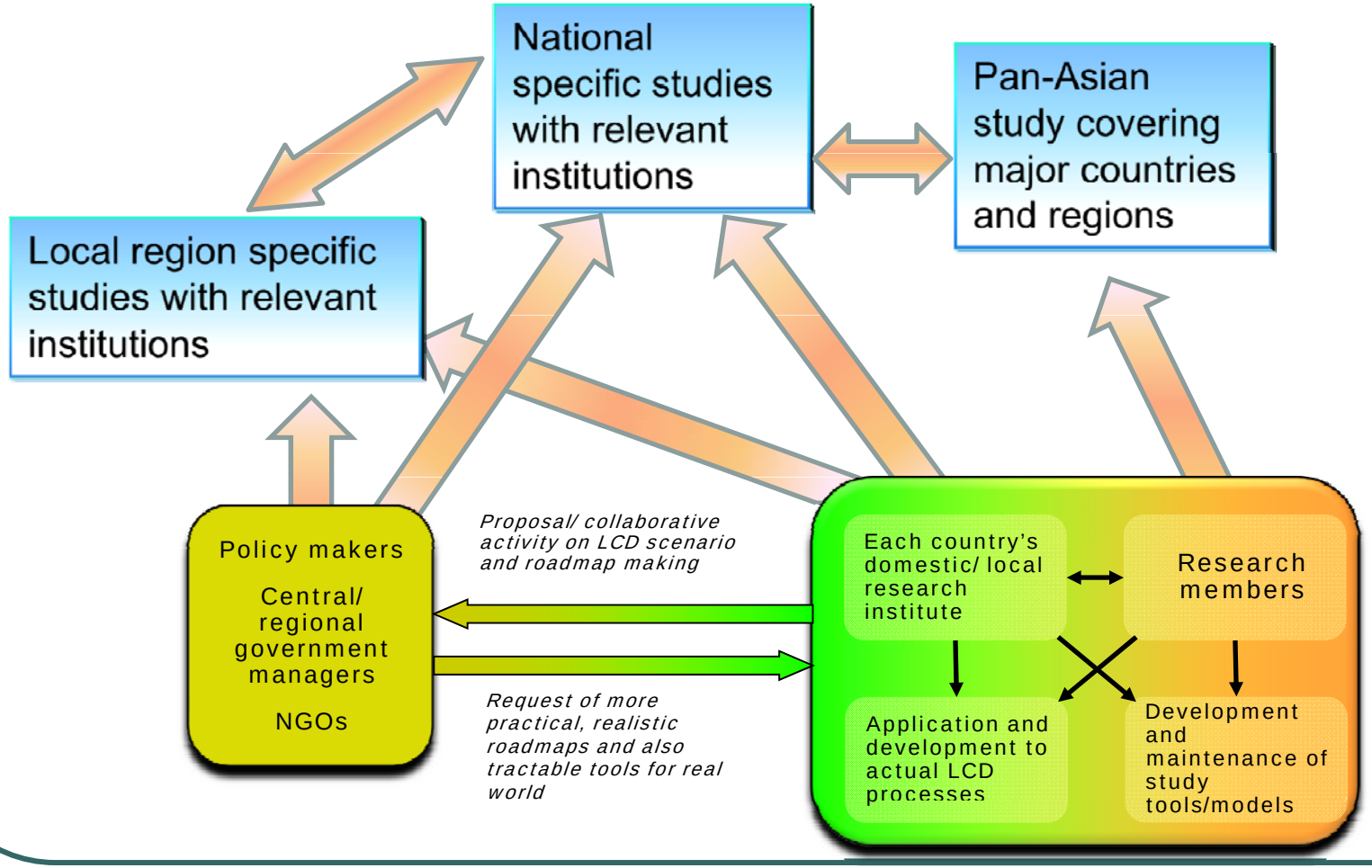
Several different issues in LCD scenario making process

Type	Focusing issues
(1) Design of LCD Vision and Reduction Potential	Analysis of GHG reduction targets and reduction potential
(2) Economic analysis	Economic analysis of LCD policies
(3) Roadmap	Design of policy packages and roadmaps

