Low-Carbon Society Modeling and Scenario Making Process

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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, GEO and Millennium Ecosystem Assessment 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

Seniors and Youngs in AIM

2. What we are now doing, ...

In order to realize Asian Low Carbon Societies,

1. We are focusing on domestic and international factors which control the realization of LCS,
2. Describing the development, accumulation, and deepening of factors which control LCS 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 towards the LC societies, in each region with a back-casting methodology.

3. What are the Asian Low Carbon Societies, we target ?

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 each region's national reduction target that consists with the global low carbon target, under the global, national and regional constraints on fossil and renewal energy resources, and land resource,
3. Promoting LCS policies based on each region’s characteristics ,
4. Also utilizing effectively co-benefits of LCS policies and neighboring policies.

Also, in order to taking account of multilayered characteristics of Asian LCS issue and not to loose perspective and reality of LCS, we are adopting

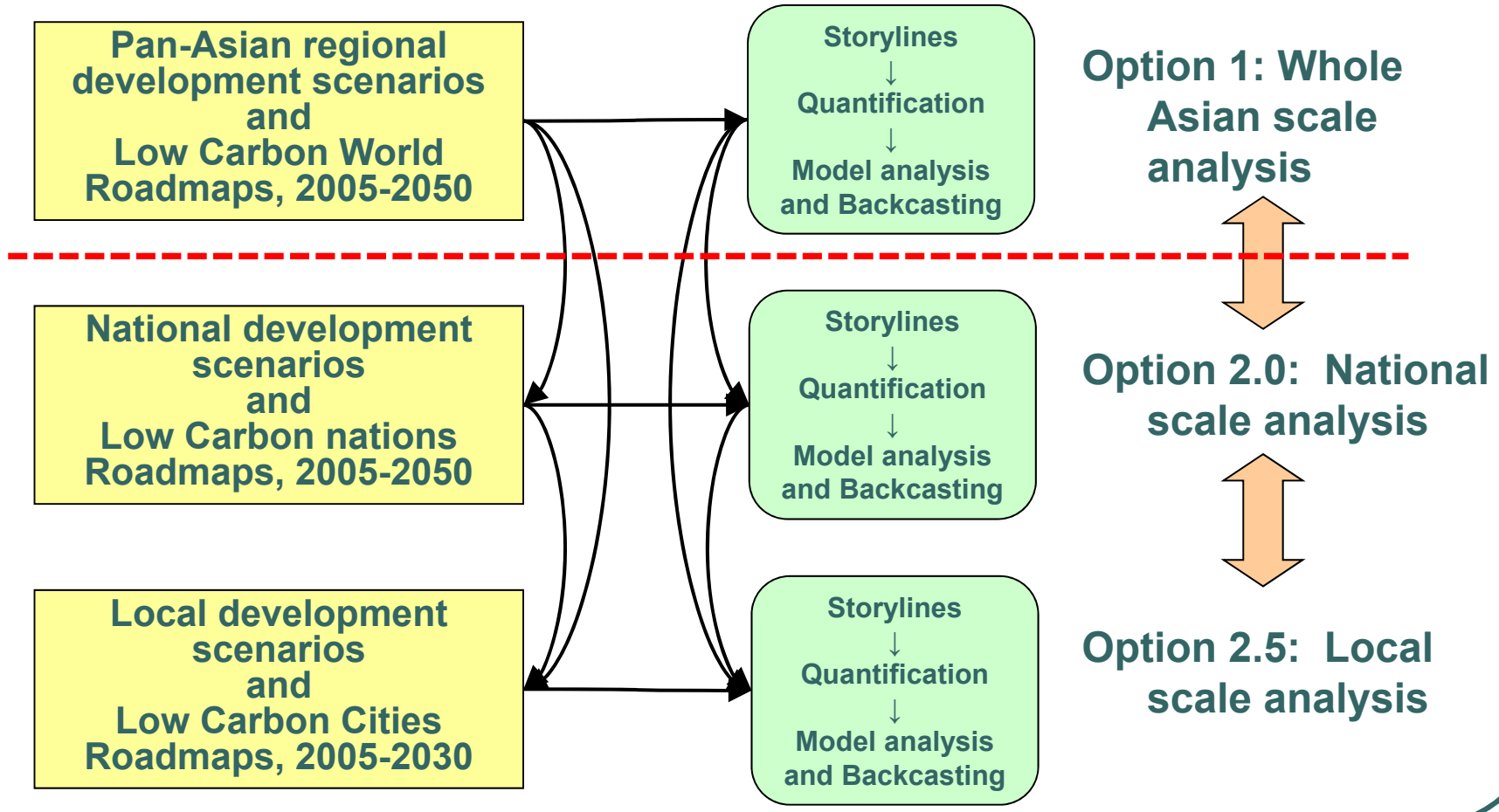
Two approaches in regional and time scales

1. Pan Asian-Pacific approach : Put more emphasis on comprehensiveness and compatibility among global and pan Asian-Pacific regions

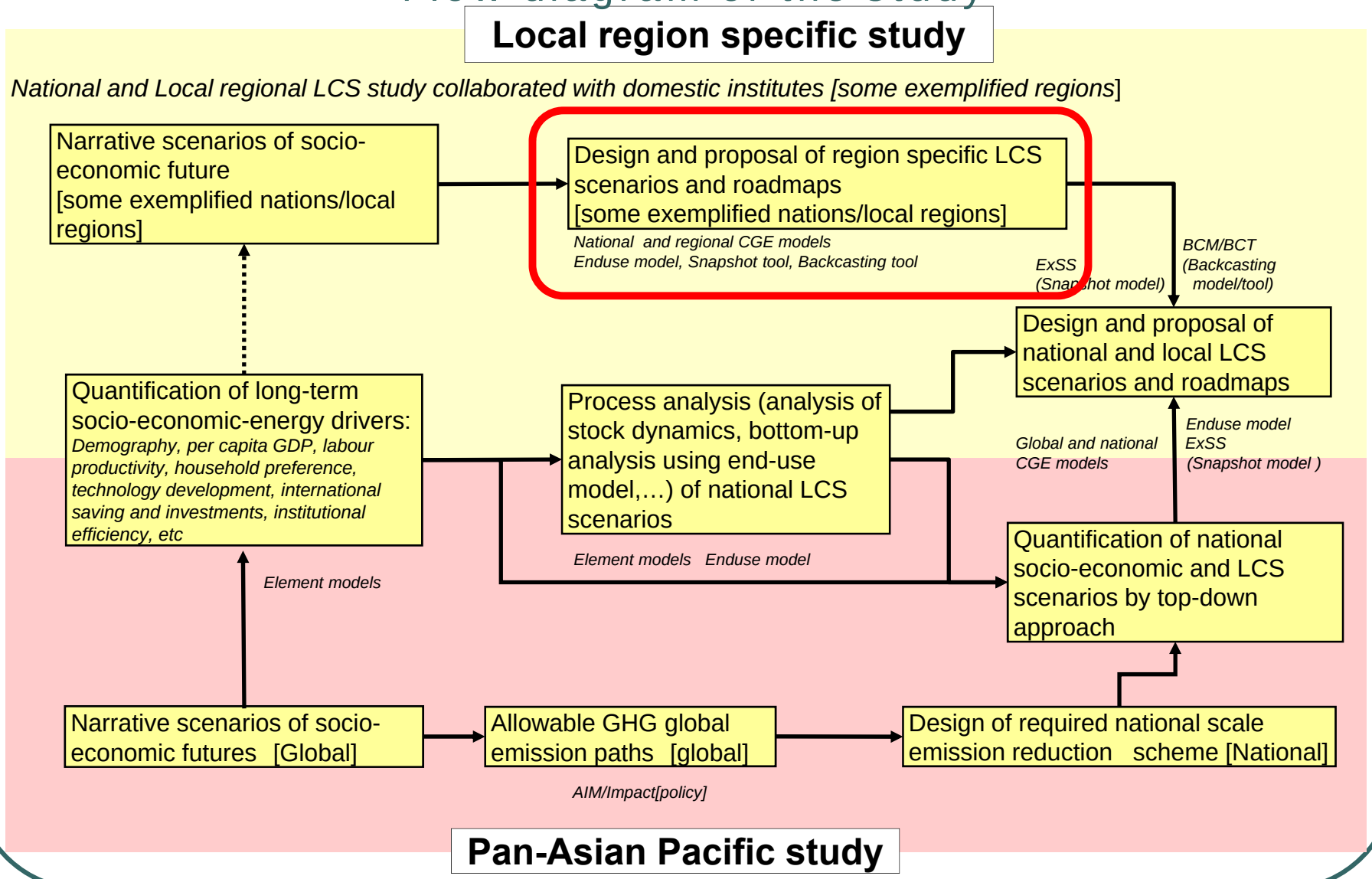
2. National or Local region specific study : Country/local region specific approach collaborating with domestic research institutions, and putting more focus on regional initiative and acceptability

Two and half regional/time scales of concern

To all scales, our methodology has been applied, and they are inter-connected each other.



How do we implement these approaches?
Flow diagram of the study



4. Modeling

Development, maintenance and application of multi-layered modeling system

Two groups of models and tools have been developed.

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

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

Manual of these models is available from http://www-cger.nies.go.jp/publication/I072/I072.html

Up to now, we developed nine national/local scale models for projecting energy services, energy consumption, 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. ***AIM/enduse[air]:*** an atmospheric environment model to estimate co-benefits caused by low carbon policies.

Three integrated models/tools for developing LCS scenarios

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

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

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

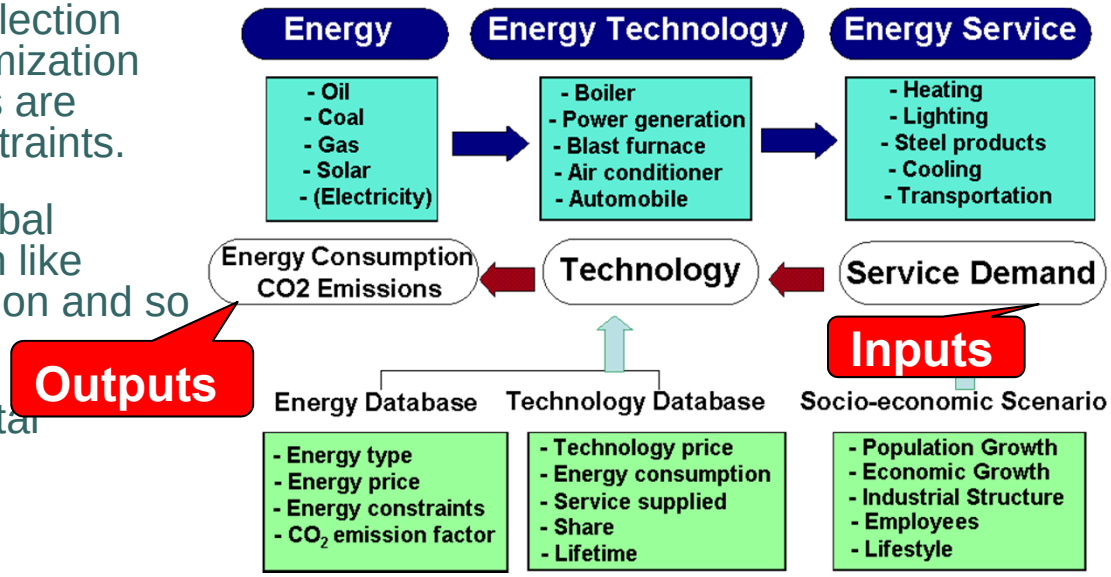
Model Implementation

- 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

An example of Element models: AIM/enduse Model

A model for describing the engineering mechanism of GHG emissions and their reduction

- Bottom-up type technology selection model, based on a linear optimization framework in which total costs are minimized under several constraints.
- Analyze policies related to global warming and local air pollution like emission tax, subsidy, regulation and so on
- Considering local environmental constraints
- Simplified Structure
- Flexible model structure to cope with various practical situation in different regions



Structure of the AIM/End-Use Model

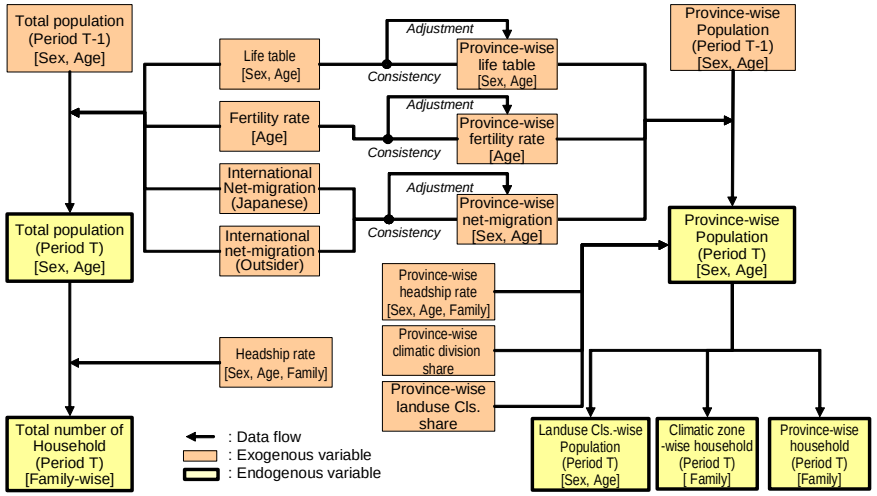
- *"Energy technology" refers to a device that provides a useful service by consuming energy*
- *"Energy service" refers to a measurable need that must be satisfied.*

An example of Element models: Population and Household Model

- A cohort component model for population, a household headship rate model for household types, with spatial resolution of provinces, land-use types and climate zones and five family types was developed, and is used to analyze effects of depopulation and changes in family composition on the realization of LCS.

- In case of Japan, drastic change is foreseen in the population structure by 2050. Downturn in birthrate, depopulation and aging will continue until 2050, and they affect greatly the future vision.

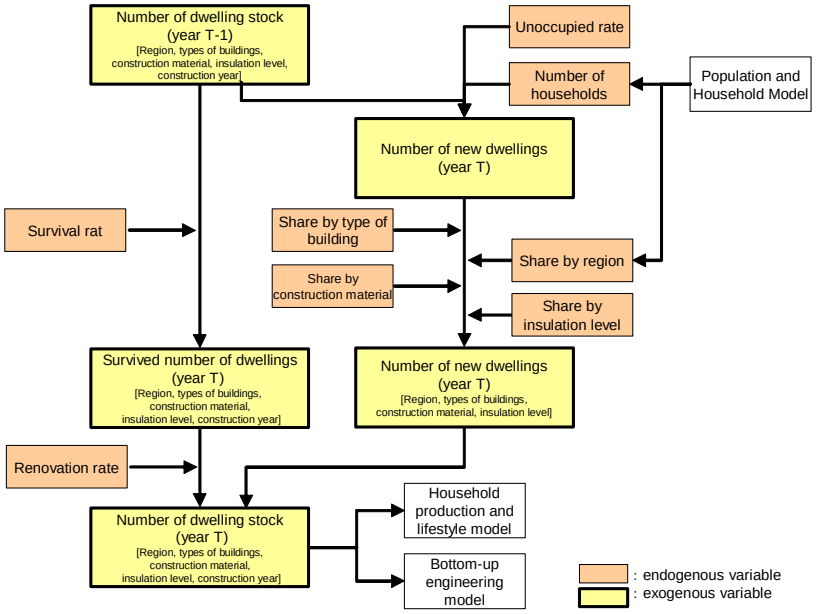
- Outputs: Future population and household structure



Flowchart of PHM

An example of Element models: House and Building Dynamics Model (BDM)

- Enhancement of building insulation is an effective countermeasures. For example, in Japan, 60% of the heating demand from the residential sector can be cut down, if appropriate insulation systems are installed. Future dynamics of building construction and rebuilding, besides configuration of buildings in urban and rural area affects total energy efficiency greatly.
- In order to take account these factors, a model of building dynamics (BDM) was developed.
- It is a cohort model with a spatial resolution of climate zones, four heat insulation levels, four residential building types, and six commercial building types.
- Outputs: Future type/age/insulation of buildings



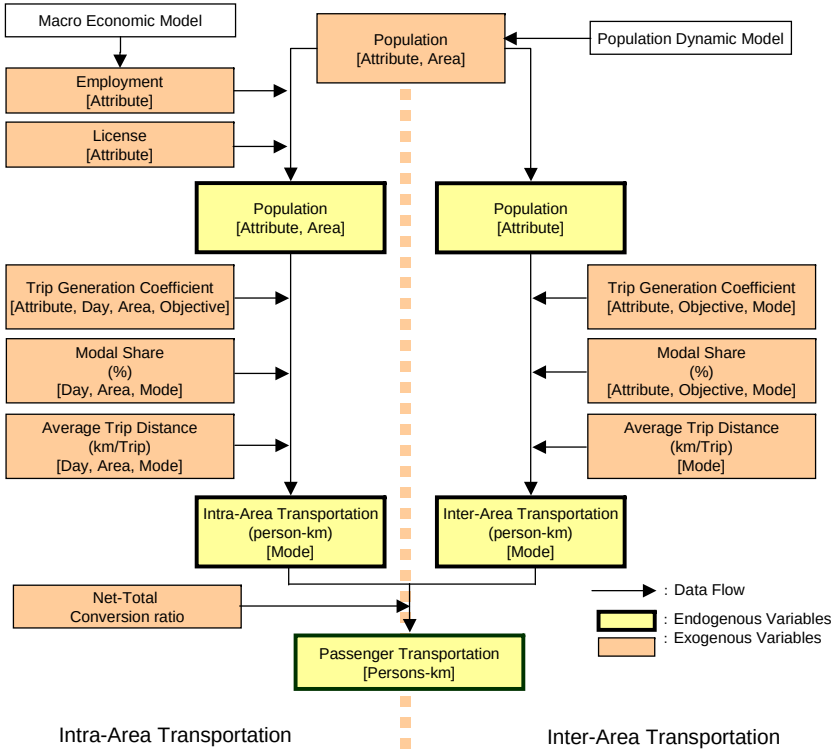
Flowchart of BDM (residential)

An example of Element models: Passenger Transportation Demand Model (PTDM, a part of TDM)

- Many effective countermeasures exist related with transportation. Modal shift from private motor vehicles to mass transit systems, urban planning towards compact cities, transportation substitution with diffusions of tele-working and virtual communication systems and so on.