Correspondence between the Issues and models



5. Collaboration with Asian colleagues for designing LCD scenario

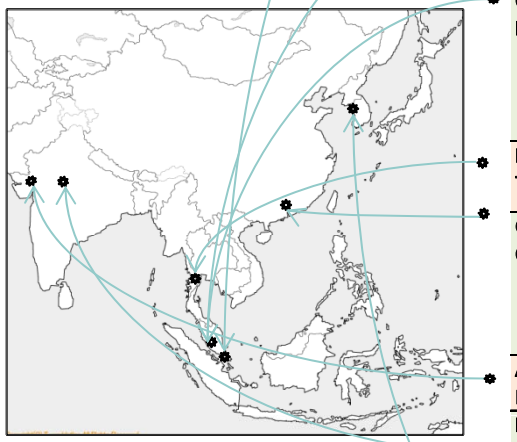


National level collaborative studies now going on

National Studies

	Progress up to now	Collaborating Research Institutes
China	Extending ERI's national study (Low Carbon development, China) with AIM models. Preparing provincial energy, industrial, and economic database in order to integrate national level and provincial level scenarios	Energy Research Institute(ERI), National Development and Reform Commission
India	Constructing Indian national scenarios with "Conventional Mitigation" and "Sustainable development" which corresponding to global 2 C scenarios	Indian Institute of Management, Ahmedabad
Thailand	Thailand national study using coupled CGE and enduse model and applying Thailand NAMA	Thammasat University
Indonesia	Indonesia national study using coupled Energy/enduse model and AFOLU model	Institut Teknologi Bandung Bogor Agriculture University
Vietnam	Preliminary analysis of Vietnam energy related and AFOLU related GHG emission reduction was finished	Institute of Strategy and Policy on Natural Resources and Environment (ISPONRE), Institute of Meteorology, Hydrology and Environment, Ministry of Natural Resources and Environment
Bangladesh	Preliminary analysis of Bangladesh LCS with energy ExSS. Finished	Department of Environment, Bangladesh
Malaysia	Extending the reduction plan of the 2nd National Communication with ExSS and AFOLU models	Universiti Teknologi Malaysia

Local regional level collaborative studies now going on

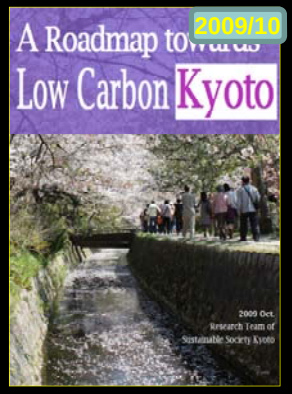


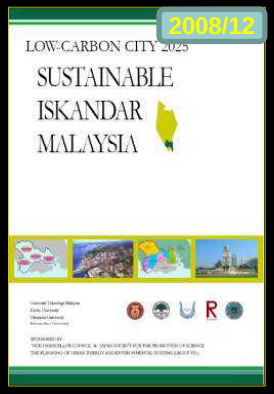
Local region studies

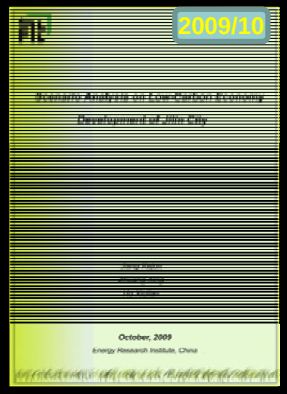
	Progress up to now	Collaborating Research Institutes
Iskandar, Malaysia	1. Start full scale collaboration with related governmental institutions 2. Preparing a draft of "Blueprint to Low Carbon Iskandar" including 12 actions 3. Start assessment study on cobenifits by 3R policies and Air quality management 4. Developing Regional Diffused Energy Supply System Model 5. Developing a systematic methodology of Consensus Building towards LCS	Universiti Teknologi Malaysia (UTM) Iskandar Regional Development Authority (IRDA) Federal Department of Town and Country Planning Malaysia (JPBD) Malaysian Green Technology Corporation (MGTC)
Putrajaya, Malaysia	Finished preliminary design of "Actions towards Putrajaya Green City 2025". Conducted "Focus Group Meeting" with regional stakeholders	Universiti Teknologi Malaysia (UTM) Putrajaya Corporation Malaysian Green Technology Corporation (MGTC)
Cyberjaya, Malaysia	Start "Cyberjaya Digital Green City 2025 (Cyber DGC 2025) project with four pillars; "Low-carbon Cyberjaya" for climate change mitigation, "Smart 3R Cyberjaya" for solid waste management, "Livable & Vibrant City" for a good living environment, "Smart Digital Network City" for an ICT-based society.	Universiti Teknologi Malaysia (UTM) Multimedia Development Corporation Sdn. Bhd ((MDeC) Cyberview Sdn. Bhd
Ratchaburi, Thailand	Preliminary analysis of energy related part almost finished with ExSS, now adding AFOLU part	King Mongkut's University of Technology
Guangzhou, China	Finished preliminary design of "Actions for Guangzhou Low-carbon Social development" including 5 actions; Action 1: Convenient transport, Action 2: Green Building, Action 3: Decarbonation of Industry, Action 4: Fuel Switch, Action 5: Low-carbon Electricity	Guangzhou Institute of Energy Conversion
Ahmedabad, India	Preliminary analysis of energy related part finished with ExSS	Indian Institute of Management, Ahmedabad
Bhopal, India	Finish the 1st phase study on "Low Carbon Society Scenario Bhopal, 2035" with 7 actions; Had a symposium with regional policy makers and stakeholders to stimulate Actions, on Sept. 2011	Maulana Azad National Institute of Technology, Bhopal School of Planning and Architecture, Bhopal
Kyonggi Province, Korea	Preliminary analysis of energy related part are conducting with ExSS, finished	Seoul National University