- Passenger Transportation Demand Model (PTDM) can simulate transportation demand associated with changes in population distribution, people's activity patterns, modal shares and average trip distances.
- The trafic demands in this model are divided into two types,
  1) Intra-regional transportation within the daily living area,
  2) Inter-region transportation between the daily living areas,

  and they are calculated with keeping mutual dependency
- Outputs: Future transport volume/modal structure of passenger travel



Three integrated models/tools for developing LCS scenarios

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

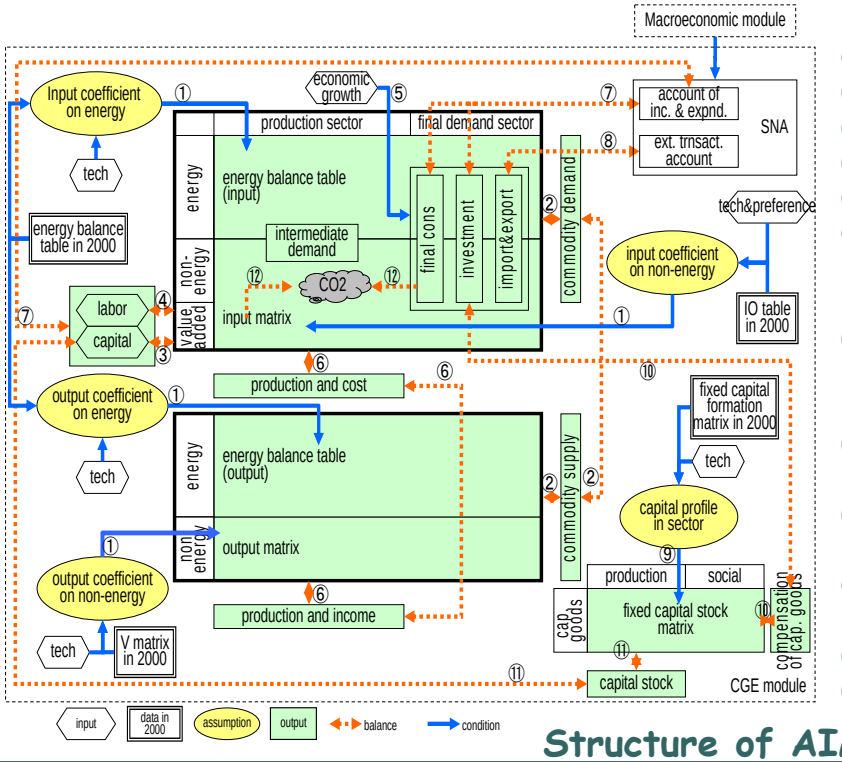
- ***Extended snapshot tool (ExSS):*** A tool to design future social accounting matrices, energy balance tables, GHG emission and reduction tables of the target societies. One or multi-regional static model.

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

An example of Integrated models: Computable General Equilibrium model (AIM/CGE)

- AIM/CGE consists of a GE (general equilibrium) module, detailed energy balancing module and several satellite modules. This model is used to project macro economic activity, sector production, based on descriptive future economic scenarios.

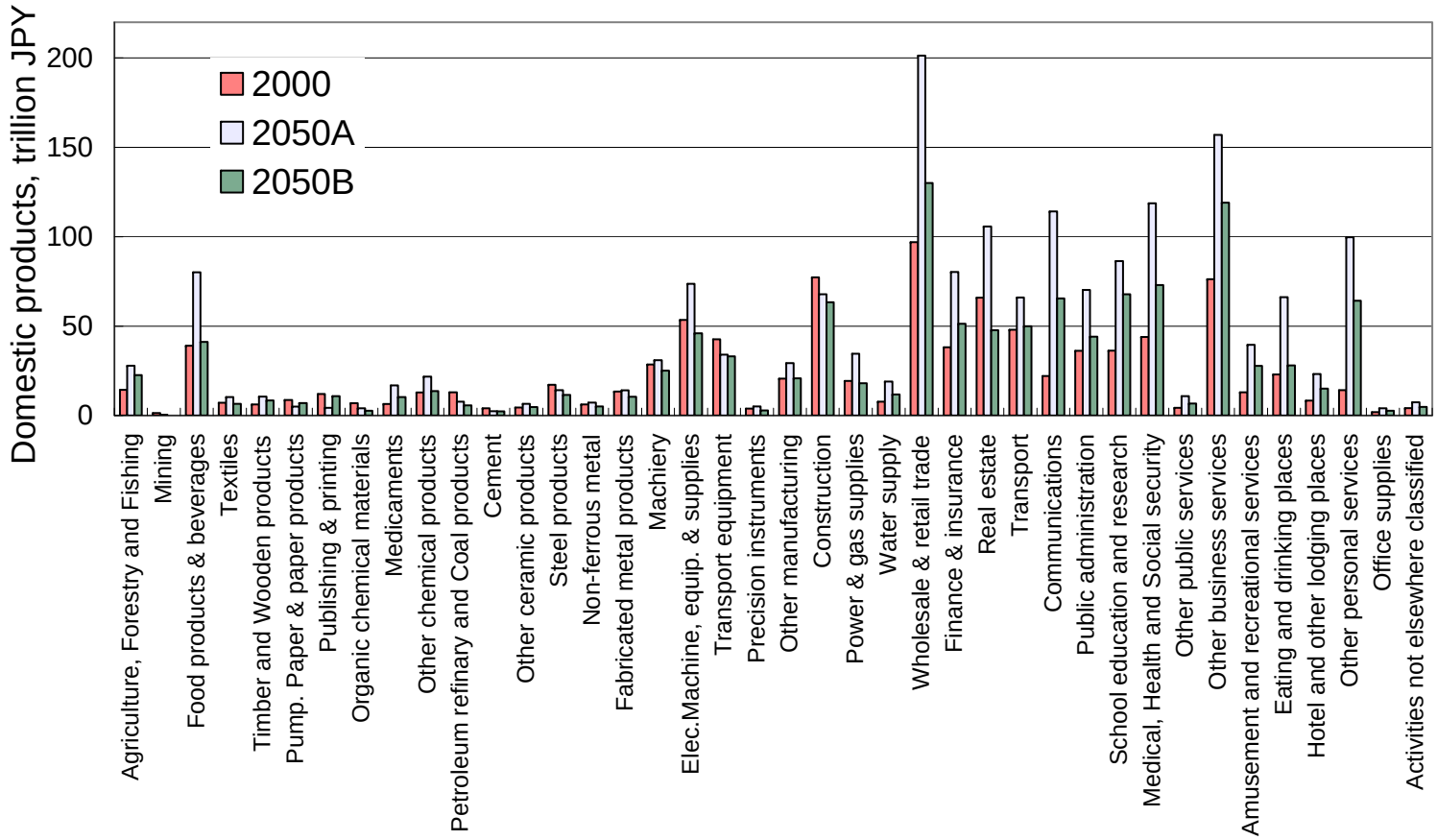
- Also the model can be used to estimate the economic effect of diffusion of energy efficient technologies and dematerialization technologies in industrial sectors, development of ICT, increase of service sectors, change of people's good's and service preference.



Structure of AIM/CGE

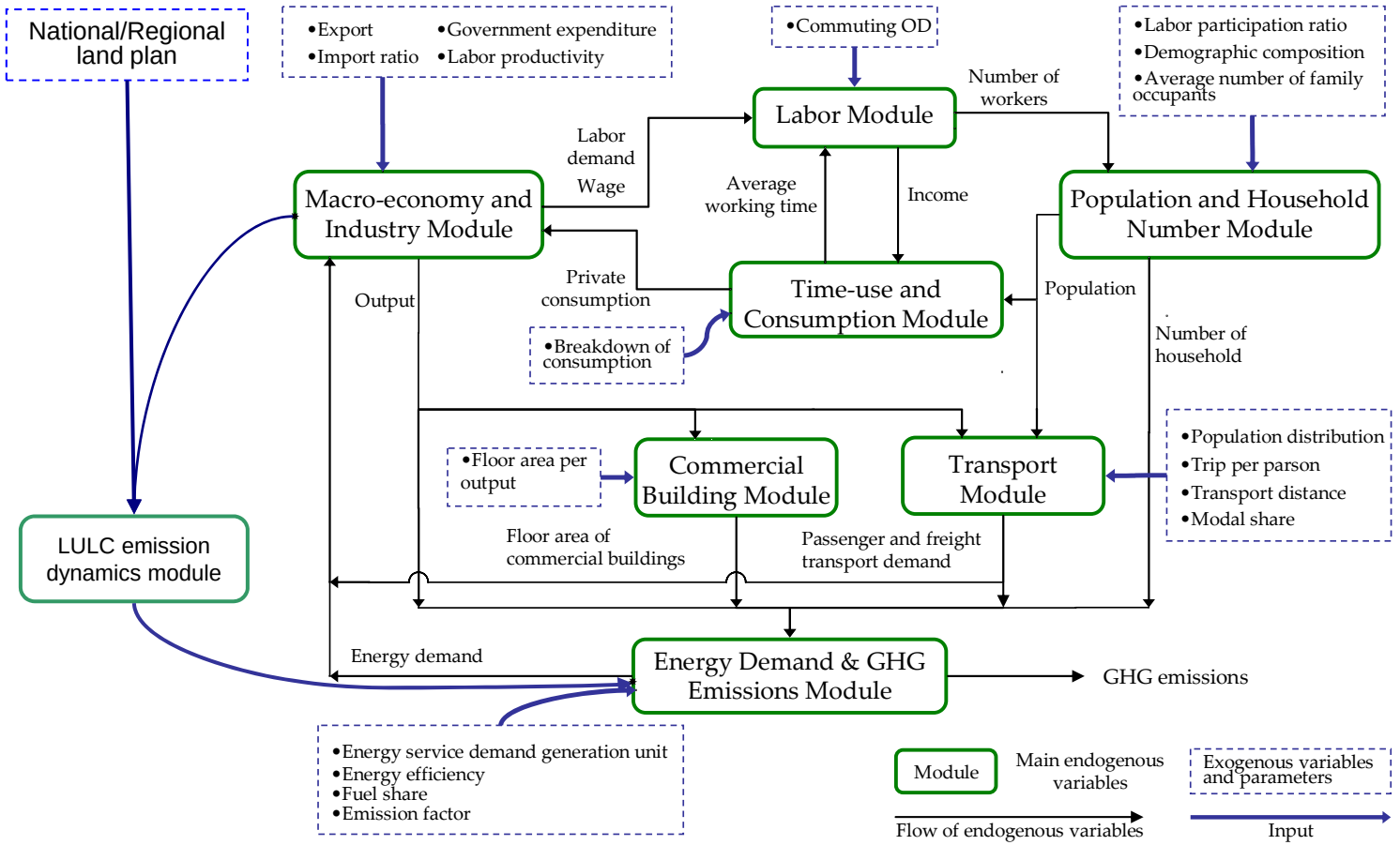
① production function
② commodity market
③ capital market
④ labor market
⑤ calculation of GDE
⑥ expenditure and income in production sector
⑦ expenditure and income in household and government
⑧ assumption of import and export
⑨ fixed capital stock matrix
⑩ investment goods market
⑪ capital stock
⑫ CO_2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

An example of AIM/CGE outputs in the Japan 2050 LCS study

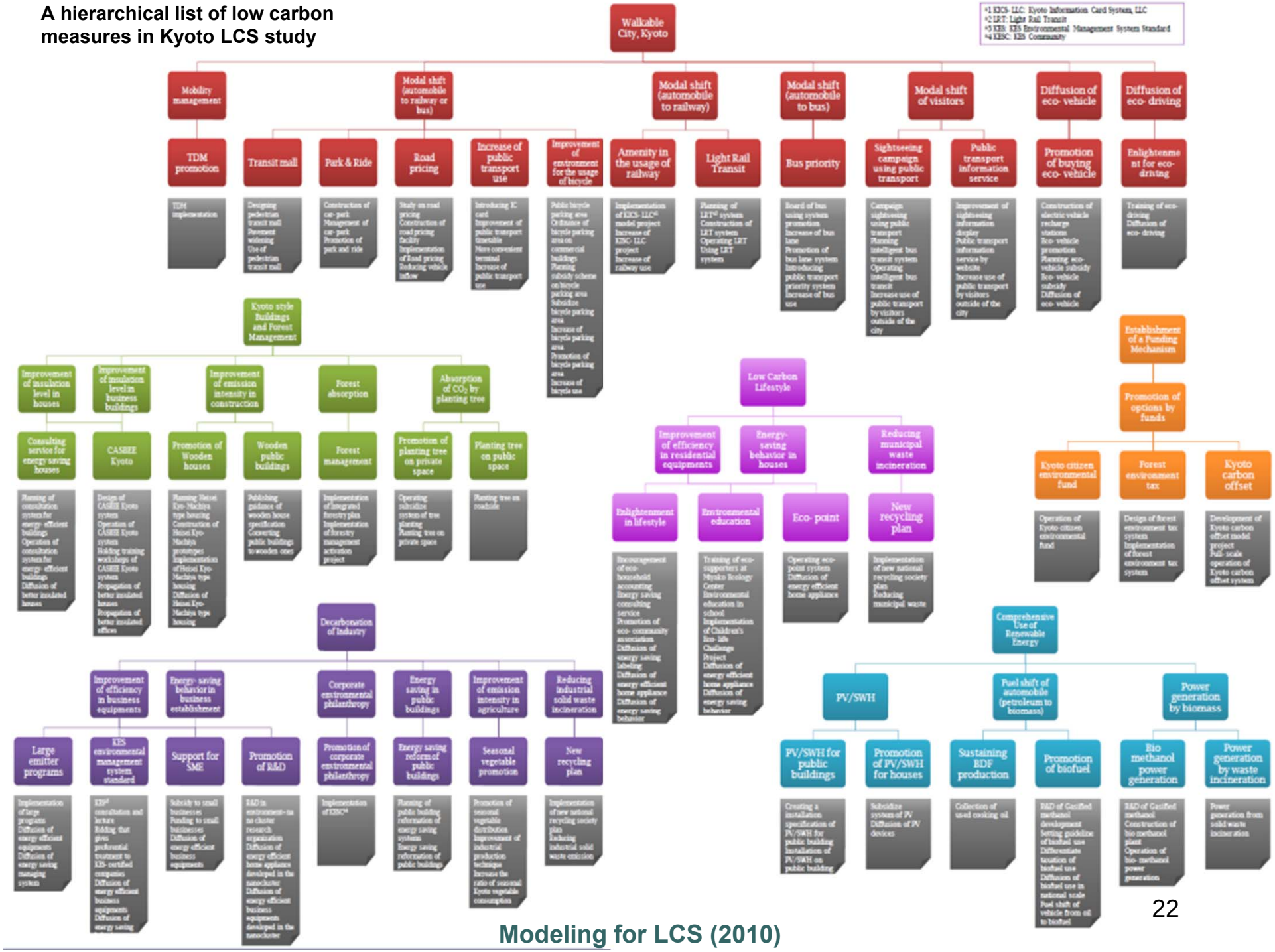


Extended Snapshot Tool (ExSS)

- A tool to designing social accounting matrices, energy balance tables, GHG emission and reduction tables of the target societies -