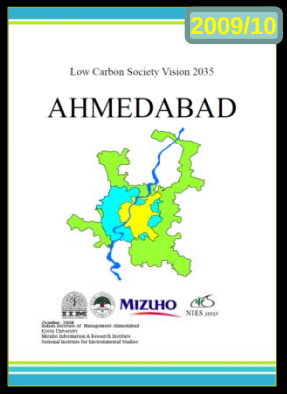
Brochures introducing national and regional specific LCD studies

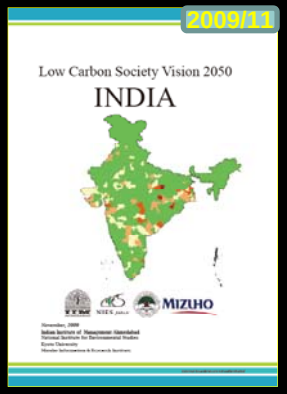
Communication and feedbacks of LCD study to real world

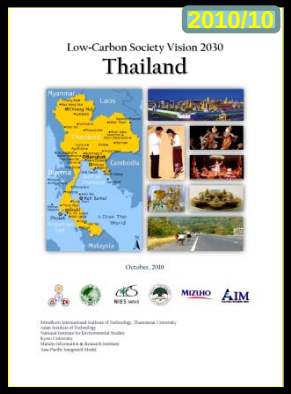


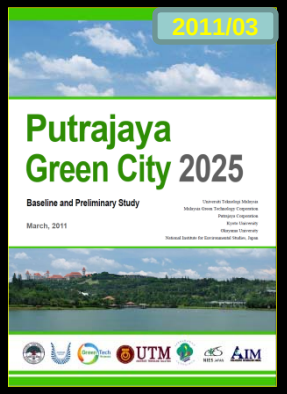


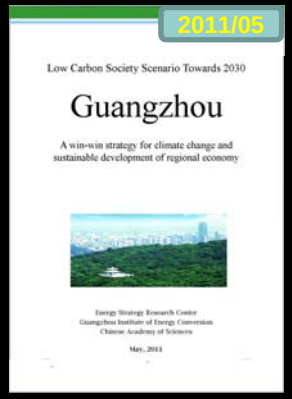


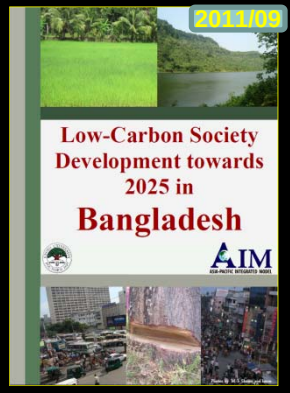


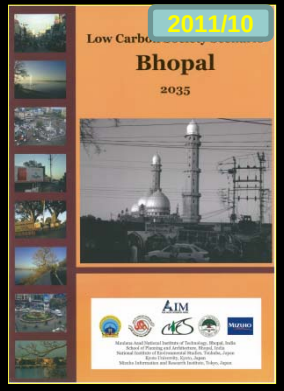


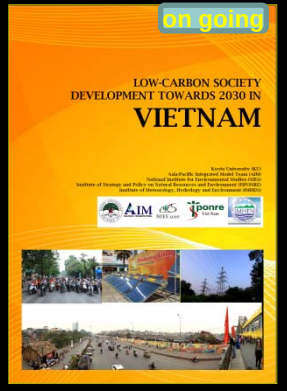


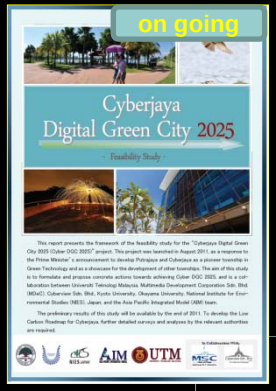












Asian Low Carbon Development Scenario Making and Capacity Building Activity Since 1991

15th AIM International Workshop on 20-22 February 2010

AIM Training Workshop on 27-31 October 2008

AIM Training Workshop on 16-20 October 2006

Asian Modeling Meeting at Tsukuba on 17-18 September 2009

14th AIM International Workshop on 14-15 February 2009

AIM Training Workshop on 2-14 August 2010

1st AIM International Workshop on 1-2 February,1996

17th AIM International Workshop,17-19, February 2012

16th AIM International Workshop on 19-21 February 2011

AIM Training Workshop on 22-26 October 2007

6. Final remarks

1. **“Low Carbon Development (LCD)” issue is not only related with GHG emission activities but also essentially connected with national development planning. Real and quantitative integration is necessary in order to design Low Carbon Development.**

2. **Myopic tactics can not drive us to LCD. In order to realize LCD, policy measures with well calculated strategies and time horizon of more then several decades are necessary.**

3. **From that point of view, we have developed tools in order to design quantitatively the visions of LCD and roadmaps for LCD. We applied them to the real fields in Japan and some Asian countries.**

4. **Collaborating with Asian colleagues, we want to extend our approach to Asia region, acquiring experience, improving and intensifying the applicability to real world.**