A hierarchical list of low carbon measures in Kyoto LCS study



A hierarchical list of low carbon measures in Kyoto LCS study

Output from ExSS

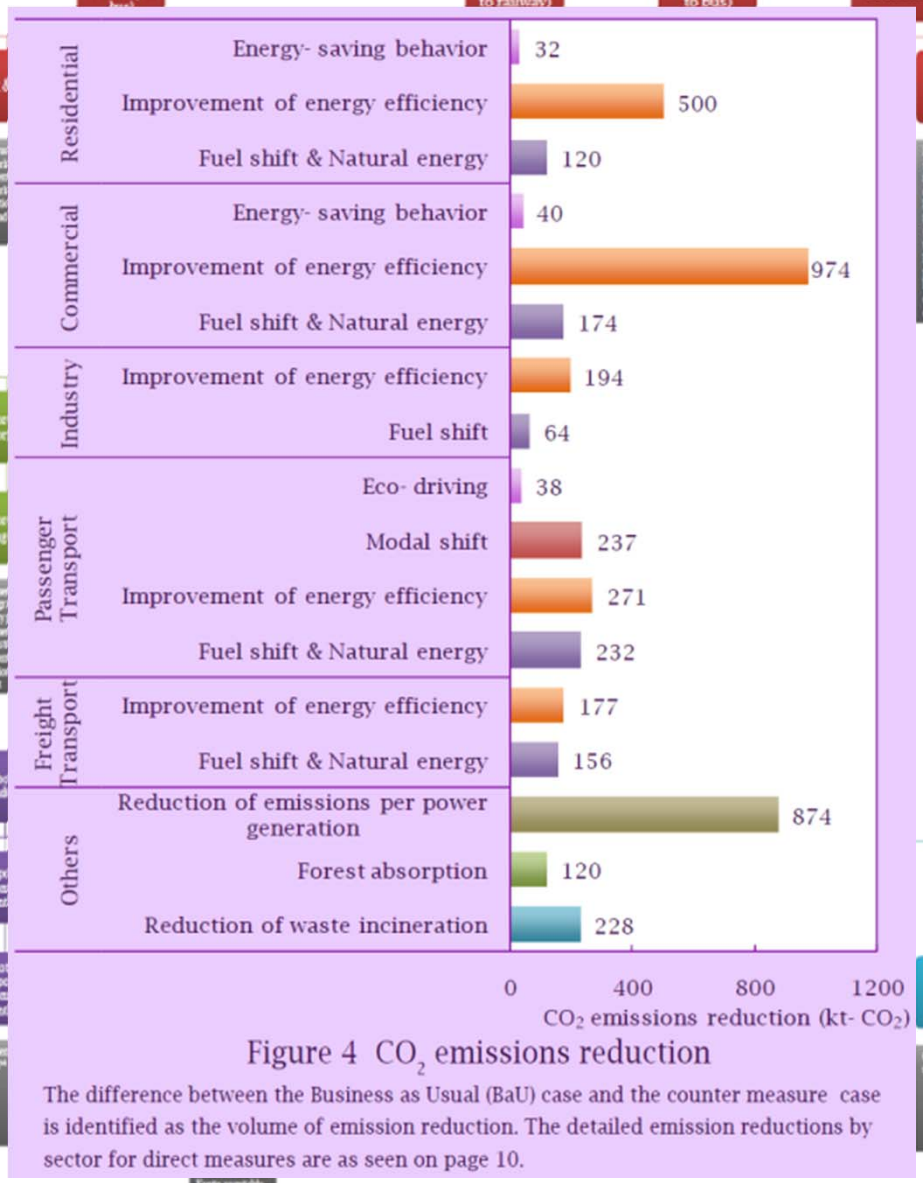


Figure 4 CO_2 emissions reduction

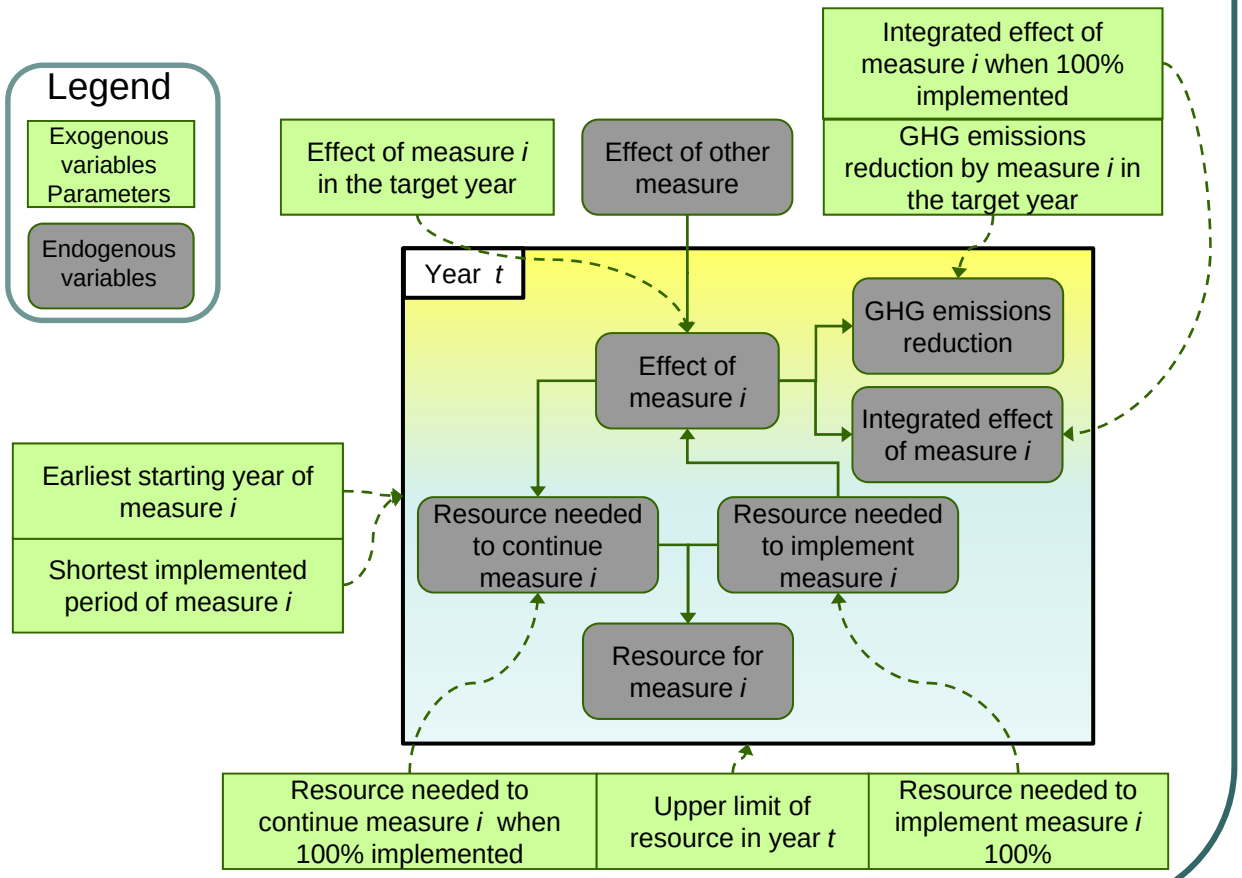
The difference between the Business as Usual (BaU) case and the counter measure case is identified as the volume of emission reduction. The detailed emission reductions by sector for direct measures are as seen on page 10.

An example of Integrated models:
Back-Casting Tool (BCT)

Designing tool of implementation schedule of policy measures

Design time schedule and combinations of measures towards the target LCS, which maximizes integrated benefits including co-benefits during planning period , under the following six types of resource constraints.

Constraints considered are financial, human and administrative resource (capacity) constraints in private and public sectors.



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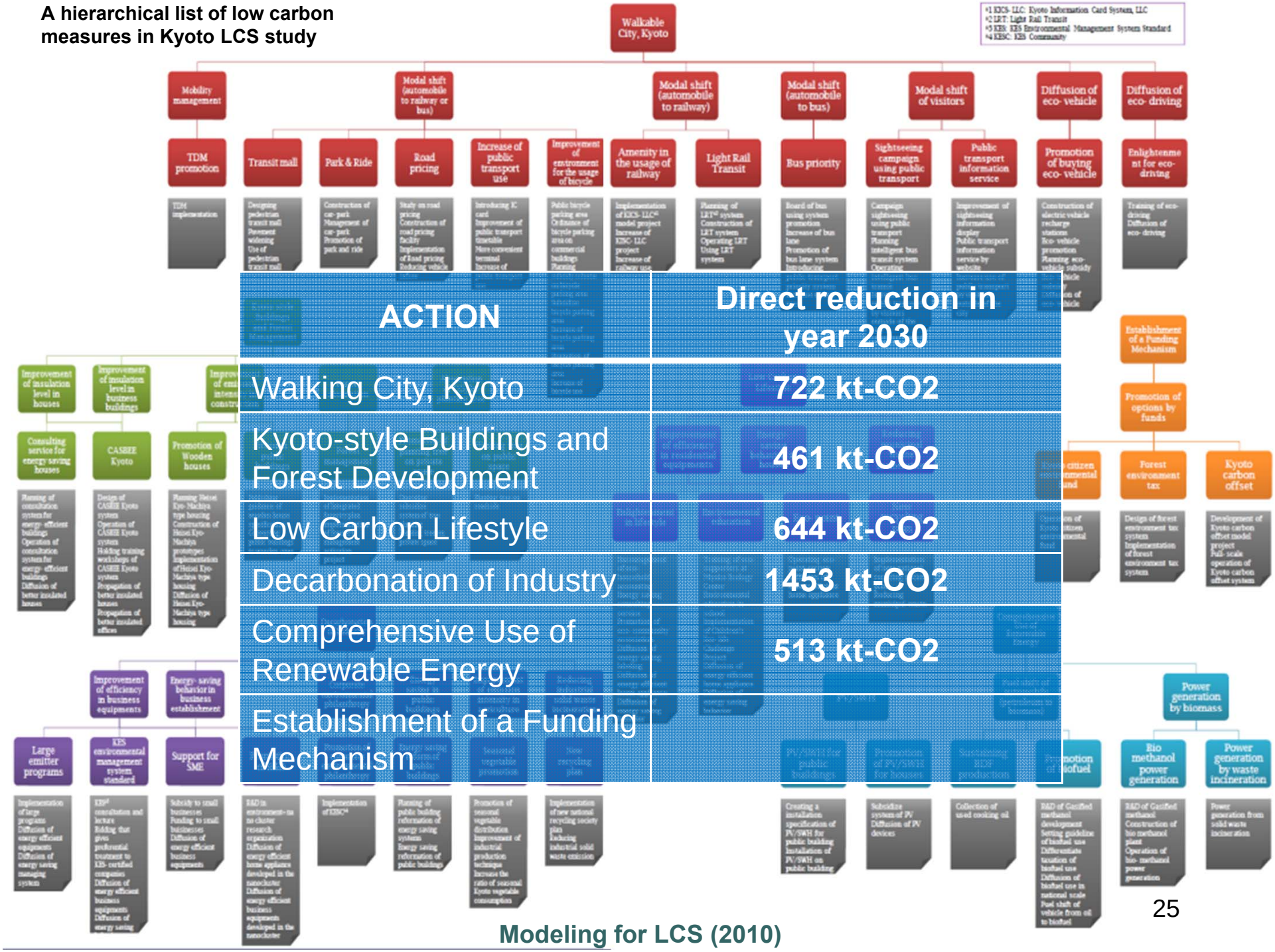
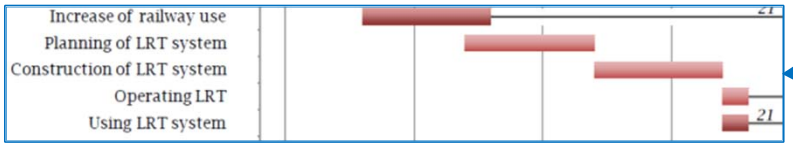


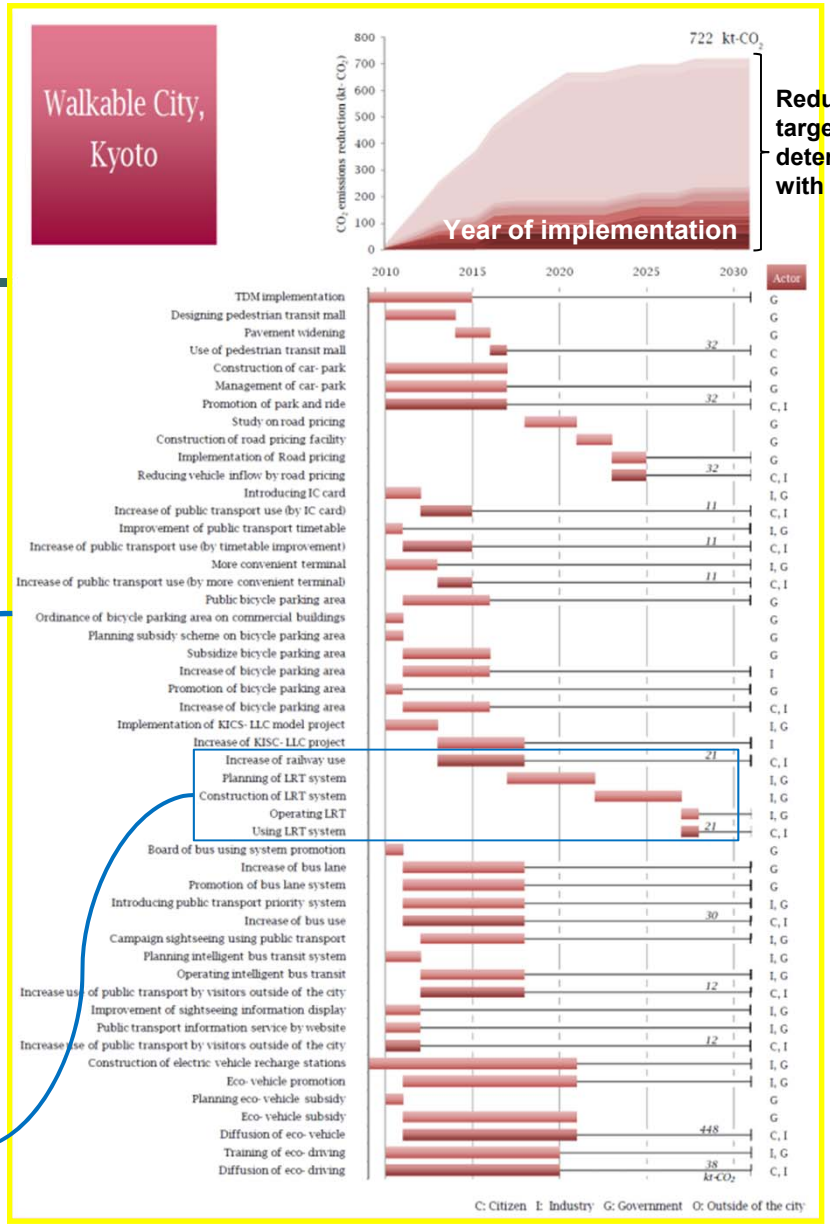
ACTION	Direct reduction in year 2030
Walking City, Kyoto	722 kt-CO2
Kyoto-style Buildings and Forest Development	461 kt-CO2
Low Carbon Lifestyle	644 kt-CO2
Decarbonation of Industry	1453 kt-CO2
Comprehensive Use of Renewable Energy	513 kt-CO2
Establishment of a Funding Mechanism	

An example of the output of the Back-casting tool

- From Low Carbon Kyoto study -

Narrative description of an Measure Roadmap in the action “Walkable City, Kyoto”





5. Two stages of LCS scenario development

Stage 1: Design of a Low Carbon Society

1. Creation of narrative storylines of future Low Carbon Societies
2. Description of sector-wise details of the future LCSs.
3. Quantification of the Macro-economic and social aspects of the LCSs.
4. Identification of effective policy measures and packaging them

Stage 2: Putting them together and design roadmaps towards LCS

1. Design of policy roadmaps toward the Low Carbon Society
2. Feasibility analysis of the roadmaps considering uncertainties involved in each policy option
3. Analysis of robustness of the roadmap caused by social, economical and institutional acceptability and uncertainties

Group 1: Element models;

1) Snapshot models;
   - *CGE[country]:* Quasi steady computable general equilibrium (CGE) model
   - *enduse[country]:* Energy technology bottom-up models
   - *ESM:* Energy supply model
   - *HPLM*: Household production/lifestyle model
   - *TDM:* Transportation demand model

2) Transition models;
   - *PHM:* Population and household model
   - *BDM:* Building dynamics model
   - *MSFM:* Material stocks and flow model
   - *EME:* Econometric type macro-economy model

Group 2: Extended Snapshot Tool (ExSS) and CGE

Group 3: Backcasting Model for roadmap design and transient control (BCM/BCT)

Stage 1: Creation of narrative storylines of future Low Carbon Societies

- Examples of Japan 2050 LCS study -

For Japan, we prepared two different but likely future societies

	Vision A	Vision B
Goal of life	Pursue economical "success" in the competitive society and spend much time on their own skill development.	Contribute to society as possible in the various fi their capabilities
Work	Pursue high productivity and efficiency. "Success in the economic society has the highest priority over any other factors.	Although working is one worthwhile activities, mo placed on balance betwe and life
Residence	Prefer sophisticated and convenient urban life.	Prefer slower and health
Acceptance of advanced technologies	Positively accept new and advanced technologies. People tend to expect advent of new technologies to overcome various social issues.	Take a cautious attitude some advanced technolo Genetic technologies, at power). Accept inconven lifestyle to some extent.
Presence of Japan	Japan should continue to be a great economic nation and lead the world. In order to achieve the goals, more stress should be placed on economic development policies	Japan should show our p by our own culture or international cooperation, although economy is also important

Vision A	Vision B
Vivid, Technology-driven	Slow, Natural-oriented
Urban/Personal	Decentralized/Community
Technology breakthrough Centralized production /recycle	Self-sufficient Produce locally, consume locally
Comfortable and Convenient	Social and Cultural Values
2%/yr GDP per capita growth	1%/yr GDP per capita growth
	

An example of Quantification of Scenario A and B in Japan 2050 national LCS study

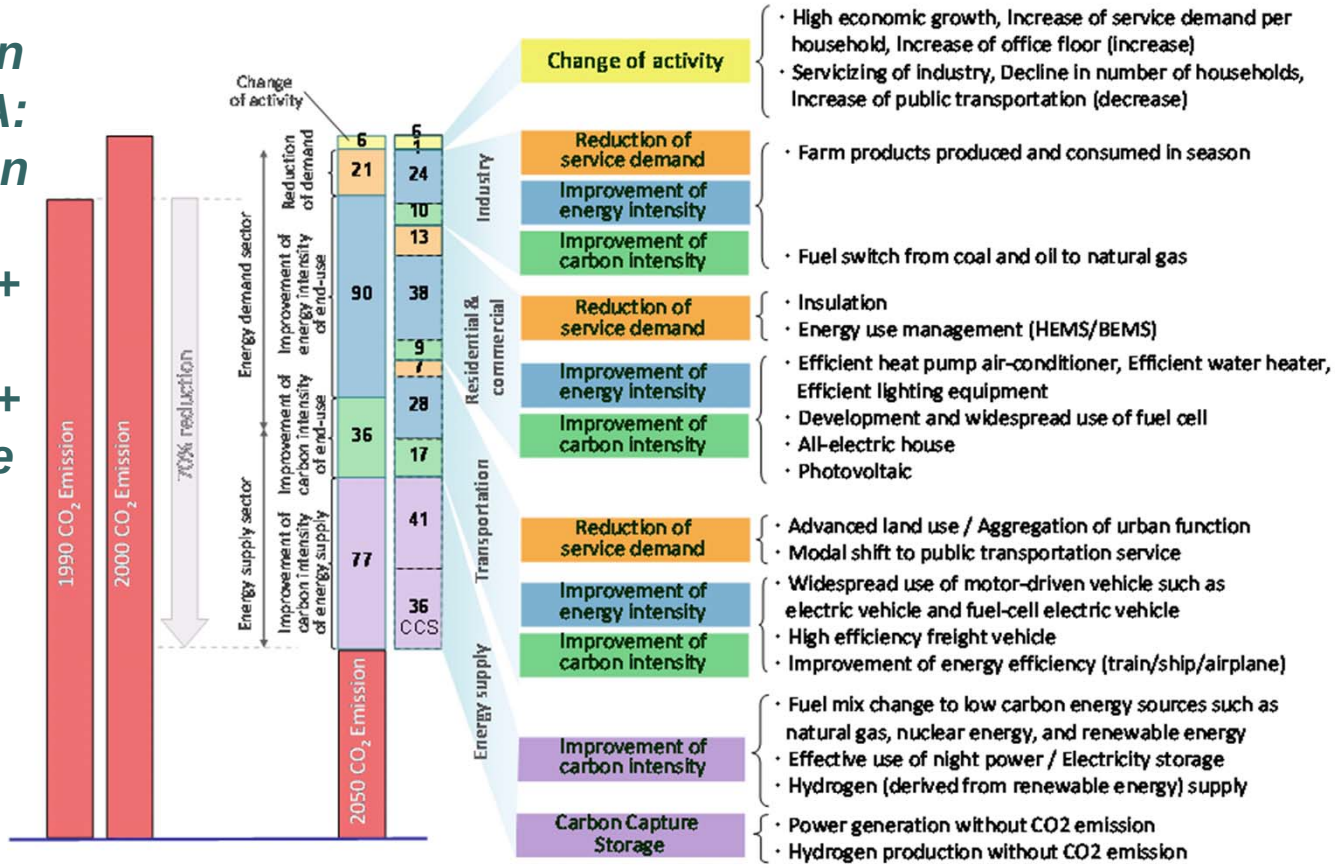
year	unit	2000	2050 A	2050 B	model
Population	Mil.	127	94 (74%)	100 (79%)	Population and Household model (PHM)
Household	Mil.	47	43 (92%)	42 (90%)	
Average number of person per household		2.7	2.2	2.4	
GDP	Tril.JPY	519	1,080 (208%)	701 (135%)	Macro-economy model(EME), Household production model & AIM/cge
Share of production					
primary	%	2%	1%	2%	
secondary	%	28%	18%	20%	
tertiary	%	71%	80%	79%	
Office floor space	Mil.m^2	1654	1,934 (117%)	1,718 (104%)	Building dynamics Model & AIM/cge
Travel Passenger volume	bill. p·km	1,297	1045 (81%)	963 (74%)	Traffic demand model (TDM) & AIM/cge
Private car	%	53%	32%	51%	
Public transport	%	34%	52%	38%	
Walk/bycycle	%	7%	7%	8%	
Freight transport volume	bill. t·km	570	608 (107%)	490 (86%)	
Industrial production index		100	126 (126%)	90 (90%)	Macro-economy model (EME), Material stocks and flow model (MSFM) and AIM/cge
Steel production	Mil.t	107	67 (63%)	58 (54%)	
Etylen production	Mil.t	8	5 (60%)	3 (40%)	
Cement production	Mil.t	82	51 (62%)	47 (57%)	
Paper production	Mil.t	32	18 (57%)	26 (81%)	

(%) is a percentage compared with year 2000

Stage 1-3 : Evaluation of LCS policies and counter-measures

- An example from Japan 2050 study -

GHG 70% reduction in 2050 Scenario A: Vivid Techno-driven Society, demand side energy -40% + Low carbonization of primary energy + CCS with moderate cost of technological options as 0.3% of GDP in the year of 2050



Roadmaps of Actions

- An example of "Comfortable and Green Built Environment" in Japan's 2050 LCS study -

When the actions of other stakeholders can be crucial to achieve the future objectives, their expected contributions are mentioned here.

Future images expected from introduction of each action are described. Clear and quantitative targets are set where possible.

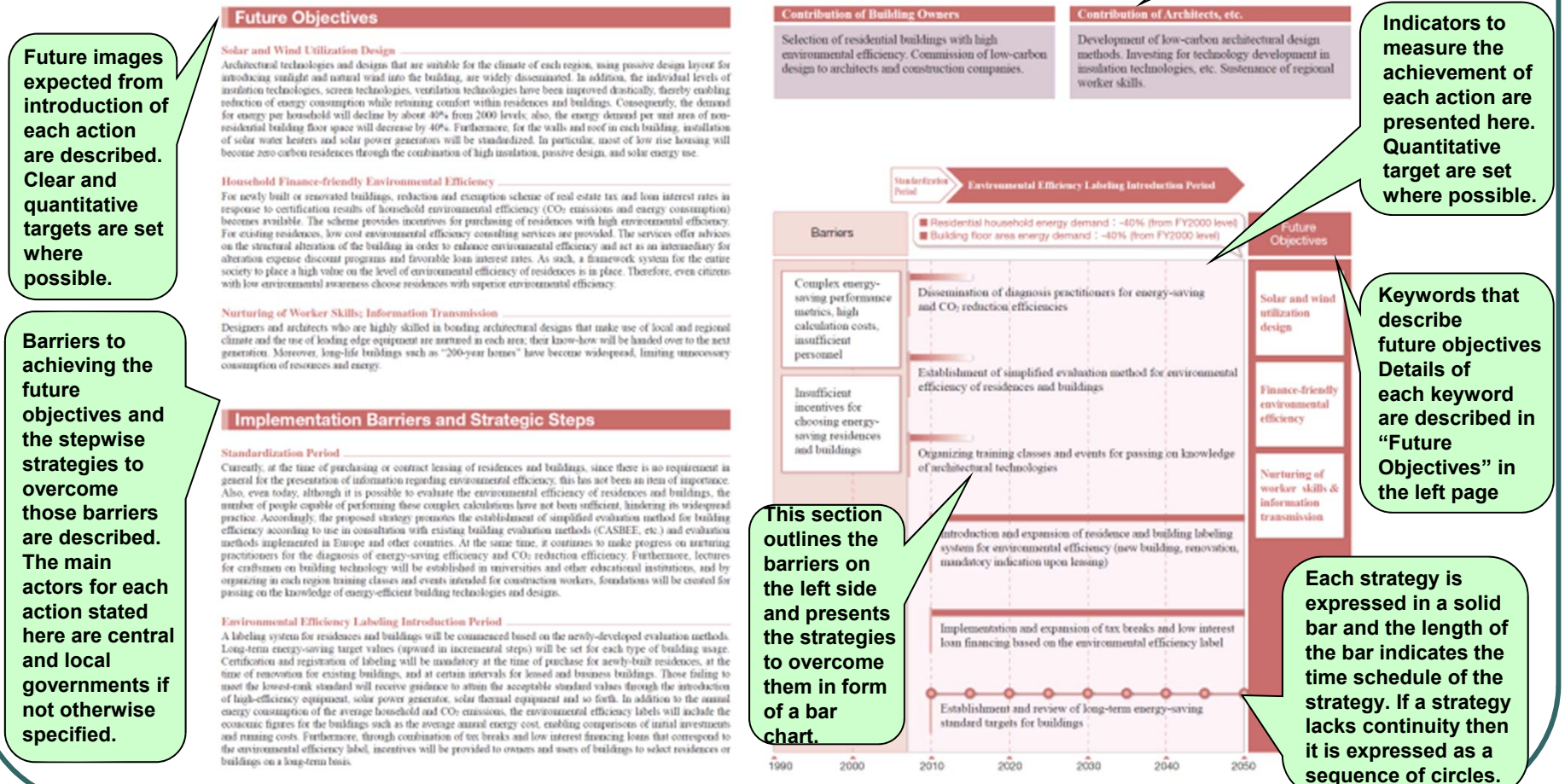
Barriers to achieving the future objectives and the stepwise strategies to overcome those barriers are described. The main actors for each action stated here are central and local governments if not otherwise specified.

Indicators to measure the achievement of each action are presented here. Quantitative target are set where possible.

Keywords that describe future objectives Details of each keyword are described in "Future Objectives" in the left page

This section outlines the barriers on the left side and presents the strategies to overcome them in form of a bar chart.

Each strategy is expressed in a solid bar and the length of the bar indicates the time schedule of the strategy. If a strategy lacks continuity then it is expressed as a sequence of circles.



Future Objectives

Solar and Wind Utilization Design

Architectural technologies and designs that are suitable for the climate of each region, using passive design layout for introducing sunlight and natural wind into the building, are widely disseminated. In addition, the individual levels of insulation technologies, screen technologies, ventilation technologies have been improved drastically, thereby enabling reduction of energy consumption while retaining comfort within residences and buildings. Consequently, the demand for energy per household will decline by about 40% from 2000 levels; also, the energy demand per unit area of non-residential building floor space will decrease by 40%. Furthermore, for the walls and roof in each building, installation of solar water heaters and solar power generators will be standardized. In particular, most of low rise housing will become zero-carbon residences through the combination of high insulation, passive design, and solar energy use.

Household Finance-friendly Environmental Efficiency

For newly built or renovated buildings, reduction and exemption scheme of real estate tax and loan interest rates in response to certification results of household environmental efficiency (CO_2 emissions and energy consumption) becomes available. The scheme provides incentives for purchasing of residences with high environmental efficiency. For existing residences, low cost environmental efficiency consulting services are provided. The services offer advices on the structural alteration of the building in order to enhance environmental efficiency and act as an intermediary for alteration expense discount programs and favorable loan interest rates. As such, a framework system for the entire society to place a high value on the level of environmental efficiency of residences is in place. Therefore, even citizens with low environmental awareness choose residences with superior environmental efficiency.

Nurturing of Worker Skills; Information Transmission

Designers and architects who are highly skilled in bonding architectural designs that make use of local and regional climate and the use of leading-edge equipment are nurtured in each area; their know-how will be handed over to the next generation. Moreover, long-life buildings such as "200-year homes" have become widespread, limiting unnecessary consumption of resources and energy.

Implementation Barriers and Strategic Steps

Standardization Period

Currently, at the time of purchasing or contract leasing of residences and buildings, since there is no requirement in general for the presentation of information regarding environmental efficiency, this has not been an item of importance. Also, even today, although it is possible to evaluate the environmental efficiency of residences and buildings, the number of people capable of performing these complex calculations have not been sufficient, hindering its widespread practice. Accordingly, the proposed strategy promotes the establishment of simplified evaluation method for building efficiency according to use in consultation with existing building evaluation methods (CASBEE, etc.) and evaluation methods implemented in Europe and other countries. At the same time, it continues to make progress on nurturing practitioners for the diagnosis of energy-saving efficiency and CO_2 reduction efficiency. Furthermore, lectures for craftsmen on building technology will be established in universities and other educational institutions, and by organizing in each region training classes and events intended for construction workers, foundations will be created for passing on the knowledge of energy-efficient building technologies and designs.

Environmental Efficiency Labeling Introduction Period

A labeling system for residences and buildings will be commenced based on the newly-developed evaluation methods. Long-term energy-saving target values (upward in incremental steps) will be set for each type of building usage. Certification and registration of labeling will be mandatory at the time of purchase for newly-built residences, at the time of renovation for existing buildings, and at certain intervals for leased and business buildings. Those failing to meet the lowest-rank standard will receive guidance to attain the acceptable standard values through the introduction of high-efficiency equipment, solar power generator, solar thermal equipment and so forth. In addition to the annual energy consumption of the average household and CO_2 emissions, the environmental efficiency labels will include the economic figures for the buildings such as the average annual energy cost, enabling comparisons of initial investments and running costs. Furthermore, through combination of tax breaks and low interest financing loans that correspond to the environmental efficiency label, incentives will be provided to owners and users of buildings to select residences or buildings on a long-term basis.

Contribution of Building Owners

Selection of residential buildings with high environmental efficiency. Commission of low-carbon design to architects and construction companies.

Contribution of Architects, etc.

Development of low-carbon architectural design methods. Investing for technology development in insulation technologies, etc. Sustenance of regional worker skills.

Standardization Period → Environmental Efficiency Labeling Introduction Period

■ Residential household energy demand : -40% (from FY2000 level)
■ Building floor area energy demand : -40% (from FY2000 level)

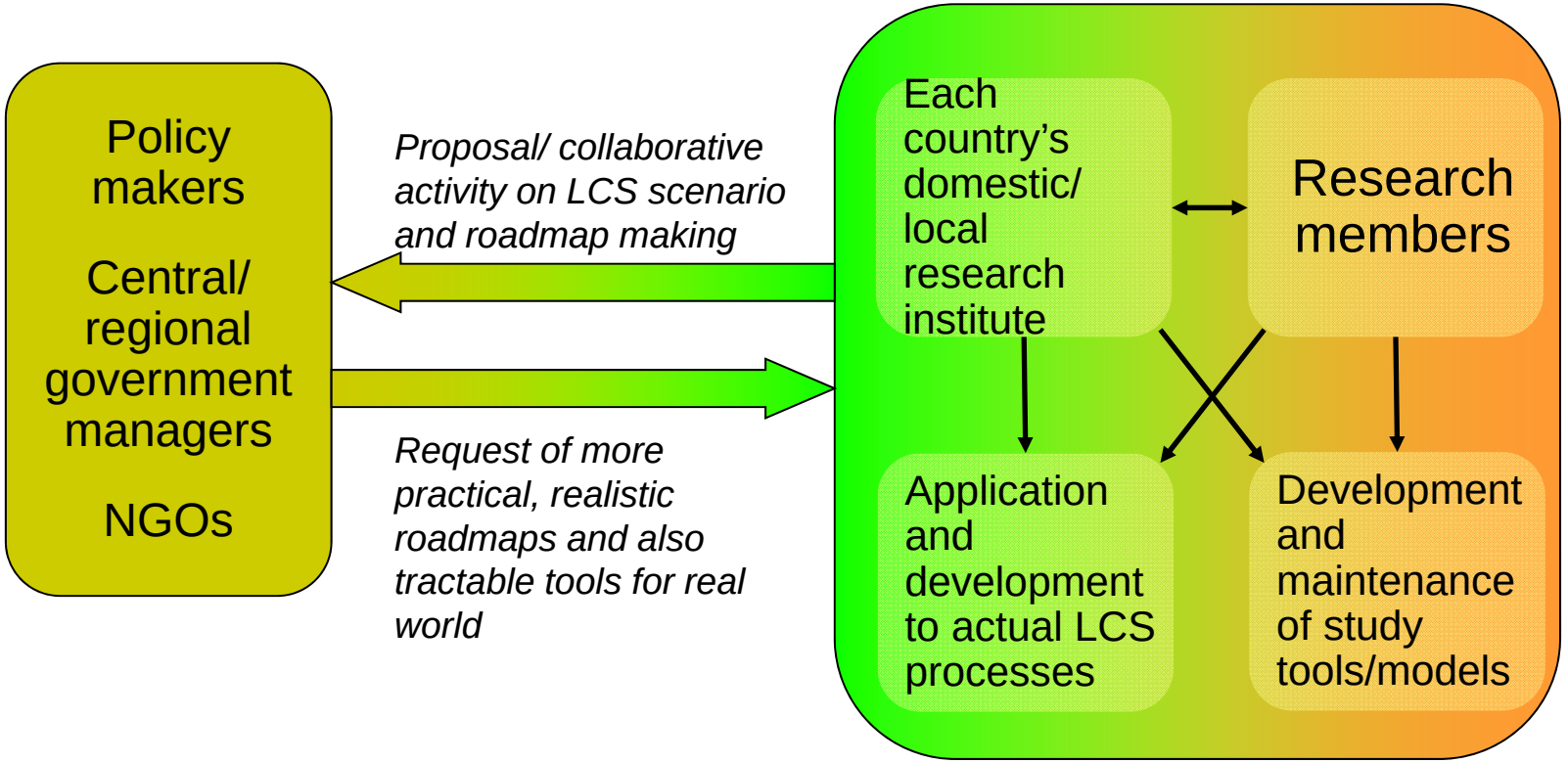
Barriers		Future Objectives
Complex energy-saving performance metrics, high calculation costs, insufficient personnel	Dissemination of diagnosis practitioners for energy-saving and CO_2 reduction efficiencies	Solar and wind utilization design
	Establishment of simplified evaluation method for environmental efficiency of residences and buildings	Finance-friendly environmental efficiency
Insufficient incentives for choosing energy-saving residences and buildings	Organizing training classes and events for passing on knowledge of architectural technologies	Nurturing of worker skills & information transmission
	Introduction and expansion of residence and building labeling system for environmental efficiency (new building, renovation, mandatory indication upon leasing)	
	Implementation and expansion of tax breaks and low interest loan financing based on the environmental efficiency label	
	Establishment and review of long-term energy-saving standard targets for buildings	

1990 2000 2010 2020 2030 2040 2050

Several different focusing points exist depending on audiences and degree of the study progress

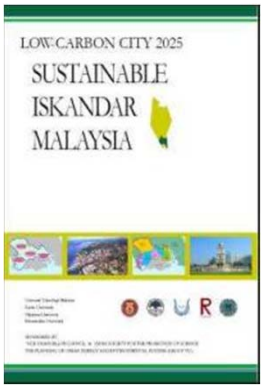
Focusing points	Type
Analysis of GHG reduction targets and reduction potential	Design of Target Society and Reduction Potential analysis
Economic analysis of LCS policies	Economic analysis
Design of policy packages and roadmaps	Roadmap design
Analysis of co-benefits of LCS policies	Co-benefit analysis

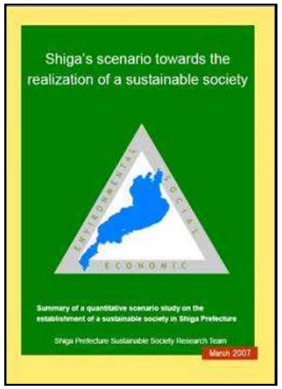
6. Collaborating with Asian colleagues

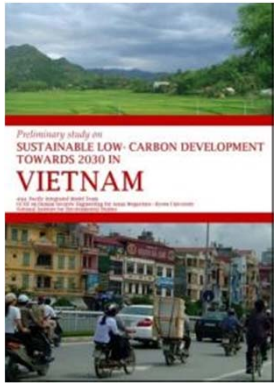


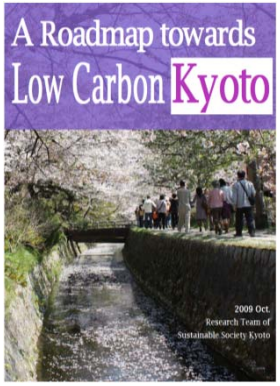
Region specific studies now we are going on

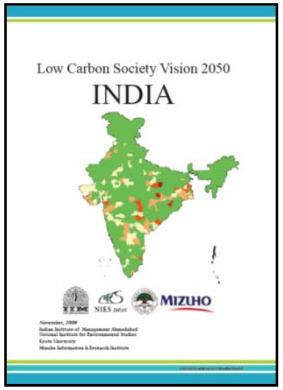
Communication and feedbacks of LCS study to real world

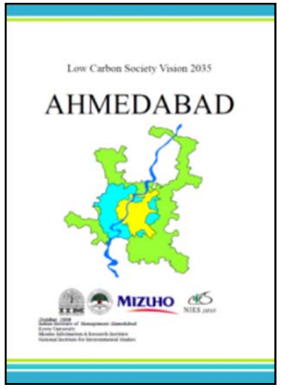


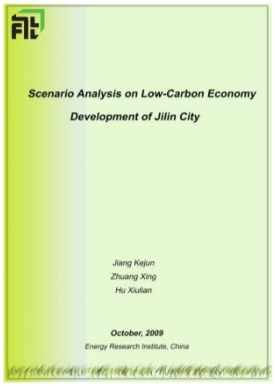


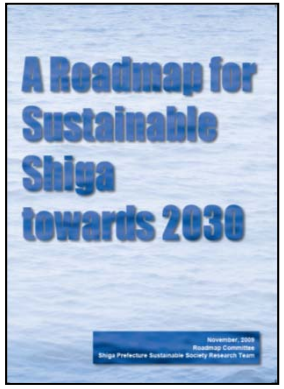












Asia Modeling Network

Asian Modeling Meeting at Tsukuba on 17-18 September 2009

14th AIM International Workshop on 14-15 February 2009

AIM Training Workshop on 2-4 August 2010

7. Final remarks

1. **“Low Carbon Society (LCS)” issue is not only related with energy supply and consumption systems but also essentially connected with socio-economic-industrial planning. Real and quantitative integration is necessary in order to design Low Carbon Society.**

2. **Myopic tactics can not drive us to LCS. In order to realize LCS, 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 LCS and roadmaps towards LCS. We applied them to the real fields mainly in Japan.**

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